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Food, Health and Environmental Issues in Developing Countries: The Nigerian Situation

Edited by

Odunayo C. Adebooye
Kehinde A. Taiwo
Andrew A. Fatufe

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DEDICATION

This book is dedicated to the Alexander von Humboldt Foundation, Germany for its special support for outstanding African Scholars.

The book also is dedicated to the poor and hungry people in the African Continent who have woken up today to uncertainty, insecurity and poverty.

Foreword

Research on food, health and environmental issues is of major importance for developing countries. This peer-reviewed publication provides an overview of current Nigerian research projects on these topics. The book, containing peer-reviewed articles, is based on a conference, which took place at Obafemi Awolowo University in Ile-Ife, Nigeria, in August 2008 and which was mainly sponsored by the Alexander von Humboldt Foundation.

The Humboldt Foundation is a German non-profit organisation promoting academic cooperation between excellent scientists and scholars from Germany and abroad. Every year, the foundation sponsors approximately 1,800 research fellowships and awards.

The greatest asset of the Humboldt Foundation is its international alumni network. It embraces approximately 23,000 scientists and scholars from all disciplines in more than 130 countries who are closely associated with Germany. Nigeria has one of the strongest Humboldt networks on the African continent. It comprises about 180 scientists and scholars from all major Nigerian universities.

To support its international network, the Humboldt Foundation provides financial support to organise regional and specialist conferences (so-called "Humboldt Kollegs"). The Humboldt Kollegs have rapidly become one of the most popular instruments for strengthening regional and specialist networks. The majority of participants in these conferences are Humboldtians from a specific region or a major specialist field.

The Humboldt Kolleg at Obafemi Awolowo University has been part of the "Africa Initiative 2008-2009" that the Humboldt Foundation has launched with special support of the German Foreign Office to strengthen the local and regional networks in Africa. The Humboldt Foundation is grateful to the organisers and co-sponsors of the conference for their commitment.

The Humboldt Foundation is confident that the proceedings of this conference will contribute to the development of Nigerian education and research.

Dr. Felix Streiter
Alexander von Humboldt Foundation
Head of Division Middle East, Africa, Latin America

FROM THE EDITORS

It is our joy to publish the full texts of the peer-reviewed articles presented at the Humboldt Conference of August 3-7, 2008. We thank the Alexander von Humboldt Foundation, Bonn, Germany for providing the funds for the Conference and for the publication of this book. The Editors also appreciate the painstaking efforts of the reviewers who responded promptly to peer-review requests. Reviewers' comments went a long way to improve the academic qualities of all the articles contained in this book.

We are certain that the articles contained in this book will be of immense values to undergraduate, postgraduate, postdoctoral and full-time researchers on topics that are related to food, health and environmental issues in developing countries.

Editor-In-Chief:
Odunayo C. Adebooye PhD, MCRA, Humboldtian

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Alexander von Humboldt
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Comparative Analysis of Livestock Resources and Productivity In Nigeria With Some Selected Countries of The World

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Abstract

The critical role of livestock industry in the economy of any nation, including Nigeria cannot be underscored. This sector represents the main animal protein resources for the population. The livestock production potentials of Nigeria was examined and compared with those of African countries and some selected developed countries of the world. Nigeria holds a total of 212.8 million livestock with cattle, sheep and goats contributing 7.1%, 10.8% and 13.2% of the total population respectively. Pigs and poultry represent 3.1% and 65.8%, respectively. Nigeria holds about 12% of African continents of goats, 9% of sheep, 31% of pigs and 10% of poultry. The livestock population in Nigeria is about 58%, 56% and 14% higher than found in countries like Italy, Spain and Germany respectively but the level of productivity (meat, milk and egg) is comparably lower. The major reasons for this short fall are diseases, poor management techniques, poor genetic composition of the local breeds and unsustainable government policy measures, to mention but a few. It was suggested that government at different levels, in concert with the private sector, should come up with sustainable policy measures that will enhance animal agriculture in the country. This will lead to improve animal protein production and consumption, and consequently, abate the associated health implications often occasioned from poor consumption of animal protein among the protein vulnerable groups.

Keywords: Livestock resources, Productivity, Nigeria, Selected Countries

Introduction

Livestock industry plays a major role in the economy of any nation especially in a developing nation like Nigeria (Alokan, 2008). In Nigeria for example, the contribution of agricultural sector to the Gross Domestic Product (GDP) was immense dated back 1970 before the discovery of crude oil. Consequently, livestock plays significant role in the supply of animal protein to the Nigerian populace. Protein derived from animal is known to be superior in terms of amino acid component and biological value to that of plant protein.

The component of animal protein in human diet varies from country to country and it is a function of the available numbers of animals (cattle, sheep, goat, pigs and poultry) and products (beef, mutton, goat, pig and chicken and eggs) derived from the animals. Compared with other parts of the world, the livestock resources in Nigeria are higher than found in most developed countries but the products derived from these animals are ridiculously lower than obtained in these advanced countries (FAO, 2003). The implication of this is that the consumption of animal protein in Nigeria and Africa is inadequate. The poor performance could be due to many factors, which include disease (ILRAD, 1990) and the poor genetic make up of these animals in Nigeria and Africa at large. Therefore, this paper attempts to review the livestock policies in Nigeria and also examines the livestock resources in Nigeria vis-à-vis animal products and compares same with those of some selected

countries of Africa and the world at large. Also, some factors that are militating against good performance of these livestock and their products will be highlighted with a view to proffer some solutions. This is envisaged will help to improve animal production with attendant increase in animal protein consumption in Nigeria.

Review of Policy on Livestock Production in Nigeria

A review of government objectives and policies for the Livestock Sector in Nigeria can be conveniently divided into 5 periods: the colonial period preceding independence in 1960, the immediate post-independence period up to the end of the Sahelian drought in 1974, the oil-boom period from 1975-1985, the period from 1986-1999 marking the commencement of the Structural Adjustment Programme (SAP) and the period from 1999 during democratic dispensation culminating in the National Economic Empowerment Development Strategy (NEEDS).

The colonial era: Initial colonial objectives with respect to the livestock sector (LSS) were not explicitly stated, but the commitment to expand exports of livestock products had emerged prior to World War II. The colonial government objectives were primarily implemented through a policy of investment in both physical infrastructure and basic research. However, most of the schemes embarked upon during this period were oriented toward ranching and thus had little impact on smallholder or pastoral systems. Furthermore, attention appears to have been focused mainly on cattle, particularly dairy production, to the exclusion of other species.

Independence to 1974: The onset of independence saw both a continuation and a shift in livestock development policy in Nigeria. On the one hand, some of the programmes initiated during the colonial period such as the tsetse eradication and livestock breeding programmes were continued. On the other hand, driven by a desire to improve the rate of growth of the economy and to achieve a more equitable distribution of income, the new regional governments initiated a number of programmes in an attempt to improve smallholder and pastoral systems. By 1965, grazing reserves were introduced to secure a year-round source of fodder for ruminants and to encourage the settlement of pastoral nomads. Trade and production investment policies were also emphasized during this period. Trade policy towards the sector initially took the form of import duties.

1975-1985: Policies instituted in the immediate post-independence period were largely continued in the 1975-85 period. The basic economic objective remained income growth with some new concern for increased animal protein intake. The rise in government revenue as a result of the oil boom initially led to a relaxation of livestock trade policy. Between 1974 and 1977, quantitative import restrictions were removed and tariff rates were reduced such that, once again, customs duties on most livestock products fell in the range of 10-30%. Institutional policies involving land and credit were introduced during this period. The 1978 Land Tenure Decree vested all rural land not under active exploitation in state governors. Although an official title to land (i.e. certificate of occupancy) can be obtained through this decree, the process is both time consuming and expensive and, thus, out of the reach of most pastoralists. Further, it has been argued that the decree with its recommended high levels for land compensation has militated against land acquisition for the establishment of new grazing reserves (Waters-Bayer and Taylor-Powell, 1986). The Agricultural Credit Guarantee Scheme (ACGS) was also introduced in 1978. The scheme was established to guarantee loans granted by commercial and merchant banks for agricultural purposes. Lending to the LSS has featured prominently since the inception

ot the scheme. The lending, however, has been lopsided firstly in favour of the crop sector and secondly for the livestock sector, it has tended to favour mostly the modern poultry sector. Loan guarantee statistics showed that between the inception of the scheme in 1978 and 2002, total guaranteed loans amounted to ₦4, 354,525.4 million. Out of this total, ₦457, 952.2 million went to livestock (Amos and Ayanda, 2004) and the scheme also appeared to have catered mainly for the large commercial producer.

1986 -1999: The Structural Adjustment Programme (SAP) initiated in September 1986 has brought about a variety of sector reforms in the Nigerian economy. As it affects the livestock sector, it involves a reduction in the role of the state in production activities with a corresponding emphasis on using the private sector as an instrument for production and input supply. Since early 1988, a ban on imports of fresh, chilled or frozen meat has been applied to protect domestic producers. For live animals, except poultry, import duty rose to 20% in 1986 from the 15% duty applied in 1984. However, since most live animals are trekked across the border from neighbouring countries, the herders avoid official crossing posts and the animals are, therefore, not directly affected by these tariff rates. Live poultry imports were banned in 1986, except for foundation and grandparent stock used for research or multiplication purposes.

Since independence, two of the major long-run goals of livestock policy have been to raise the low level of supply of animal protein, and to improve and stabilize rural income emanating from livestock production and processing. Concerns about balance of payments problems may have directed increased policy attention towards the need to attain self-sufficiency in livestock production in Nigeria.

Post 1999 era

The Policy thrusts of the Nigerian government as it relates to animal production are:

- to provide the right policy environment and target incentives for private investment in the sector
- implement a development policy aimed at addressing the constraints in the sector
- foster effective linkage with industry to achieve maximum value added and processing for export
- modernize production and create a sector that is responsive to the demands and realities of the Nigerian economy in order to create more employment opportunities which will increase the income of farmers and rural dwellers
- reverse the trend in the importation of food through a progressive program for expansion
- invest in improving the quality of the environment in order to increase yields

Government's aims over the years have been to:

- Achieve minimum annual growth rate of 6 percent in agriculture
- Raise agriculture exports to $3 billion by 2007
- Drastically reduce food imports by 14.5 percent
- Develop and implement a scheme of land reparation services to increase cultivable arable land by 10 percent a year and foster private sector participation through incentive schemes
- Promote the adoption of environmentally friendly practices
- Protect all prime agricultural lands for continued agricultural production.

These are laudable goals which can be achieved but needs a lot of efforts. Governments at different times have tried to achieve these laudable goals by establishing the Agricultural Credit Guarantee Scheme Fund (ACGSF),

instituting tax free quota for some imported livestock drugs/vaccines, establishment of grazing reserves in different parts of the country and establishment of training schools for different manpower development.

Comparative Analysis of Livestock Population

As found in most countries of the world, the major livestock species found in Nigeria are cattle, sheep, goats, pigs and poultry. Figure 1 indicates that Nigeria as at 2005 had 15.2 million heads of cattle, 23.0 millions of sheep, 28.0 millions of goats, 6.6 millions of pigs and 140.0 millions of poultry (FAOSTAT, 2007). The livestock resources in Nigeria are fairly large compared with the total holding on the African continent but in some cases lower than those in selected countries in America and Asia (Figures 2 & 3). However, they are in some cases higher than those found in some countries in Europe (Figure 4). Nigeria holds about 12% of the continent of African goats, 9% of sheep, 31% of pig and 10% of poultry. These proportions gave Nigeria a pre-eminent position in livestock industry in Africa (Alokan, 2008).

Larmode (1998) reported that Nigeria was the largest livestock producer in West Africa sub-region and third largest producer in the sub-Sahara Africa following Ethiopia and Sudan. Compared with countries like Italy, Spain and Germany, the livestock population of Nigeria is about 58%, 56% and 14% higher suggesting that Nigeria has more livestock potentials than even some well-known livestock producers of the world. However, the livestock population is managed by small holders and a considerable proportion is managed on free range traditional system. According to Rim (1992), 85% of all species found in Nigeria are been traditionally managed while commercially managed livestock was only significant for poultry (13.8%) and to a lesser extent for pigs (3.2%),

Cattle (0.5%), goats (0.03%) and sheep (0.2%). This is the trend contrary to what is obtainable in Europe and N America where over 97% of the livestock are managed intensively.

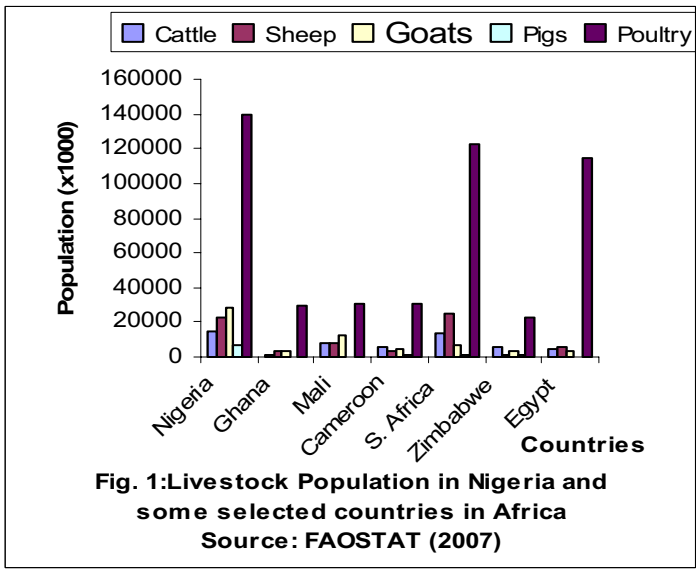

Fig. 1:Livestock Population in Nigeria and some selected countries in Africa
Source: FAOSTAT (2007)

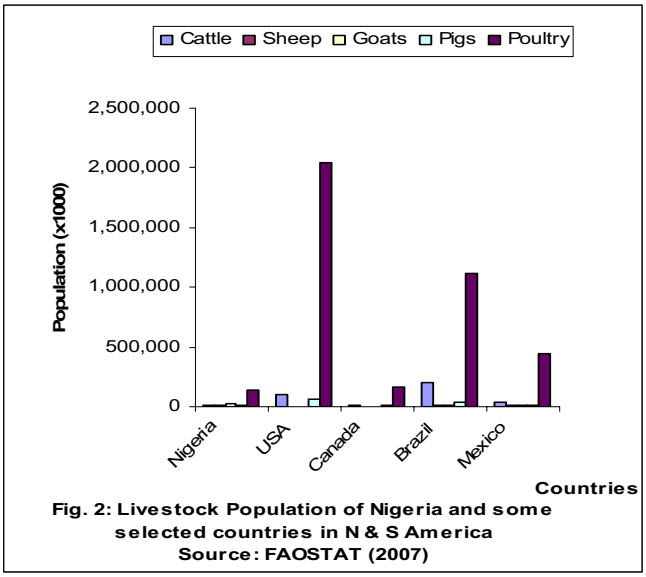

Fig. 2: Livestock Population of Nigeria and some selected countries in N & S America
Source: FAOSTAT (2007)

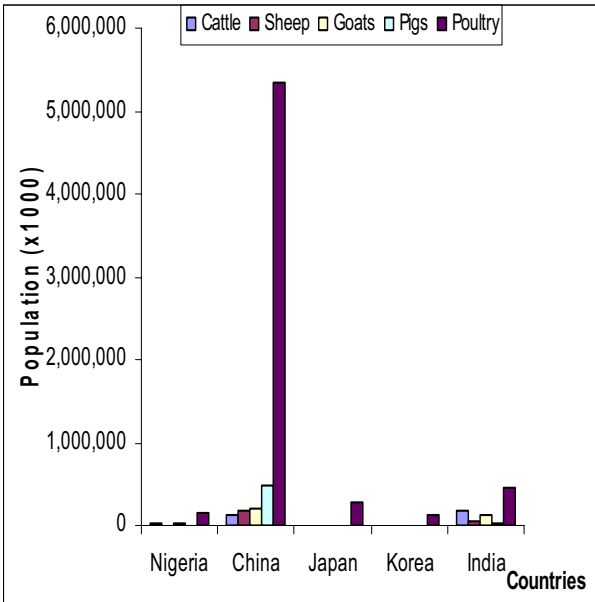

Fig. 3: Livestock Population of Nigeria and some selected countries in Asia
Source: FAOSTAT (2007)

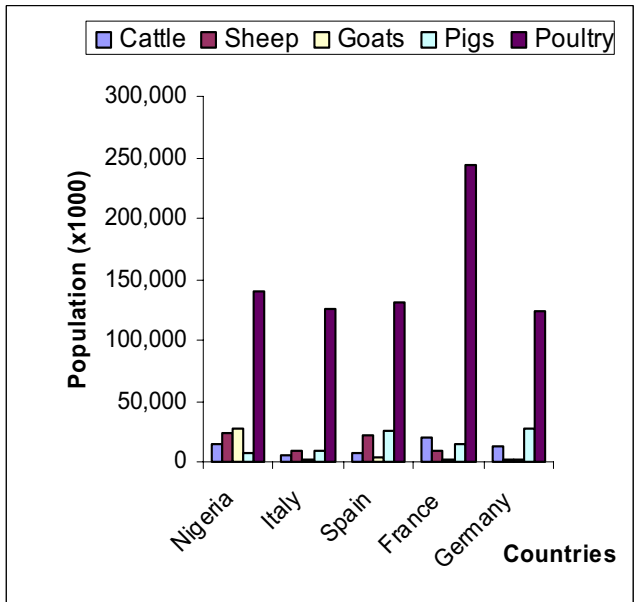

Fig. 4:Livestock Population of Nigeria and some selected countries in Europe
Source: FAOSTAT (2007)

Comparative Analysis of Livestock Products

Table 1 shows that the livestock products (meat and milk) in Nigeria is consistently higher in most cases than those found in most African countries irrespective of the species of livestock concern. However, in comparison with other countries of the world, the livestock products from America (Mexico, Argentina, Brazil, Canada and USA), South and eastern Asia (China, Japan and India) and Europe (Italy, Spain, France and Germany) are much higher than found in Nigeria and Africa in general.

With a population growth of about 3.0% per annum, Nigeria present population of about 140 million will reach about 200 million by year 2020. This explains why large numbers of live cattle, sheep and goats were imported as well as various milk products (up to US$275 M) in year 2004 (FAOSTAT, 2006; Alokan, 2008). To be able to meet the protein needs of the populace, the urgent need to improve animal agriculture is imperative in Nigeria.

Factors Militating Against Livestock Production in Nigeria

The number of livestock resources in Nigeria out weighs those found in many developed countries of the world but with a resultant poor productivity. Thus, the inability of the Nigerian livestock industry to meet the protein needs of her populace compared with those of developed nations like France, Italy, Germany, Canada and USA, could be as a result of some factors affecting the industry. These factors include livestock and human (farmers) diseases, poor management techniques, cultural belief, poor nutrition and high cost of finished feeds, poor genetic make of the indigenous breeds, vagaries of weather, reduction in the available grazing land due to urbanization and industrialization, poor research output from our research stations including universities and, inconsistent and unsustainable government policy on agriculture.

The combined effects of these factors are poor productivity, low income for the livestock farmers, increased animal protein importation to ameliorate the deficit, high mortality and morbidity and of course, gross reduction in animal protein intake in Nigeria. Consequently, resource-poor families cannot afford sufficient animal protein such as egg, meat and milk in their diets. The consequence of this is increase incidence of kwashiorkor, retarded growth, poor mental alertness, marasmus, mortality and morbidity among the protein vulnerable groups such as pre-school children, infants, nursing mothers and aged people.

Conclusion

The livestock potential of Nigeria was compared with those of some selected countries. Livestock populations in Nigeria compared and in some cases are more than found in many countries of the world including the developed countries. However, the level of products production is comparably lower than found in the developed nations. This has an adverse effect on the gross domestic product and the resource-poor populace that constitute over 85% of the population. The reasons for the poor productivity are highlighted. From the foregoing, government at all levels should work in concert with private sector to sustain animal agriculture policy in the country. This is envisaged will increase animal protein consumption and abate the adverse effects of the associated health implications among the protein deficiency vulnerable groups.

Table 1: Livestock products (x1000MT) of Nigeria and of some selected countries of the world

COUNTRIES	BEEF	MUTTON	GOAT	PIG	POULTRY
Africa					
Nigeria	280F	99F	142F	200F	1042F
Ghana	24F	11F	11F	10F	172F
Mali	113F	36F	46F	2F	259F
Cameroon	95F	16F	15F	16F	218F
S/Africa	590F	104F	36F	113F	1686F
Zimbabwe	102F	1F	13F	27F	206F
Egypt	250F	75F	33F	3F	1445F
Malawi	16F	-	6F	21F	59F
America					
Mexico	1496	40	42	1043	4908
Costa Rica	74	7	-	36	182
Argentina	2800*	52F	10F	216F	4163
Brazil	7526	68F	40F	3059	18684
Colombia	680F	7F	7F	110F	1442F
Canada	1171	-	-	1952	4248
U.S.A	11906	90	-	9064	38748
Asia					
China	6218*	1991*	1603*	46048*	71041
Japan	505*	-	-	1259	2991
Rep. Korea	185*	-	3F	1153*	1771
India	1490F	234F	473F	630F	6038F
Pakistan	445*	174*	373*	-	1892
Europe					
Greece	62F	82F	44F	140F	484F
Italy	1125	58*	4*	1587*	4224
Spain	700	237	14	3322	5442
France	1650F	135F	7F	2340F	6516
Germany	1220	44	-	4238	6597

F = FAO Estimate, * = Unofficial figure
Source: FAO (2003)

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The Food Situation In Nigeria: Issues, Perspectives and lessons for developing countries.

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Abstract

Over 90% of foreign exchange earnings in Nigeria comes from crude oil (petroleum) export while more than 60% of the population lives in the rural areas and practice subsistence agriculture. Small-scale farmers cultivating tiny plots of land produce about 90 per cent of the country's food. Over 70% of the labour force is employed by agriculture, yet Nigeria is gross food importer. Average life expectancy is 47.4 years, with 46 years for male and 48 years for female. Generally, population is growing at 2.5% per year while food production keeps on falling on yearly basis. If this growth rate is maintained, it is possible that Nigeria population will double in about 40 years (around 2048). Recent statistics (World Bank) have shown that over 70% of Nigerians live below poverty line, on less than one dollar ($1) per day. Poverty is especially severe in rural areas, where social services and infrastructure are limited or non-existent. Information on global food production shows that Africa (Nigeria included) at the current level of consumption will have to increase food production by 300% to provide "minimally" adequate diets for over 2 billion people projected in 2050. As the population grows (based on projection), people will try to obtain higher output (food, water) from heavily used natural resources which eventually will lead to land degradation, poor soil, fresh water scarcity, increased pollution and general breakdown of social and environmental balance. The net effect will be a total decline in Nigeria's capacity to expand food production and subsequently inability to sustain the well being of the citizenry. This paper examines the Nigeria's journey since independence in her effort to produce food to feed the citizens, what went wrong along the line and the present situation.

Keywords: Agriculture, Food, policy issues, programmes.

Introduction

Food production capacities are deteriorating in many low-income food-deficit countries. Since 1961 food production has kept pace with population growth in all developing regions except sub-Saharan Africa. (Mellor and Paulino, 1989; Ho, 1990) The Food and Agricultural Organization of the United Nations (UNFAO) projects that more than half of developing countries (62 of 115 studied) may not be able to feed their projected populations from their own land by the year 2050 using current low levels of farming technology. Most of these 62 countries (Nigeria inclusive) may be able to feed less than half of their projected population from their own land (UNFAO, 1996) Though, Nigeria is among the few countries that can afford to import food, this is said to be more expensive than local production and more so food importation uses foreign exchange that could be used for other development purposes such as importing capital equipment for manufacturing.(Population Reports, 1996).

In Nigeria agriculture contributes 40% to the GDP, employs about two-thirds of the total labour force of the nation, provides a livelihood for the bulk of the rural population (nearly three-quarters of the poor live in the rural areas) and is dominated (about 90%) by its over 14million smallholder farmers. Agricultural production grew from 2.9% in 1999 to 7% in 2006. Nigeria has potential of 68 million ha for agriculture with 33 million ha cultivated. The country also has 3.4m ha of irrigable land with only 220,000 ha under irrigation.

According to Wells (1969), Nigerian agriculture had been a leading sector of export growth and had contributed sufficient food and raw materials to meet the requirements of a growing population. In the pre-independence

perıod, agricultural commodities were almost all the exports Nigeria had. Coastal trades brought in textiles, spirits, and tobacco in exchange for palm oil kernels and rubber, output which Eicher (1970) called "naturally occurring products". The response of indigenous Nigerian agriculture to contact with the other economies in need of Nigeria's products was substantial. Between 1900 and 1950 cocoa exported from Nigeria increased from 202 tons to 99,949 tons; palm kernels exports increased from 85, 624 tons to 415, 906 tons; and groundnut exports increased from 599 tons to 311, 221 tons. This increase was reported to have resulted from local entrepreneurs responding to export prices (Olusanya and Pursell, 1981).

A significant shift in agricultural investment policy was introduced in the *First National Development Plan 1962-1968*. Government was brought directly into production through investment in public into production through investment in public farms and plantations. Provision was made for extension workers, funds were budgeted for research and further improvements in infrastructure was provided. Agriculture continued to expand, however, as a result of increases in efforts from the private sector. Output from public sector agricultural projects has not made any significant contribution to total production. (Olusanya and Pursell, 1981).

Past Government efforts at achieving food securiy:

The Federal Government of Nigeria at pre- and post-independence periods established programmes aimed at achieving food security and these include:

- Cooperatives (1935 to Date)
- Commodity Boards (1947 to 1986)
- Agricultural Research Institutes (1964 to Date)
- National Accelerated Food Production Project (1970s)
- Nigerian Agricultural Cooperative Bank (1973 to Date)
- Agricultural Development Projects (1975 to Date)
- Operation Feed the Nation (1976 to 1979)
- River Basin Development Authorities (1977 to Date)
- Directorate of Foods, Roads and Rural Infrastructure (1986 to 1993)
- National Agricultural Land Development Authority (1991 to 1999)
- Presidential Initiatives on Cocoa, Cassava, Rice, Livestock, Fisheries and Vegetables (1999 to 2007)

It is rather unfortunate that these progrmammes with lofty objectives did not perform up to expectation for the following reasons:

- Policy inconsistencies
- Over emphasis on production without due consideration to other value chain requirements
- Corruption and misapplication of funds

What can be done?

Achieving food security means addressing several related issues: slowing population growth, increasing food production, and safeguarding the environment. Since not every country can be self-sufficient in food production, International trade will become increasingly important in the future to achieve food security worldwide. To provide food security for all of the 8 billion people, projected by 2025, the world would have to

double food production over current levels (FAO, 1995; UNFAO, 1965-1980). Recent years have brought some promising developments. These include a new strain of super rice capable of boosting yields by 25% (Mydans, 1997; Pearce, 1996), improved varieties of corn that could increase yields perhaps by 40% and that could be grown on marginal land (Grier, 1994), and a new blight-resistant potato (Pearce, 1996).

To achieve food security, the food-deficit countries must reverse the current course of land degradation and begin to manage soil and water resources on a sustainable basis. There are many ways to protect agricultural land. In many areas, for example, irrigated land could be managed better by using hand pumps and traditional water harvesting techniques rather than relying on large-scale automated sprinkler systems. Specific solutions will vary from one area to another. Virtually everywhere, however, protecting the environment will help produce more food to feed more people.

Accomplishing a Second Green Revolution: The first Green Revolution in agriculture of the 1960s helped food production keep pace with population growth. Because population growth continued, the Green Revolution was only a "Temporary success", said Norman Borlaug upon receiving the 1970 Nobel Peace Prize as one of its architects. Today, as population moves toward 8 billion in 2025, a second Green Revolution should focus on the food crops grown by the 2 billion people who lack food security. It should concentrate not only on improving the yields of the big three staples-rice, corn, and wheat-but also on such crops as sorghum, millet, and cassava ((FAO, 1995; FAO, 1996).

Rediscovering forgotten foods: another way to help achieve food security is to cultivate traditional food plants that modern agriculture has neglected. Amaranth and quinoa, two grains grown by the ancient Aztecs of Mexico and Incas of Peru, are examples. Both grains are versatile and nutritious, containing more high-quality protein than most other commercial grains, including corn and rice. Moreover, both grow well under difficult conditions. Amaranth thrives in hot climates, while the quinoa plants are frost-resistant and can be grown at high elevations (World Bank, 1996).

Increasing yields: Some countries are improving crop yields with new approaches that use low-level inputs. Examples include fertilizing with animal wastes (organic agriculture) instead of chemicals, recycling nutrients, conserving water, and selecting a variety of crops better suited to soil conditions and climate ((FAO, 1995; FAO, 1996)

Another techniques is Integrated Pest Management (IPM). IPM uses several related strategies: preserving natural pest predators, using pest-resistant seed varieties, and drastically cutting amounts of pesticides. This approach has increased yields while reducing use of pesticides and fertilizers ((FAO, 1995). The FAO (1965-1980) report identified five 'tasks' for Nigerian agriculture; (i) to provide and adequate and well balanced food supply, (2) provide raw materials for domestic use, (3) provide export earnings (4) provide employment for additional workers, and (5) contribute a major proportion of the capital required for development.

One of the general policy recommendations considered important in expanding agricultural output was to bring under cultivation relatively unoccupied land, particularly the middle belt. One important study of three Northern Nigerian villages concluded that labour inputs were the major constraint on output. The FAO report calls Nigeria fortunate in having potentially good farming land available for exploitation. In particular the report states that the middle area offers the possibility of becoming an excellent mixed farming area. The main obstacle to be overcome is the tsetse fly. Until it is eliminated, permanent farming in the area will be difficult and farming animals are considered necessary for successful farming in this middle region.

It is very important to consider exactly what is involved in converting "unoccupied land" into occupied, productive land lest this resource be mistakenly thought of as a free input. The term unoccupied land implies that with minimal effort land can be brought into production. This is quite misleading. Before it is brought into production, capital and labour inputs are required to clear the land, perhaps only minimSll1y. But there is tsetse fly in the middle belt and it must be eliminated. This will require additional capital and labour inputs long before the area is ready for increased production. If the tsetse programme is successful, then the unoccupied regions will require additional capital and labour inputs in preparation for production before the first full crops can be realized. Thus, unoccupied land looks more like marginal land because of' the presence of some factor or factors which must be overcome before it can be effectively brought into production. The unoccupied land in Nigeria, given present technical skills, is not very productive, does not appear well integrated into the economy, and lacks infrastructure. Before production on a large scale can begin, a substantial amount of investment resources will be required to prepare the land. Noting the problems that Brazil has faced in bringing unoccupied land into production, Nigeria should undertake feasibility studies before committing scarce resources to a plan designed to make relatively unoccupied land productive. There is no evidence to contradict the view that agricultural investment funds placed elsewhere (other than the middle belt) might have a higher rate of return that possible from the middle belt. (Olusanya and Pursell, 1976).

Nigeria's Agricultural Policy (2007)

The guiding objectives of federal agricultural policy were:

1. Ensuring food supplies in adequate quantity and quality to keep pace with increased population and urbanization, having regards to changing tastes and the need for fair and stable prices.
2. Expanding the production of export crops, with a view to increasing and further diversifying the country's foreign exchange earnings so vital in the development process.
3. Propagating the production of agricultural materials for extensive domestic manufacturing activities, especially in the field of agro-based industries.
4. Creating rural employment opportunities to absorb more of the increasing labour force in the nation, and minimizing the tendency for inadequate and inefficient use of human resources in the rural areas generally.
5. Evolving appropriate institutional and administrative apparatus to facilitate a smooth integrated development of the agricultural potential of the country as a whole.

A potential deterrent to expand food crop production is the fact that farmers apparently view export crop expansion a sure thing if price rises. When food prices rise, farmers are skeptical of their ability to sell additional output at higher prices since the market is too limited. Experiences of having to sell additional food output at greatly reduced prices have convinced farmers that food crop expansion is risky. Consequently farmers view food crop expansion as a relatively unattractive means of increasing cash income since extra inputs frequently result in small incremental cash rewards.

The current federal agricultural policy objectives include:

(i) Attainment of self-sufficiency in basic food commodities with particular reference to those which consume considerable shares of Nigeria's foreign exchange arid for which the country has comparative advantage in local production.

(ii) increase in production of agricultural raw materials to meet the growth of an expanding industrial sector;

(iii) increase in production and processing of exportable commodities with a view to increasing their foreign exchange earning capacity and further diversifying the country's export base and sources of foreign exchange earnings;

(iv) modernization or agricultural production, processing, storage and distribution through the infusion of improved technologies and management so that culture can be more responsive to 'the demands of other sectors of the Nigerian economy;

(v) creation of more agricultural and rural employment opportunities to increase the income of farmers and rural dwellers and' productively absorb an increasing labour force in the nation;

(vi) protection and improvement of agricultural land resources and preservation of the environment for sustainable agricultural procedure;

(vii) establishment of appropriate institutions and creation of administrative organs to facilitate the integrated development and realization of the country's agricultural potentials.

Appraisal of impact of the agricultural policy:

The agricultural policy was designed to stimulate growth and development of agriculture so as to positively impact on the overall growth of the Nigerian economy. The response of the sector to the various policy measures have been mixed. Between 1970-1982 agricultural growth rate stagnated at less than 4% with sharp decline in the production of export crops. Per capita calorific food supply declined from surpluses in the 1960s to a deficit of 38% in 1982, while Nigeria turned a net importer of vegetable oil, meat, dairy products, fish and grains, notably rice wheat and maize with the food import bills rising astronomically. Some factors at work included increasing rate of urbanization, high population growth rate, impact of the civil war and unfavourable external environment.

The performance of the sector was undermined by disincentives created by the macro economic environment. The Economic Stabilization Act enacted in 1987 affected expenditures on agriculture and restricted imports of agricultural products and inputs. The trade policies which placed bans on imports of some foods and the provision of some other incentives induced marginal improvement in the performance of the sector. The minimum administrative control of economic activities and the wide scope. for free market forces in the economy attendant on the 1986-88 Structural Adjustment programme (SAP) led to policy shifts relating to agricultural pricing trade, investment, production extension and technology transfer as well as credit. It was in this period that the first formal and deliberate agricultural policy was formulated and launched in 1988 with the strategies for its implementation.

Under SAP, the tariff structure was adjusted to encourage local production and to protect agricultural and local industries from unfair international competition. The Marketing Boards for scheduled crops, were abolished. Bans were placed on the importation of a number of food items including most livestock products, rice, maize, wheat and vegetable oils. Agricultural input subsidies were phased out. A number of new institutions were created for agricultural and rural development namely; the Directorate of Food, Roads and Rural Infrastructure (DFRRI) and the National Directorate of Employment (NDE). Some existing institutions were also reorganized (e.g. the River Basin Development Authorities), while most public-owned agricultural enterprises were privatised or commercialized. These SAP measures to some extent had positive impact on the

agrıcultural sector due mainly to price increase as a result of devaluation of the currency and ban on importation of wheat, rice and maize.

The ban placed on the importation of some food items increased the output of local production especially rice. However poultry and fishery production became less profitable because of the resultant exorbitant costs of imported inputs attendant on SAP. Sharp rises on imported inputs such as fertilizer, agro-chemicals etc. were also witnessed while the cost of providing large scale irrigation rose because of the high cost of foreign components. The increase in the cost of the import component of equipment for research and technology development stultified their further growth.

Although SAP substantially addressed problems of price distortions to farmers, new problems were created by the effects of the changes in macroeconomic policies. Implementation bottlenecks arising from scarcity of basic farm inputs and slower rate of adoption of new technology also contributed their impending achievement of policy objectives. These produced the expected benefits of yield accruable from the adoption and use of modem farm inputs such as improved variety of seeds. The withdrawal of subsidies which increased production costs, substantially reduced the profitability of agricultural activities leading to reduction in size of farm holdings and enterprises. The problem of inefficient marketing persisted as a result of existing, imperfection in the markets, dwindling marketing infrastructures and limited availability of storage facilities.

Despite the problems enumerated above, the performance of agriculture in the post SAP era 1989-1997 was one of steady positive progress in production, growth rate and contribution to the Gross Domestic (GDP). - From a food deficit situation of the late 1970s and early 1980s the country recorded significant improvements in agricultural production through the 19908. The percentage contribution of agriculture to the GDP was 38.00 in 1994, 38.20% in 1995, 39.0% in 1996, 39.20% in 1997,40.40% in 1998 and 41.30% in 1999. The average growth rate during the period 1990 to 199 was 4.0. Agriculture accounts for 88% of the non-oil foreign exchange earnings and employs about 70% of the active labour force of the population. The sector is a catalyst and major source of raw materials for the industrial sector and provides most of the staple food consumed by the 140 million Nigerians.

With the exception of a few commodities, the period 1999-2000 witnessed a rising trend in agricultural output generally. Table 1 shows the output of some major food commodities.

Table 1: Output of some major agricultural commodities 1998-2000 (1000 tonnes)

Commodity	1998	1999	2000
Maize	1998	5476	4107
Rice	5127	3277	4298
Sorghum	3275	7520	7711
Millet	7516	5960	6105
Cassava	5956	32697	33854
Yam	32695	5873	26201
Cowpea	2055	2148	3150
Groundnut	2534	2894	2941
Palm oil	845	896	899

Beef	226	228	230
Goat-meat	14	144	147
Mutton	90	92	94
Pork	463	487	511
Poultry meat	250	268	273
Fish	483	477	482

Source: Federal Government of Nigeria records (2007).

Total food output increased from 64.76 million tonnes grain-equivalent in 1998 to 57.11 million tonnes in 1999 and to 57.70 million tonnes grain equivalent in 2000. The aggregate index of agricultural production rose by 4% in 1999 and 2.5% in 2000 which is about 3.3% on the average during the two-year period. All the sub-sectors of agriculture contributed to the increase. Using 100 for 1984 as the base year, the index of crop production rose from 288 in 1998 to 298.8 in 1999 and 308 in 2000 with percentage increase of 3.7% between 1998 and 1999 and 3.1% between 1999 and 2000, averaging . In the livestock sub-sector the percentage increases in the index were 1.40% :and 2.5% with an average of 2.4% while increases in fisheries were 2.9%, and 3.3% with an average of 3.4% (Federal Government of Nigeria, 2007).

The growth rate for the agricultural sector in 2000 was 4.7%, a slight improvement on the 4.50% recorded in 1999 and 4.25% of 1998. Viewed against the population growth rate of 2.83% the agricultural growth rate which is higher than. the population growth rate, has continued to guarantee the sector's ability to meet the demands on it for food. Food prices have, however, risen in recent months in tandem with the general price rise in the macro economy and in response to increase in Government spending arising from
increased income from oil exports, high cost of democracy, high level of money supply and declining value of the Naira. The famine in neighbouring West African countries and the consequential increase in trans-border out-flow of food have also contributed to the client high food prices in Nigeria. There are indications that cassava products export to Europe for livestock feeds in the wake of the foot and mouth disease have reduced domestic supply. The rising food prices and increased demand for agricultural products are expected to stimulate food production by farmers in this and subsequent years. There is therefore need to ensure sustained increase by putting in place mechanism to absorb the expected production surpluses to break the cyclical glut experienced in the past.

The experience gained in the implementation of the agricultural policy over the years and the recent trends in agricultural development world wide have necessitated the formulation of more focused sub-sectoral policies. The most current efforts in this direction are the Land Resources Policy which will guide sustainable use of agricultural lands, National Agricultural Mechanization Policy, National Cooperative Development Policy, and. the National Seed Policy which assigns primary responsibility for commercial seed supply to the private sector while Government shall be responsible for foundation and breeder seed development, seed certification and quality control and certification while providing the enabling environment for the seed industry development. The National Policy on Integrated Rural Development will integrate the rural economy into the mainstream of national development process to ensure its effective coordination and management and make the rural areas more in tune with the urban areas so as to moderate the rural-urban draft, redress the past neglect through provision of critical rural infrastructure and empowerment of the rural population to create wealth and

eradicate rural poverty. These are prelude to the general of the entire body of the national agricultural and rural development policy, which is now due.

Recommendations:

- Honest implementation of budget on agriculture
- Strengthening of agricultural research and development capacity for improved crops and seed varieties, breeding livestock and fingerlings.
- Provision of seed capital grant towards enhancing extension service delivery.
- Development of subsidy framework on harvested commodities
- Establishment of a comprehensive market information system.
- Establishment of a guaranteed minimum price on select commodities to protect farmers from product price fluctuations.
- Institution of buyer-of-last resort framework to encourage farmers' continuous participation in farming activities.
- Special Intervention Fund Programmes (Natural Resources Fund /ADF)
- Enhancing the national strategic food reserve programme by completing on-going silos, construction of specialized warehouse and establishment of conditioning and processing centres.
- Promotion of massive market infrastructural development in partnership with State Governments
- Support for agricultural research and training through research system development, strengthening of research institutes and federal colleges of agriculture and other components of the national agricultural research system
- Development of an effective and efficient credit system for agribusiness through the development and use of micro-finance institutions.
- Development of an agricultural land mapping programme that would facilitate certification of farmlands
- Facilitation of land clearing and development activities for factory driven commercial farming in selected commodities.

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Soil Fertility Management Strategies for Peri-Urban Vegetable Production in the Southwestern Nigeria.

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Abstract
Achieving food security is a major task confronting the Nigerian government and there is a growing concern that the current method of applying inorganic fertilizers to peri-urban vegetables could pose environmental and health hazards to many Nigerians. This study evaluates the soil fertility management strategies of vegetable growers in Southwest Nigeria. Four farm locations were sampled during rainy season (March to June) of 2007. These farms were under (i) bush fallow for two years and treated with urea + NPK fertilizer, (ii) continuous NPK fertilizer, (iii) sole poultry manure and (iv) continuous urea fertilizer application. Soil organic matter content, soil pH, exchangeable cations, particle size distribution, total nitrogen (N) and available phosphorus (P) were determined. Amaranth plants were partitioned into leaves, stems and roots and the nutrient compositions of the plant tissues were determined. Results showed that applied urea fertilizer promoted rapid growth of amaranth vegetable, when compared with NPK or poultry manure. Soil organic matter content was significantly higher for soil that was previously under bush fallow and received urea + NPK fertilizers. Urea fertilizer treated soil has significantly high P and sodium (Na). Off concentration of Ca, K and Na in amaranth vegetables from the four locations only urea treated amaranth maintained high levels of Na concentration in leaf, stem and root. While urea treated amaranth contained 0.1, 0.14 and 0.5 mg g^{-1} of Na, farm previously under fallow contained 0.03, 0.03, and 0.06 mg g^{-1} for leaf, stem and root of amaranth, respectively. This result confirmed the earlier report that most imported fertilizers into the country contain a significant amount of soluble sodium. The awareness of presence of Na in food vegetables could compensate for the amount of table salt added to food. In addition, as problem of drought and increasing salinity from irrigation water would also increase in this era of climate change therefore applying sodium containing fertilizers could increase the problem of salinity in the nearest future. There is an urgent need for research enlightening the vegetable growers about improved soil fertility and water management strategies, using both inorganic and organic fertilizers under peri-urban culture in Nigeria.

Keywords: Peri-urban, Soil fertility, mineral fertilizer, organic fertilizer and Amaranth quality

Introduction
Deficiency of vitamins and mineral is one of the major health problems facing most women at reproductive stage and young children in the developing countries, which results into high susceptibility to most diseases (Nicoli *et al*., 1999; Quebedeaux and Eisa, 1990). Consumption of adequate amounts of fruits and vegetables has been reported to enhance their immunity to the diseases (Quebedeaux and Eisa, 1990). Unlike in the rural areas of Nigeria where most vegetable crops are obtained wild, in urban centres, peri-urban vegetable production has been accepted as a solution to food shortage and improved human health especially during the dry season. Amaranth (*Amaranthus sp*.) is a leading vegetable commercially cultivated in many urban cities of Nigeria. It is high in protein, calcium, folic acid and Vitamin C It requires adequate supply of nutrient, water and sun for optimal yields. Problem of amaranth cultivation is more critical during the dry season due to low availability of soil water and depleted soil fertility.
Nigerian soils are known for their low organic matter and low activity clay, which make their water and nutrient holding capacities low (John *et al*., 1997). In addition, environmental factors such as high temperature and precipitation oxidize the available organic matter, erode the soil and leach the essential nutrients that could have otherwise been utilized by crop plants (Idowu, 2006)Attention to urban agriculture is increasing in cities around the world (Veenhuizen, 2008). Urban farming systems need to be adapted to specific urban conditions such as confined space, closeness to consumers and health consideration due to closeness of farming sites to people. Farmers who have recently migrated to cities bring along their rural farming knowledge that may not always apply in the urban setting in which they find themselves. There is little formal support to upgrading their knowledge and improving their farming practices. Little researches have been done into the development of urban farming in Nigeria. Soil fertility and soil water management are the major constraints to urban vegetable cultivation. The application of mineral fertilizer has been based on farmer's discretion and in most cases the

type, quantity and method of fertilizer application to vegetable crops are often not inline with the scientific standard, and hence under mining the quality of soil and vegetables. Water and air pollution by NO^{-}_{3}, PO^{-3}_{4} and NH_3 and sedimentation of rivers could possibly result from the current soil fertility management strategies of vegetable growers in urban cities, exacerbating the negative impact of climate change on people.
The aim of the study was to investigate the effects of current soil fertility management strategies on quality of soil and amaranth vegetables, with the view to establishing the appropriate fertilizer application for improved soil and vegetables under per-urban.

Materials and Methods

Experimental sites

Four vegetable fields were randomly sampled during rainy season (March to June), 2007. These farms were under (i) bush fallow for two years and treated with urea + NPK fertilizer, (ii) continuous NPK fertilizer, (iii) sole poultry manure and (iv) continuous urea fertilizer application in Ile-Ife area of Osun State, Nigeria. Ile-Ife lies between latitudes 7 ° 31 ' and 7 ° 33 ' N and longitudes 4 ° 33 ' and 4 ° 34 ' E, in the forest zone of southwestern Nigeria. The wet and dry seasons extend from April to October and November to March, respectively. The pattern of rainfall is bimodal, with the average annual rainfall estimated to be about 1400 mm. The average monthly temperature ranges from 18.9 to 34.6 ° C and the mean monthly relative humidity is 61 % and 83 % for the early and late planting seasons, respectively. Farms were under different fertility management practices.

Chemical analysis of plant tissue

Ten stands of amaranth vegetable samples were randomly selected from each vegetable field. Plant tissue was ground in a Wiley micro-hammer stainless mill to pass through a 1mm sieve (Piper, 1944; Aduayi, 1972). Before chemical analyses of the individual plant part, a portion of each sample was re-dried at 105^0C, placed in a desiccator and 0.5 g portion of ground plant tissue was ignited in a muffle furnace at 450 ^{o}C for two hours (until ash was whitish / grayish white). The ash was dissolved in 5 ml of 4 N HCl solution as described by Piper (1944). Concentrations of Ca, K and Na were determined using flame photometer (Jenway PFP7, England).

Soil sampling, preparation and analysis

Soil samples directly under the vegetable were taken at 0 – 15 cm depth. Soil samples were air dried, crushed in an agate mortar, passed through a 2-mm sieve, and analyzed. Exchangeable K, Ca and Na were extracted with a neutral (pH 7) solution of 1 N NH_4OAc. Potassium, Ca and Na were determined using a flame photometer (Jenway PFP7, England). Particle size distribution was determined by the modified hydrometer method (Bouyoucous, 1962) using 0.2 M NaOH solution as the dispersing agent. Soil pH was determined using a glass electrode pH meter in both distilled water and 0.01 M $CaCl_2$ solution, using 1:2 soil: $CaCl_2$ solution as described by Thomas (1996). Soil organic carbon was determined using the chromic acid digestion method of Walkley and Black (1934) as described by Sparks (1996). The total N concentration was determined using macro-Kjeldahl method according to Bremner (1996), and the available P was determined using Bray-1 method as described by Kuo (1996).

Data analysis

All data collected were subjected to analysis of variance (ANOVA) to assess treatment effects and the significant differences between means were determined using Least Significant Difference (LSD) according to the methods of the SAS Institute (1990).

Results and Discussion

Women, men and youths engaged in vegetable production. It is a mean of livelihood to many families. Most farmers use urea fertilizers rather than NPK and organic fertilizers. While women farmers spent a lot of money paying hired- labour for land preparation men farmers provided labours by themselves. Dry season vegetable production is more profitable than the rainy season's.

Soil Properties:

Soil sand, clay and silt contents for the four sites are not significantly ($p < 0.05$) different. The soil was classified as Ultisol according to Soil Survey Staff (1975); Okusami and Oyediran (1985) (Table 1). Soil organic matter content was significantly higher for soil that was previously under bush fallow and received Urea + NPK fertilizer than the soil of other three sites that were not under fallow. This result confirmed the earlier report by

Agboola (1974) that fallowing technique as the most successful way to maintain soil organic matter in tropical environment. Increasing population growth and high demand for land for other uses reduced the land available for vegetable cultivation in urban cities. Fallowing is important because continuous cultivation of limited available land in the cities resulted in high deterioration of its soil physical properties and rapid disappearing of soil organic matter (Aina, 1984). Most vegetable farmers applied mineral fertilizers and poultry manure in order to meet the nutrient requirements of crops. If poultry manure and domestic organic wastes are properly managed, they are cheaper sources of nutrients to farmers and could drastically improve the soil organic matter content and physical properties, resulting in high quality vegetables. Soil total N was very high for the four sites, ranges from 0.43 to 0.68 % . Critical total N index value above 0.2% was recorded by Adepetu (1986) as high level for crops in the southwestern Nigeria. The high N content could be because of continuous application of inorganic nitrogen fertilizers. The critical value of available P (Bray 1) greater than 15 mg/kg was also assumed as high level for most crops in the southwester Nigeria by the previous workers. For the current study the available P values for all the sites are high and at this high level no application of fertilizer was expected. But the farmers argued that the growth and yield of vegetable will be reduced greatly if no fertilizer was applied. They also observed high disease and pest infestations on vegetables but they could no relate it to the types of fertilizer use.

Soil exchangeable calcium, potassium and sodium are shown in Figure 1, exchangeable Ca was significantly highest at site 1 and lowest at site 4. This observation was directly contrary to the distribution of exchangeable Na where site 4, with continuous application of urea contained the highest value of exchangeable Na. The site with continuous application of poultry manure contained a significantly ($p < 0.05$) highest exchangeable K. For the four sites the exchangeable Ca, K and Na were generally at low levels when compared with the earlier findings of Enwezor *et al*. (1990). These results are in-line with the earlier report that soils of tropics are predominantly kaolinitic clay mineralogy and strongly weathered resulting in low cation reserve. Consequently, soil organic matter in the surface layer becomes very important as the kaolinitic clay has little contribution to retain adequate levels of nutrient cation to meet the crop demand.
However, there is limited information on complementary use of organic and mineral fertilizers for peri-urban vegetable production in Nigeria, thereby justifying the urgent need for research on this subject.

Calcium, potassium and sodium content of amaranth vegetable:
Unlike Na^+ in the amaranth plant, the average Ca^{2+} of amaranth are 0.12, 0.12, 0.15 and 0.12 mg/g dry matter for sites 1, 2, 3 and 4, respectively (Figures 2 to 4). The values recorded for Ca^{2+} in the three plant organs (root, stem and leaf) are not significantly ($p < 0.05$) different,with exception of leaf- Ca^{2+} that was significantly higher at the site 3. Site 4, with continuous application of urea fertilizer contained the lowest leaf Ca^{2+} per plant dry weight (0.12 mg/g).The leaf contained the highest Ca^{2+}, which was directly opposite to the distributions of Na^+ in the plant, where root contained the highest value of Na^+. According to Marschner (1998) the Ca^{2+} content of plant varies between 1 – 50 mg/g of dry weight depending on the growing conditions, plant species and plant organs.
The result of this study, confirmed the earlier report by Marschner (1998) that increase in Ca^{2+} content of external medium, increased Ca^{2+} in the leaf but not necessarily in low transpiring organs. The function of Ca^{2+} in plant has attracted much interest in plant physiology and molecular biology because of its function as a second messenger in the signal conduction between environmental factors and plant responses in terms of growth and development. The function of Ca^{2+}, is related to its strict compartmentation at the cellular levels. Exchange between Ca^{2+} other cations such as Na^+ and K^+ at the biding sites has also been reported. Calcium provides stable but reversible intermolecular linkages between the cell wall and the plasma membrane (Hanson, 1984).

Potassium contents of amaranth leaves were 0.05, 0.04, 0.03 and 0.03 mg/g dry weight for sites 1, 2, 3 and 4, respective while for the stem at sites 1, 2, 3 and 4 the K values were 0.03, 0.04, 0.06 and 0.05, respectively. The root content of K^+ of amaranth was not significantly different within the four sites and from the stem and leaf of amaranth (Figures 2 to 4). Potassium is the mineral nutrient required in the largest amount by plant next to nitrogen. According Marschner (1998), the K^+ requirement for plant optimal growth is in the range of 20 – 50 mg/g dry weight. The K^+ content of the amaranth vegetable in all the sites from where samples were taken for this study was very low. When the soil water supply is limited, loss of turgor and wilting are typical symptom of K^+ deficiency. The lower sensitivity of K^+ sufficient plant to drought stress is related to several factors such as the role of K^+ in stomata regulation which is the major mechanism controlling the water regime of higher plants and the importance of K^+ for the osmotic potential in the vacuoles maintaining a high tissue water content even under drought conditions. High biomass production and yield could also result from high K^+ concentration in the stomata, and correspondingly higher rates of photosynthesis. When K^+ is deficient growth is retarded and net retranslocation of K^+ is enhanced from mature leaves and stems (Lindhauer, 1985). Potassium could be a limiting factor to sustainable amaranth production under peri-urban in Nigeria.

Average Na content of 0.05, 0.04, 0.08 and 0.25 mg/g dry weight were observed for site 1, 2, 3, and 4 respectively (Figures 2 to 4). Na concentration increased consistently from leaf to stem and to root. This result indicated that amaranth plant has the capacity to control or regulate transportation of Na to the leaf where plant organs could be damaged. A previous study by classified amaranth tricolor as a plant that responses to Na, and some of K requirement could be replaced by Na. Amaranth, a C_4 photosynthetic pathway plant has some advantages over a C_3 plant such as tomato, under a low ambient CO_2, supply of Na as low as 0.02 % in the shoot dry weight increased the efficiency of CO_2 utilization, which was not so in tomato. An enhanced nitrate uptake by root and nitrate reductanse activity was also observed in Na sufficient plant (Ohta *et al*., 1989). Sodium also improved water balance of plant when the water supply is limited, this obviously occurs via stomata regulation according to Hampe and Marschner (1982). With a sudden decrease in the availability of water in the substrate (drought stress) the stomata of plant supplied with Na closed more rapidly than plant supplied with K only and after stress release, exhibit a substantial delay in opening. A recent study by Idowu and Aduayi (2006) obtained increased plant water content and reduced floral abortion and increased fruit yield of tomato at the application of NPK with low concentration of Na, as low as 2 mg/kg. The presence of Na in the soil and / or fertilizer used in the fields could be the reason for low content of K in the plant. However, Na content of amaranth from site 4 (continuous application of urea fertilizer) was significantly higher ($p < 0.05$) than for the amaranth from other sites. The result showed a significant increase in sodium concentration in the soil, roots, stems and leaves of amaranth plants when compared with the soil and vegetables treated with either poultry manure or NPK 15-15-15 fertilizer. This observation requires further research.

Environmental impacts

Possible environmental impacts that could emanate from the current method of fertilizer applications under peri-urban vegetable production in the farm locations are (i) Water pollution by NO_3^-, washing of nitrate from farm land to the drinking water bodies could cause blue baby syndrome when water is consumed by little children, nitrate would be reduced to nitrite, absorption of nitrite into the bloodstream would oxidize iron (II) Fe^{2+} in the haemoglobin to iron (III) Fe^{3+} , (ii) pollution of water by PO_4^{3-} , concentration of available P in soils was at high level (iii) Most vegetable farmers use urea fertilizer and urea must be covered when applied to soil, broadcast is the main method of urea application by farmers in the region which could result into volatilization of NH_3 into the atmosphere thereby contributing to the greenhouse gases, (iv) Sedimentation of rivers and streams from continuous cultivation of soil for vegetable production without an appropriate soil management, and (v) Soil salinization due to continuous application of sodium containing fertilizers.

Conclusion

Generally, soils collected from amaranth vegetable field based on the current soil fertility management practices of farmer have adequate pH, while soil organic matter, total N and available P were at high range, soil exchangeable Ca, K and Na were at low levels. Calcium content of leaves was significantly higher in the vegetable that received poultry manure than others. Potassium content was high in the stem and leaf of amaranth from the site 4. Soil and amaranth samples from the site that received urea fertilizer alone contained the highest concentration of Na, it was highest in the root but lowest in the leaf. Sodium concentration in vegetables could be posing health risks to individuals suffering from hypertension is not regulated. The awareness of presence of Na in food vegetables could compensate for the amount of table salt added to food. In addition, as problem of drought and increasing salinity from irrigation water is increasing it implies that with changing climate, continuous application of sodium containing fertilizers could increase the problem of salinity in the nearest future. Farmers considered urea, which containing 45% nitrogen (N) as the best because it promoted rapid growth of amaranth vegetable and delay fruit formation when compared with NPK or poultry manure. Domestic organic waste is about 76.9 % of domestic wastes, if sorted from the kitchen it is a high quality fertilizer. Poultry manure is another organic fertilizer that is under utilized in Nigeria. These materials should be given more attention in soil quality management for Nigerian agriculture. Overall, the current ways of soil fertility management for peri-urban vegetable production could be posing a great health risk to many Nigerians. Therefore, an urgent participatory and interdisciplinary research is required in order to improve the knowledge of the farmers on this subject.

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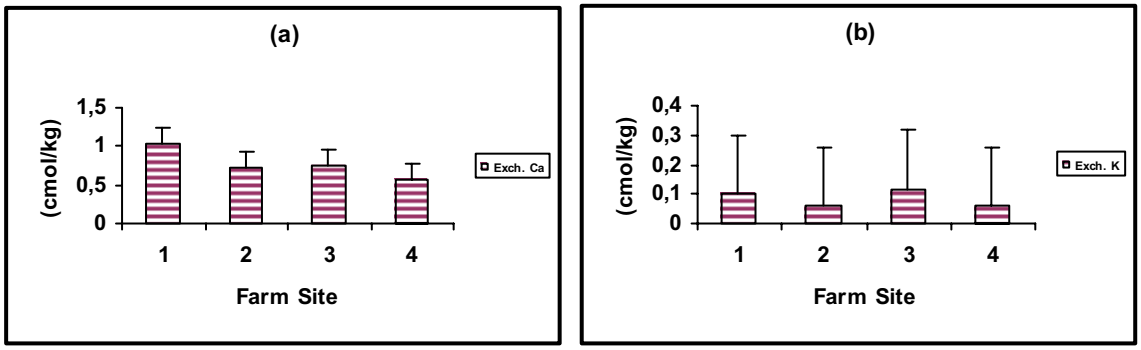
TABLE 1: pH, Organic Matter Content, Total Nitrogen and Particle Size Distribution of Soils from the Four Vegetable Fields

Farm site	pH_{H2O}	pH_{CaCl2}	Organic matter (%)	Total N (%)	Sand (%)	Clay (%)	Silt (%)
1	6.70c	6.50a	4.60a	0.68a	57.04a	26.15ab	16.81a
2	7.00a	6.50a	3.80b	0.60a	58.84a	26.84ab	15.12a
3	6.85b	6.50a	3.90b	0.65a	58.04a	25.14b	16.82a
4	6.70c	6.50a	3.56b	0.43a	53.04a	28.04a	18.92a
LSD	0.10	0.00	0.37	0.53	5.54	2.75	3.95



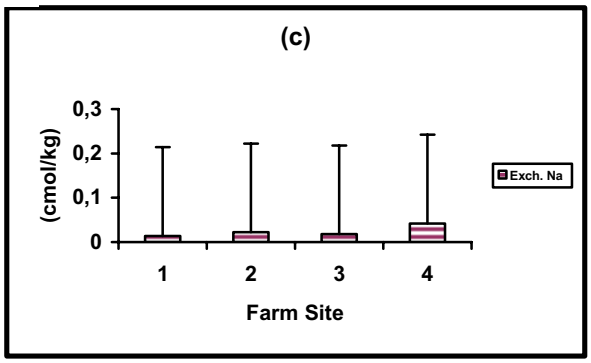


FIG 1: Farm Sites Showing Soil Exchangeable (a) Ca, (b) K and (c) Na: The bars rep. error bar.

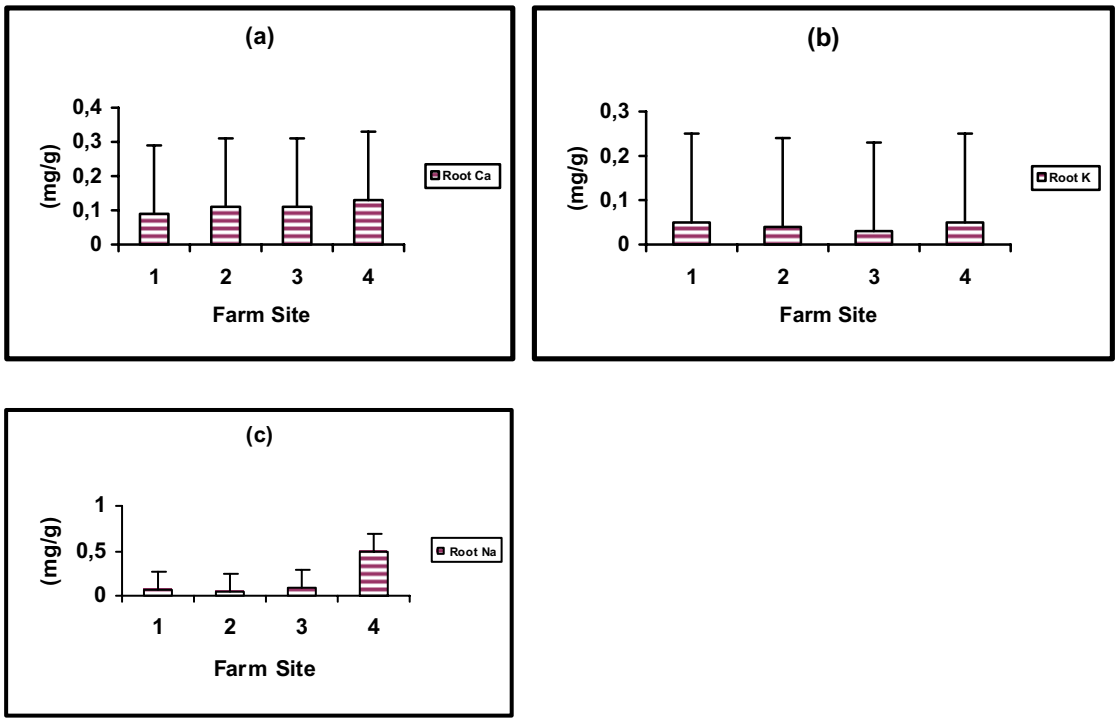
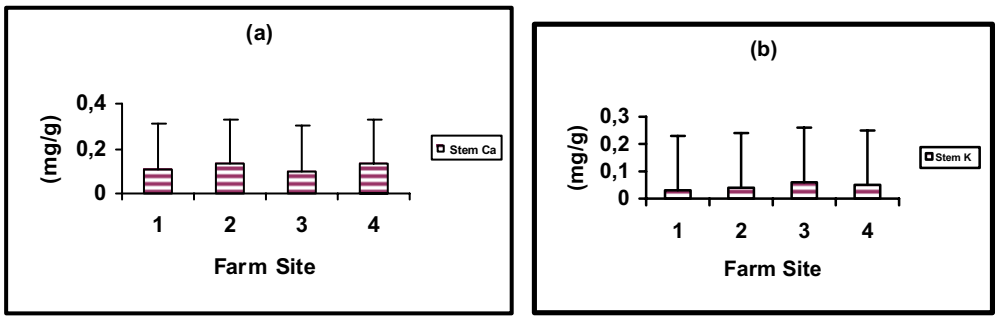


FIG 2: Root content of (a) Ca, (b) K and (c) Na in the Farm Site. The bars rep. error bar.



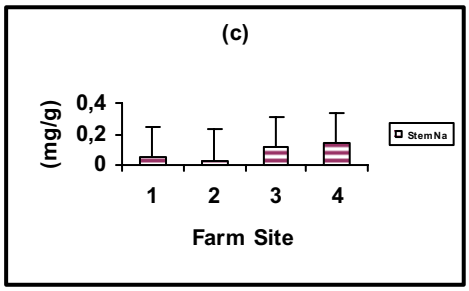
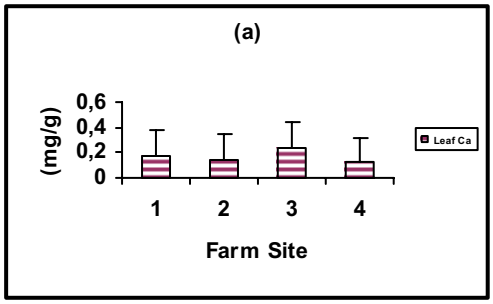
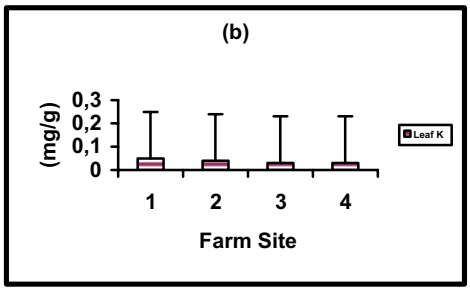


FIG 3: Stem content of (a) Ca, (b) K and (c) Na in the Farm Site. The bars rep. error bar.





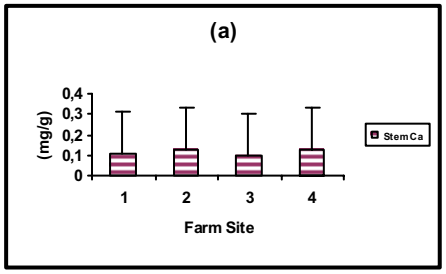


FIG 4: Leaf content of (a) Ca, (b) K and (c) Na in the Farm Site. The bars rep. error bar.

Commercial Farm Credit Support Programmes and Agricultural Growth in Nigeria.

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Abstract
One of the major causes of declining agricultural production in Nigeria is the shortage of primary production credit. Hence, in order to address the financial services requirements of entrepreneurs in the agribusiness sector, the Federal Government established the Agricultural Credit Guarantee Scheme [ACGS] through Decree 20 of 1977. Results of previous studies conducted on the operations of the Scheme are inconclusive. The purpose of this study is to determine whether any relationship exists between operations of ACGS and the level of production in each of the five categories of farm enterprises. In achieving this objective, secondary data spanning 1978 – 2005 were collected on value of loans guaranteed and agricultural production. Using Pearson's correlation and cointegration analyses, the study found some positive significant relationship between value of loans guaranteed and agricultural production in the sectors. These results are in contrast to earlier studies that found no significant relationship between operations of ACGS and agricultural production. It may therefore be recommended that the operations of ACGS be critically examined in an attempt to further strengthen the positive relationship in order to enhance agricultural growth.

Key Words: Commercial farms, credit support, agricultural production, cointegration analysis

Introduction

The agricultural sector remains the dominant sector in the Nigerian economy. For instance, it accounted for over 60 per cent of the gross domestic product (GDP), 80 per cent of employment, and about 60% of Nigeria's export earnings in the 1960s. However, its contribution to these important areas of the economy has declined to less than 40%, 60% and less than 5%, respectively (Akinyosoye, 2005). This notwithstanding, it is still a major source of raw materials to agro-allied industries and also constitutes about 70 per cent of non-oil exports. The challenges constraining the performance of Nigeria's agriculture have been well discussed in the literature (Olayemi,1988; Olayemi and Akinyosoye, 1989; Njoku, 1998; Onyenweaku, 2000 and Manyong, *et. al*., 2003). The major constraints have been classified into four major areas, viz: technical, resource, socio-economic, and organisational.

Technical problems include the high incidence of pests and diseases, inadequate infrastructural facilities, and low-level technology, limited use of improved modern inputs. Others include poor extension services, as well as inefficient inputs supply and distribution system. One notable problem of the resource constraints is the increasing migration of able-bodied youths from rural to urban areas, thereby leading to seasonal labour shortages during the peak periods of labour demand. In addition, there is an increasing population pressure on land, with its attendant declining quality. This is made more pronounced by the general low rate of land improvement. The socio-economic problems present themselves in form of scarcity and high cost of improved farm inputs, inefficient marketing arrangements characterised by high marketing margins, lack of grades and standards, and lack of legally enforceable ownership and control rights over land which discourages investment in agriculture. Other socio-economic factors include low rate of international demand for primary export commodities, which results from competition with synthetic products; and low income elasticity of demand. Organisational constraints arise from the fact that agricultural production is in the hands of a multitude of small

scale unorganised farmers that are scattered across the country. The dispersed nature of farm lands and lack of organisation often hinder participation of farmers in agricultural and rural development.

Agricultural development efforts undertaken to address these problems include [i]Farm enhancement programmes (Farm Settlement Scheme, National Accelerated Food Production Programme, Operation Feed the Nation, Green Revolution Programme, River Basins Development Authorities, Agricultural Development Projects, etc); [ii]Rural household empowerment programmes (Better Life Programme, Family Support Programme, Family Economic Advancement Programme, Poverty Alleviation Programme, etc); [iii] Rural infrastructural development programmes (Directorate of Food, Roads and Rural Infrastructure, Rural Electrification Projects, National Food Storage Programme, Agricultural Projects Monitoring and Evaluation Unit); [iv] Market expansion and improvement programmes (marketing Boards); and [v] Agricultural financing and credit support programmes (Rural Banking Scheme, Nigerian Agricultural and Cooperative Bank, People's Bank, Nigerian Agricultural Cooperative and Rural Development Bank, Agricultural Credit Guarantee Scheme).

This paper focuses on the operations of the Agricultural Credit Guarantee Scheme Fund (ACGSF), which came into being, following a study conducted in 1976 by the Central Bank of Nigeria (CBN). Shortage of primary production credit was identified in that study as one of the major causes for declining agricultural production. The shortage was attributed to the reluctance of the banking sector to provide credit for real sector activities, especially agricultural production. In order to remove the bottleneck, the ACGSF was established by the Federal Government (60 percent) and the CBN (40 percent) through Decree No. 20 of 1977 (and as amended on 13th June 1988) with an initial Fund of ₦100 million. The share and called-up capital of the Fund has been increased to ₦3.0 billion.

The scheme provides guarantee cover for loans advanced to the agricultural sector by banks. The cover pledges to pay to the banks, 75% of any outstanding default balance by borrowers, provided that the collateral pledged has been realized and applied to the account. The agricultural activities the Fund can guarantee include:

- The establishment or management of the production of rubber, oil palm, cocoa, coffee, tea and similar crops;

- The cultivation or production of cereal crops, tubers, fruits of all kinds, cotton, beans, groundnuts, sheanuts, benniseed, vegetables, pineapples, banana and plantains;

- Animal husbandry, that is, poultry, piggery, cattle rearing and the like, fish farming and fish capture; and

- Processing in general where it is integrated with at least 50 percent of farm-output e.g. cassava to garri, oil palm to palm oil and kernel, groundnut to groundnut oil etc;

The CBN manages the Fund, and is responsible to a Board. From its inception in 1978 to 2004, it guaranteed a total of 397,422 loans valued at ₦7.603 billion (Olaitan, 2006).

The results of the studies conducted on the operations of the Scheme are mixed. While some concluded that the scheme has impacted positively on the Nigerian economy, others concluded otherwise. For example, Akinyosoye (2005) observed that AGCS had little or no impact on agricultural production because the eligible collaterals which banks could accept under the scheme were not within the reach of small-scale farmers, for whom the scheme was designed, thereby limiting their participation in the scheme. On the other hand, Garba (2002) and Olaitan (2006) opined that the scheme has contributed to improving the livelihoods of farmers and other agribusiness entrepreneurs. Because of the inconclusive nature of the results on the performance of the scheme, a further analysis of the scheme using a set of statistical methods different from those employed by earlier studies is worthwhile. The purpose of this study therefore, is to determine whether any relationship exists between operations of ACGS and the level of production in the livestock, crops, fishery and food crops sub-sectors. The specific objectives of the study are to: (1) determine whether any relationship exists between operations of ACGS and the level of production in selected farm enterprises. (2) If so, to determine whether it is attributable to a spurious or coincidental relationship or whether a linear long-term economic relationship between the variables can in fact be inferred, and (3) If cointegrated, to determine the direction of causality between agricultural production and value of loans guaranteed under the scheme.

Hypothesis Tested

The following hypotheses were tested in this study:

H_0: There is no long-term economic relationship between level of agricultural production and value of loans guaranteed under the scheme.

H_0: Value of loans guaranteed does not Granger cause level of agricultural production.

Material and Methods

Secondary data spanning 28 years (1978 – 2005) were used to assess the relationship between value of loans guaranteed under the Scheme and agricultural production in the period under review. Data on value of loans granted to crops, fishery, staples and livestock sub-sectors and their respective level of production were obtained from the Statistical Bulletin of the CBN. Pearson's correlation and cointegration analyses were employed to analyze the data collected. The former is used to determine the degree of association between the operations of the Scheme and agricultural growth, while the latter was used to determine the existence of a linear long-term economic relationship between the variables. Since cointegration does not necessarily imply causality between two variables, Granger causality was carried out to establish this, as well as determine the direction of causality. In other words, whether value of loans causes agricultural production or vice versa or bi-directional causality. Correlation between two random variables is a measure of the strength of the linear association between them. Sample correlation must be between -1 and +1, with positive values indicating a direct linear association and negative values the inverse. A zero correlation coefficient therefore implies the absence of any such linear association. However, it does not rule out the presence of more complicated non-linear associations between two variables. It is not enough to show that the variables in the hypothesized (long-run) relationship are highly correlated. If such variables were non-stationary then even high correlations between them may be entirely

spurious. We used EView 3.1 to test for the stationarity of each of the variables for cointegration and Granger causality between agricultural production and the value of loans guaranteed. The estimation of the annual growth rate (using exponential model) of the variables, and the correlation between the dependent and the independent variables were done with the aid of version 11.0 of SPSS.

Results and Discussion

Time series analysis:

The estimated annual growth rate of agricultural production as well as value of loans over 1978-2005 are presented in Table 1 below. As indicated in the table, the rate of growth in loans guaranteed is far higher than that of agricultural production in each sub-sector.

Table 1: Annual growth rate (1978 – 2005)

Sub-sector	Production (%)	Value of loans (%)
Crops	**6.6**	**23.0**
Staples	**7.4**	**22.0**
Livestock	**5.8**	**9.1**
Fishery	**1.7**	**14.9**

Correlation Analysis:

Pearson's correlation coefficients between agricultural production and value of loans were 0.588, 0.630, 0.717 and 0.460 for crops, staples, livestock and fishery, respectively. All the coefficients were statistically significant at the 5% level, thus indicating that there is a positive linear association between the ACGSF and agricultural growth over the period under review. The implication of this result is that higher agricultural production is associated with higher value of loans guaranteed since they both exhibited the same trend over sampled period.

Testing For Stationarity of the Series:

The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were employed to determine the order of integration of each of the series considered. Such tests were conducted on the data using the following data generating process (DGP): $yt = \alpha + py_{t-1} + u_t$. The results of the tests are presented in Table 2. The unit root test statistics in the table may be compared with the critical value at 5 % level (i.e. -3.7076) for both tests. A test statistic that is less than the critical value confirms that the first difference is stationary for agricultural production series, while the second difference is stationary for loans series. As can be observed from Table 2, all the variables were non-stationary and could be integrated of order one or two. This is confirmed by their respective correlograms (not reported). It can also be seen from the table that differencing the production series once is sufficient to achieve stationarity in them. However, the loans series may need to be differenced twice to achieve stationarity. The fisheries loans can be said to be integrated of order one because correlogram strongly suggests this.

Table 2: Results of Unit Root Tests

Variable	Augmented Dickey Fuller (ADF)	Phillips-Perron (PP)	Order of Integration
Crops loans	3.2612	17.9871	I (2)
Crops Production	-0.7489	-0.3505	I (1)
Fishery loans	1.46105	4.9090	I (1)
Fishery Production	-1.7072	-1.5233	I (1)
Staples loans	2.5915	12.3694	I (2)
Staples Production	-0.5722	-0.1291	I (1)
Livestock loans	1.4181	6.1183	I (2)
Livestock Production	1.0774	1.7340	I (1)

Testing for Cointegration:

Cointegration test was employed to establish whether the correlation observed between agricultural production and value of loans is attributable to a spurious or coincidental relationship, or whether a linear long-term economic relationship between the variables can in fact be inferred. Hence, by establishing that cointegration exists, we validate the linear regression, thereby confirming the likelihood of a long-term structural relationship by providing the absence of spurious correlation.

The Johansen cointegration test was performed on each pair of variables in each sub- sector. The likelihood ratio (LR) test statistics were compared with the cointegration critical values at 5% significance level. This led to the rejection of the hypothesis of no linear long-term relationship between agricultural production and value of loans, since the test statistic was found to be greater than the critical value. The LR test indicates two cointegrating equations at 5 % significance level for fisheries; one for crops and staples, and none for the livestock sub-sector. In other words, the hypothesis of no long-term relationship between production and loans granted under the scheme was rejected for fisheries, crops and staples, but could not be rejected for the livestock sub-sector. This suggests the likelihood of a long-term structural relationship between agricultural production and loans granted under the scheme in all but livestock sub-sector. To confirm the existence of this relationship, we then performed Granger causality test on the data series of fisheries, crops and staples sub-sectors.

The Granger causality test rejects the hypothesis that loans granted under the scheme do not Granger cause agricultural production at 10% significance level for crops sub-sector and at 1% significance level for fisheries. It however failed to reject it at any conventional level for staples. This statistical evidence strongly indicates that changes in loans granted under the scheme significantly and positively influenced changes in agricultural production for fisheries sub-sector only. The reason for the observed situation in other sub-sectors particularly, the crops sub-sector, might not be unconnected with the low participation in the scheme by small-holder farmers for whom the scheme was designed. According to Akinyosoye (2005), only about 10% of them were involved in the scheme and also there was no guarantee that the reported loans were actually applied to agriculture since credit is fungible. The internal administrative and external factors that hinge on paradigm shifts in the financial markets might also be responsible for the little impact the scheme had on agricultural production (Garba, 2002).

Conclusion and Recommendations

This study has provided some statistical evidence supporting the existence of positive and significant relationship between the operations of ACGSF and agricultural production in Nigeria. The study has also shown that the scheme still has to improve on its performance. Hence, it is recommended that the operations of ACGSF be critically examined in an attempt to further strengthen the positive relationship for the purposes of enhancing agricultural growth in Nigeria. Measures being put in place to restore the confidence of the banks and borrowers in the scheme and to address the constraints should be sustained. It is also pertinent that the scheme administration be proactive in identifying possible limiting factors and designing or proffering solutions that would meet the acceptability of the lenders.

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Fruit Production and Processing: Options For Rural Industrialization and Poverty Alleviation In Nigeria

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Abstract

Nigeria is an agrarian nation known for the production of all forms of plant, animal, fish and forest materials in large quantities. Nigeria also produces fruits such citrus, mango, cashew, pineapple, pawpaw and guava in very large quantities. The predominant mode of farming in Nigeria is however subsistent, small holding and peasant. The peasant farmers practice farming as a means of surviving and not as business. Therefore, industrial development is mostly very low in the rural areas where agricultural production is highest. Coupled with the non-business-like attitude of the peasant farmers, a lot of farm produce are lost during the post harvest handling as a result of poor road net work and lack of machines to process the raw agricultural materials. Fruits, which are essential natural sources of minerals and vitamins, are the most affected in terms of post harvest losses because of their high moisture contents and susceptibility to micro organism activities. The annual record of post harvest losses of fruit is up to 50% in Nigeria and more in some other African countries. The paper advocates that the Nigerian farmers should consider the production and processing of fruits as industry and scale up the production of fruits. Indigenous machines should be developed and commercialized for the processing of the fruits into juice, concentrates and other products in order to enhance added value, minimize post harvest loses and improve the intake of the natural vitamins and minerals provided by the fruits. This shall lead to the establishment of fruit processing industries, create jobs for the teaming unemployed youths, alleviate poverty, improve the social life in the rural communities, reduce rural-urban migration and promote the manufacturing of fruit processing equipment in Nigeria.

Keywords: Fruit, industry, poverty alleviation, rural community, machinery

Introduction

Fruits and vegetables are not only sources of food but ready sources of minerals and vitamins. For example mango fruit has vitamin A (0.2 mg), vitamin C (300 mg), protein (3.99 - 4.96 g), soluble carbohydrate (12.56 - 18.31 g), and ash & fiber {3.34 - 3.47 g} per 100g fresh weight (Ibiyemi et al, 1990). Citrus contains 60 mg of vitamin C in 240 ml of juice, which is more than the minimum daily requirement. Citrus fruits are also good source of folic acid, sugar, pectin, cellulose, vitamin B, thiamine and potassium (Naggy *et al,* 1993). Sweet orange has 11.8% solid, 0.38% ash, 0.06% ether extract, 0.65% protein, 0.05% crude fibre, 10.7% carbohydrate and 41 kilo cal per 100g energy. It has a laxative effect (Ihekoronye and Ngoddy, 1985). Cashew is especially rich in vitamin C, containing 262 mg/ 100 ml of juice, about five times the vitamin C content of orange (Egburomu, 1996)

Juice industry originated in the Northern temperate zone, including Europe and North America, where the industrial revolution was earliest. Thomas Welch and his son, Charles, in New Jersey were the first to produce juice at commercial level from grape fruit. It was followed by pineapple juice from Hawaii (James, 1998). In modern ages, taste is more diversified and exotic juice becomes a preference. Consequently, more and more tropical and sub-tropical fruits such as passion fruit, guava, lychea and papaya have joined the list of popular raw materials for juice production (James, 1998).

In developed countries such as Britain, Germany and the United States of America, various machines are available for small and medium scale fruit juice production at commercial level. The production level of the fruit is high in Nigeria and other African countries, and most entrepreneurs involved in fruit processing have

capacity for small/ medium scale, yet there is a dearth of equipment for small and medium scale production (Adewumi, 1998a, 2004, 2005, 2006, 2007a & b

Raw fruits generally have low shelf life because of the high moisture level and activities of micro organisms. Processing of fruit into juice, concentrate and other durable products increases the storability and profit margin; reduces the transport costs, spoilages, and wastages; adds value; and makes the product available all year round. Record of post harvest losses of fruits in Nigeria was up to 50% (Adewumi, 1999, 2007c) and up to 70% in Malawi (Kazembe, 2005). FAO (1995) reported that there is far less attention paid to the technology of processing juices, in the developing countries. A significant problem in developing mechanized equipment for fruit juice production is the large number of varieties available and the variations in their sizes and shapes. The cost of the processed fruits is also too expensive for the general population in developing nations where these fruits are mostly produced.

Processed fruits and other durable end products from developing countries, have considerable export potential to developed countries but most developing countries, where fruits are produced in large quantities, do not have the technology and equipment to process fruits to the high quality required in the developed countries at relatively low cost. Nanjundaswamy (1986) confirmed that lack of local and simple mechanical means for fruit processing into juice and other inter-meditate products, results in limitations on fruit utilization and thus more post harvest losses due to rotting. The non-availability of machines for post harvest handling of fruits presents limitations to the rural income by small-scale farmers (Adewumi, 2005; Olukunle *et al*, 2007).

Though fruits are seasonal, there is a general global increase in the demand for the products derived from them throughout the year. The increasing global population requiring a high demand for minerals and vitamins calls for the need to process raw fruits into juice and other durable products to make natural minerals and vitamins available throughout the year. Nigeria is one of the leading nations in the production of fruits in the tropical region. Locally available fruits that are widely grown in Nigeria include sweet orange, tangerine, cashew, mango, water melon, guava, pineapple and pawpaw. Except in the recent, majority of fruit exports from Nigeria were not processed into juice or concentrate because of lack of equipment for processing. The objectives of the paper are to sensitize Nigerian farmers to accept fruit production as an industry, increase annual fruit production and be actively involved in fruit processing in order to industrialize the rural communities, add value and increase profit margin.

Global importance of fruits:

Fruits are known for their medicinal, pharmaceutical, industrial and other economic values. Ripe fruits of mango are dissolved in sugar water and taken to prevent sunstroke and may just be rubbed on the body (Mircea, 1995). Grape fruit helps to lower cholesterol and there is evidence that its seeds have high level of antioxidants (Jarquera, 1998). It protects against cardiovascular diseases and cancer (Heber, 2005). It has low glycemic index and helps the body to burn fats. Extracts from grape fruit seed is a very strong antimicrobial with proven activities against bacterial and fungi (Bailey et al, 1998; Edward *et al.* 1997; Fakuda *et al.* 1997). Seed fats from the mango fruit is used for soap making because of its high stearic acid content (Julia, 1987). Mango seed residue after fat extraction is useable for cattle food and soil enrichment (Julia, 1987). Pickles, chutney, puree, nectar, juice, squash, jam, jelly, squash, powder, flakes and dehydrated products are also products from different fruits (Mircea, 1995, Donald and Low, 1990). Ripe mangoes are processed as canned and frozen slices, puree,

juices, nectar and various dried products such as mango bars and mango slices for home use and by cottage industry (Mircea, 1995). As well as being eaten fresh, citrus fruits are used to make juice and marmalade, and oils are extracted from the skin for use in perfumes and confectionery (Donald and Low, 1990).

Donald and Low (1990) identified citrus fruits as one of the major fruits produced world wide with more than 30 million metric tons produced annually. The citrus family include sweet oranges *(Citrus sinenesis*), lemons (*Citrus limon*), limes (*Citrus aurantifolia*), grape fruit (*Citrus paradise*), sour or seville orange (*Citrus aurantium*), tangerines (*Citrus reticulata*), and pummelos (*Citrus grandis*). The three most important types of orange are the mandarin, the sweet and the sour or bitter oranges, with. sweet orange as the most used type globally.

Sweet orange is grown throughout the world and provides greatest fresh fruit production. It is among the oldest cultivated fruits, grown for more than 4,000 years. Oranges probably originated in the part of Asia which now includes India, Myanmar and South Western China (World Book Encyclopedia, 2001). Brazil, Spain, China, Italy and Israel are among the chief producers of the oranges (Rice et al, 1987). Oranges are also grown in the warmer region of the United States along the gulf coast and California. It constitutes the leading crop in the United States. The leading production statistics of sweet orange provided by Donald and Low (1990) include 18,256,500 metric ton (Brazil), 11,729,900 metric ton (India), 3,969,810 metric ton (Mexico), 868, 000 metric ton (Egypt), 697,000 metric ton (Argentina) and 606, 000 metric ton (Morocco). Brazil was the largest producer of orange juice in the world followed by the USA. (World Book Encyclopedia, 2001).

Grape and pummelo are also fruits of importance in the global market because they are excellent sources of many nutrients and phytochemicals (Jorquera, 1998). The ten leading nations producing grape and pummelo, as identified by FAOSTAT (2002) are USA (155, 974 metric ton), China (57,128 metric ton), Mexico (43,947 metric ton), Israel (42, 632 metric ton), Cuba (38, 540 metric ton), South Africa (36, 212 metric ton), Argentina (28, 990 metric ton), Turkey (25, 580 metric ton), India (24, 215 metric ton) and Tunisia (12, 278 metric ton).

Eighty five (85) countries are known to be involved in global mango (*Magnifera indica* L) production (FAOSTAT, 2002). The global production of mango was estimated at 24, 420, 116 metric ton with the developing countries accounting for about 98% of the production (FAOSTAT, 2002). The first ten leading nations in global mango fruit production, as identified in FAOSTAT (2002) are India (11, 400, 000 metric ton), China (3, 130, 000 metric ton), Thailand (1, 750, 000 metric ton), Mexico (I, 523, 160 metric ton), Pakistan (1, 036, 000 metric ton), Indonesia (891, 566 metric ton), Philippines (880, 000 metric ton), Nigeria (730, 000 metric ton), Brazil (542, 000 metric ton) and Egypt (326, 063 metric ton). Despite the fact that mango mostly grows in the wild in Nigeria, the nation ranked 8th position in global mango fruit production with an estimate of 730,000 metric tons per annum. This is instructive as it suggests the potential of Nigeria in the production of tropical fruits. The major mango producing States in the Nigeria include Benue, Jigawa, Plateau, Yobe, Kebbi, Niger, Kaduna, Kano, Bauchi, Sokoto, Adamawa, Taraba and the Federal Capital Territory (FAOSTAT, 2002). Kazembe (2005) reported that national production of fruits in Malawi is estimated at over 200,000 metric tones per annum.

Cashew (*Aracardium occidentale*) is an important export crop in India, Brazil and parts of Africa (Egburomi, 1996). It is peculiar to the tropical climate with Nigeria as the major producer in West Africa (Yayock *et al.,* 1988). Both the fruit and seed of cashew have high commercial value. The fruit is edible and rich

in minerals and vitamins. The shell of the seed yields phenol rich oil, called cashew nut shell liquid (CNSL), which is used as lubricating oil, in the manufacture of insecticides, production of plastic, preserving and water proofing after distillation, oil proof break lining, links, cement, and when polymerized, is an important ingredient for painting (Kochhar, 1981). Cashew nut is edible and used in the production of cashew butter (Egburomu, 1996, Faborode and Favier, 1996). The nut contains 29.2% carbohydrate, 43.4% fat and 17.4% protein (Egburomu, 1996). All the essential amino acids for human being are present in the nut its protein value is equal to that of soybean and higher than that of peanut (Mrema and Nulty, 1985) Cashew oil lipid fraction contains all lipid soluble vitamins (A, D & E) among which vitamin E is 70 mg/ 100 g (Nagaraga, 1987).

The world production of cashew increased from 407, 000 to 471, 300 metric ton between 1971 and 1991 with Asia as the leading continent. Nomisma (1991) observed that cashew production in Africa could have been accelerated if processing technology and equipment were readily available in Africa. Marino (1994) however reported slight increase in cashew production in Africa, especially Mozambique and Tanzania. The Cocoa Research Institute of Nigeria is promoting the increase of cashew in Nigeria by multiplying and distributing improved seedling among the Nigerian farmers (Adewumi, 2000).

Machinery for fruit and food processing in Africa:

Majority of commercial fruit and food processing equipment in Africa are imported at very high cost and maintained by expatriates (Adewumi, 2007b). These machineries are sophisticated and have problem of climatic adaptations. One of the greatest challenges to food production in Africa is the post harvest mechanization and handling of agricultural products. Generally, storage practices are poor and there is an inadequacy in the availability of fruit and food processing machinery in Africa (Adewumi and Oduwole 1995; Adewumi 1998a; Ogunlowo *et al.*, 2005; Okunola *et al.*, 2007).

Post harvest losses of food, fruit and vegetable products are very high in Africa, sometimes up to 50% (Adewumi, 1999). There is therefore the need to develop and manufacture indigenous machinery for fruit and food processing in order to providing livelihood for rural dwellers and enhance industrialization in Africa through efficient, simple technology, low cost mechanical systems (Adewumi 1998a, 2000, 2004, 2005). Machines are required for processing agricultural materials into both primary and secondary food products. A sizable number of machines are already developed within Africa via research efforts. Hrapsky *et al*. (1985) ascertained that a promotion of efficient fruit juice processing techniques shall raise the produce market value with an internal rate of return (IRR) greater than 50%.

The status of fruit juice and cocoa processing industries were assessed in Nigeria (Adewumi 1998b, Adewumi and Amusa 2004). The study revealed that most of the machines for fruit and food processing in Nigeria are mostly imported and assembled for marketing. Where, manufacturing of machines are done, it was noted that efforts are majorly concentrated in the manufacture of small scale post harvest equipment in Nigeria (Adewumi 2007d). This is generally the same trend for other African countries. While a few of the fruit industries in Nigeria produce fruit juice from locally available fresh fruits, majority produced it from imported concentrates. It is interesting to note that concentrates are not produces in Nigeria at commercial level despite the high level of annual fruits production in the nation (Adewumi and Amusa, 2004). There is therefore the need to develop equipment for the processing of other forms of finished products from fruits in Nigeria.

It was also identified that a few and scanty medium and large scale fruit and food processing machines developed within African countries are for primary food material (Adewumi 1998b, Adewumi and Amusa, 2004). The machines required for the production of secondary/ finished fruit and food products such as boilers, heat exchangers, extruder, oven and so on are mostly not manufactured within Africa. Primary agricultural and food products (example, raw fruits, cocoa powder and cocoa butter) are exported in large quantity to the developed nations at relatively cheaper prices. The materials are thereafter processed in the developed nations to secondary products such as concentrate and chocolate. Finished food products generally have added value and higher economic values with reduced transport cost. If the agricultural materials produces within Africa are processed into finished products before export, the export earning of Africa shall improve exponentially. This calls for the need to develop and manufacture machines to process produce into finished product at commercial level within Africa where the raw materials are resident.

Inter and intra linkages and collaboration between research institutions and manufacturers/ end users is generally low in the African countries (Ageh *et al*., 2005). Most African nations do not clearly define yearly research goals and agenda for scientific development. Information exchange is also low and slow in Africa. All these have greatly affected the quality of the machines developed within Africa and slowed down industrialization. Concerted collaborative efforts are required in order to develop functional indigenous fruit and food processing machineries for mass production and commercialization.

The success story of the technological breakthrough in India should be an example for Africa. The technological breakthroughs in India could be attributed to the fact that all the key players participated actively and dynamically in a balanced proportion. Those include the Government of India taking the lead with appropriate policies and motivations, talented citizens with expertise (not just foreign expatriates), research/ academic institutions (Council for Scientific and Industrial Research, CSIR, being an example), industry and non governmental funding agencies. There exist a fairly strong interaction and ready exchange of information between the key players in India, compared to Africa (Adewumi, 2006).

Fruit processing, rural industrialization and rural development:

Africa is an agrarian continent and especially very rich in crop resources. Agriculture is the dominant economic sector in Africa. For example, Kenya has over 80% of the population dependent on agriculture for their livelihoods (SHDI, 2006). Majority of the citizens of Nigeria also depend on agriculture for their livelihood and live in the rural area. The largest percentage of raw agricultural materials is produce on the farm from the rural communities in Africa, Nigeria inclusive (Adewumi, 2005).

Rural communities in Africa are however characterized by poverty and low income as a result of low industrial activities. The major preoccupation in such communities is agricultural production, mostly with traditional implements and tools. The development and use of simple machines for the processing of agricultural material is therefore essential. This will not only enhance mechanized agriculture in the rural communities but improve income, and increase the commercial values and quality of the processed materials (Adewumi, 2005).

A nation that is not food sufficient may not sustain itself, particularly developing and under developed nations (Ademosun *et al*., 1997). For any nation therefore to attain food sufficiency, the Engineers and allied professionals who are nationals must participate actively in the development of indigenous technologies,

machines, equipment and systems that will be durable and adaptable to their environment (NSAE Communiqué, 1995).

The agricultural industry / sector have always made a substantial contribution to national development and enhanced poverty alleviation in the developing nations. It equally has a great potential and prospect for a rapid transformation of the economy of such nations. Therefore, one of the greatest challenges for the developing nations is to evolve an agricultural practice so as to reduce the drudgery encountered by peasant farmer and the small-scale industries. This is a strategy for poverty alleviation (Adewumi, 2000). The use of mechanical systems and application of scientific knowledge have contributed exponentially to an increased agricultural production over the years in the developed nations (Adewumi, 2008). Also, low literacy level and low level of awareness of indigenously developed agricultural equipment are among the key factors affecting agricultural production and rural development in the under-developed and developing nations (Ogunlowo *et al*., 2005; Adewumi, 2000).

The millennium development goals identified poverty as the bottom line problem to be addressed. Poverty is mostly pronounced in the rural areas in the developing nations where the largest population is found. The concept of urban-rural integration and the upgrading of rural socialization are essential to eradicate poverty. The dichotomy between the rural and urban areas can be removed by mechanized agriculture and technological transformation of the rural areas (Akinbamowo, 2007)

It is advocated that fruit production and processing should become a business and industry among the peasant farmers in the rural communities which are agrarian centers in Nigeria. Agro allied industry, like any other industry, can be classified as small, medium and large scale industry. The classification depends on the level of technology involvement, sophistication of machinery, production level, capital requirements and manpower requirements (Aderoba, 1997). Generally, large scale industries utilize a high level of technology, sophisticated/ automated equipment and are involved in large scale production. They are mostly capital intensive. Medium scale industries utilize intermediate technology and have reduced level of production compared with large scale industries but may require high level manpower like the case of large scale industries. Small scale industries use simple and appropriate equipment and technology, and are involved in low level production. The three levels of industrial classifications are applicable to fruit and food processing industry. Also, Adewumi (1998b) classified food processing industry either as primary product food industry or secondary product food industry, based of the types of end products. He therefore further grouped small, medium and large scale food industry into either primary or secondary, making a total of six groups. However, for convenience, the small and medium scale industries can be grouped together.

The farmer association can be formed into cooperative societies in the fruit production rural centers. The cooperative societies can include for those interested either in fruit production or fruit processing operations. The following industries can therefore emerge from the rural area:

- Small & medium scale fruit production industry
- Large scale fruit production industry
- Small & medium scale primary fruit processing industry
- Large scale primary fruit processing industry
- Small & medium scale secondary fruit processing industry
- Large scale secondary fruit processing industry

The small and medium scale fruit production industry should be preoccupied with producing raw fruits for local consumption and the small & medium scale primary fruit processing industry. The small & medium scale primary fruit processing industry should be responsible for producing both graded fruits and unrefined juice for the small & medium scale secondary fruit processing industry. The large scale fruit production industry can be preoccupied with producing raw fruits for the large scale primary fruit processing industry which in turn provides raw materials for the large scale secondary fruit processing industry.

The small & medium scale secondary fruit processing industry and large scale secondary fruit processing industry should be responsible for the production of refined fruit product such as juice, concentrate, jam and so on. While the small & medium scale fruit processing industry should be mandated to provide for local market, the large scale secondary fruit processing industry should be responsible for providing products for export. This proposal will usher the desired rural industrialization and development which shall lead to the establishment of fruit processing industries, job creation for the teaming unemployed youths, poverty alleviation, improvement of social life in the rural communities, reduction of rural-urban migration and promotion of manufacturing of fruit processing equipment in Nigeria.

Social and technological infrastructures are required to support the proposed rural industrialization. Good road networks, communication system, adequate supply of portable water are especially essential. The Government of Nigeria has to provide a good policy framework to support the proposal and the professional and research institute have to develop new breed of fruits and machinery to support fruit production and processing. Extension workers are also required to facilitate and promote the proposed rural industrialization.

Conclusion

The roles of fruits in human diet, medicine, pharmacy and industry cannot be over emphasized. The knowledge base of the uses of fruits is limited among common citizen in Africa and Nigeria. Nigeria has been identified as a major fruit production nation in the world. Production and processing of fruits in Nigeria can therefore be upgraded to become a business. This can lead to rural industrialization with a number of specialized industries emerging namely the small & medium scale fruit production industry; large scale fruit production industry; small & medium scale primary fruit processing industry; large scale primary fruit processing industry; small & medium scale secondary fruit processing industry; and large scale secondary fruit processing industry.

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Management Strategies Against Mycotoxin Contamination Of Food In Sub Saharan Africa

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Abstract:

Mycotoxins, toxic secondary metabolites of fungi posses serious food safety and significant economic concern in several parts of the world particularly in Africa due to the hot and humid tropical climate that provide conducive environment for the growth of toxigenic fungi. The three most important mycotoxins in foods produced in sub Saharan Africa are aflatoxins, fumonisins and ochratoxin A, while available data indicate that trichothecenes and zearalenone contamination might be insignificant contaminants of foods produced in the sub continent. The health consequences of aflatoxin exposure in populations are quite varied, eliciting lethal effects, and chronic outcomes, such as liver cancer, growth stunting in children, impaired immunity and decreased susceptibility to infection. Fumonisins have been implicated as the causative agents in a variety of animal diseases, such as leukoencephalomalacia of horses, pulmonary oedema in swine and have been associated to some human diseases.The various control strategies at preharvest (use of host plant resistance, biological control with atoxigenic isolates, sound field management practises to avoid stress during the reproductive growth of crops), careful harvestting practises, and post harvest (proper drying, use of improved storage facilities, and use of pesticides) were discussed. The creation of awareness of mycotoxin problem among Africans and the use of chemisorptions technology with NovalSil clay to reduce the potency of mycotoxins have also being reviewed. Traditional food processing techniques such as sorting, dehulling, washings that reduce/detoxify mycotoxins during food processing were also highlighted, while other potentially efficient strategies include diversification of diet to reduce consumption of crops such as groundnut and maize that are highly vulnerable to mycotoxin contamination and vaccination against hepatitis B.

Key words: Mycotoxin, aflatoxins, fumonisins, ochratoxin A, management strategies, Africa

Introduction

Mycotoxins are toxic secondary metabolites secreted by certain filamentous fungi, that constitute a potential risk to the health of human and animals through contamination of food and feed. Mycotoxin food contamination resulting in mycotoxicoses have undoubtedly scourged mankind since earliest times causing death, hallucination, and several other pathological effects. The evaluation of the biblical tenth plaque, the death of the oldest sons of Egypt implicated macro cyclic trichothecene mycotoxin poisoning from Stachybotrys atra contaminating stored grains, with the practice that the first son, his family and animals were often the first to open the grain stores (Marr and Malloy, 1996). The analysis of climatic data, grain production and patterns of mortality revealed the involvement of Fusarium mycotoxins in diseases from medieval Europe to American colonial times (Matossian, 1989).

In the 13th century, a 60% depopulation of Western Europe was alluded to the substitution of wheat for rye, with the former typically susceptible to Fusarium infection, while the latter was resistant (Miller, 1991). During the early years of the Second World War, the enormous causalities resulting in the elimination of several villages in the former Soviet Union from alimentary toxic aleukia (heamorrhagic syndrome) was recognized as a toxic manifestation of mould contamination of over wintered cereals. Later, the toxic metabolite was identified as T-2 mycotoxin produced by Fusarium tricinctum in over wintered millet in the field, which constituted the

greater part of the diet of the people in affected region at the time (Beardall ad Miller, 1994). As far back as 1881, a scientist in Japan was able to demonstrate that ethanol extracts of the fungus Penicillium citreonigrum were lethal to dogs, rabbits and guinea pigs, which led to the ban on the sale of rice contaminated by that fungus (Pitt, 1991). Scientists in Italy were able to demonstrate even before 1900 that the consumption of mouldy corn by children led to the development of illness, and went ahead to isolate pure culture and the toxic metabolites, though the compounds were not actually identified. However, the scientific study of mycotoxins began in 1960s with the reported death of about 100,000 turkeys in England due to aflatoxin poisoning of peanut meal imported from Brazil (Blount, 1961).

Literarily, several compounds characterized from fungi have been shown to be toxic in in vitro cell bioassay (Cole and Cox, 1981), but majority of these compounds have not been directly linked to any human or animal toxicoses. Based on the detailed analysis of the production of these metabolites by fungi, and their known and suspected impact on human and animal health, the IARC (1993) listed five mycotoxins: aflatoxins, fumonisins, ochratoxin A, zearalenone and trichothecenes produced by fungi in the genera Aspergillus, Penicillium and Fusarium as the most important ones.

Mycotoxin production constitutes one of the most important constraints to crop production in Africa (Gressel et al., 2004). Kuiper-Goodman (1998), a leading authority in risk assessment ranks mycotoxins as the most important chronic risk factor in the diet, ahead of other important dietary risk factors such as plant toxins, food additives and pesticide residues. There are several factors that combine to make mycotoxin issues of serious concern in Africa. Developed countries have access to sufficient food supply and broad array of foods, and facilities are in place for inspection and monitoring of contamination levels in food and feeds (Cardwell and Henry, 2004). Consequently, acute human mycotoxicoses is virtually non existent in developed countries. However, in the African setting, the limited food supply and the low food basket diversity restrict the life sustaining staples in many households to highly vulnerable grains such as maize and groundnuts (Egal et al., 2005; Turner et al., 2005). Agricultural exports constitute the major source of foreign exchange in Africa, and the highest quality crops are often exported, leaving the poor quality ones for internal consumption. Fungal growth can only be prevented/minimized by adoption of good agronomic practises and careful management of environmental conditions within storage that reduce mycotoxin production. While the technologies for the adoption of these practises exist in developed countries, the crop management practises of small holder farmers in sub Saharan Africa (SSA) lag behind those of other farmers in the rest of the world. Most of the storage systems in use such as storing grains on cement flours in the house, on the branches of trees or on bamboo granary offer little protection to stored grains against insect and mould deterioration (Udoh et al., 2000; Hell et al., 2000; Bankole et al., 2004; Dejene et al., 2004; Kaaya and Kyamuhangire, 2006). Furthermore, crops often move from the subsistence farmers' field that produce the bulk of the food in Africa to stores and to consumption without any test for mycotoxin or any other contaminants. Thus, while mycotoxin contamination is exclusively restricted to field crops in developed countries, it occurs at preharvest and largely at postharvest in SSA.

Though the spores of toxigenic fungi are ubiquitous, however, the high ambient temperatures and relative humidity in most parts of SSA promote fungal growth, thus making crops to be more prone to contamination with mycotoxins than in temperate zones. Even in the relatively dry areas in SSA, due to the absence of irrigation, drought creates stress that predisposes grains to mycotoxin contamination. Insect damage

to grains is aggravated by drought, cracking or breaking of kernels during manual harvesting, and presence of excessive chaff in the harvested grains (Setamou et al., 1997). The period of harvesting often coincides with period of heavy rainfall in the coastal parts, and drying which relies on sundrying the grains before loading into stores is often faced with great difficulty. Harvesting of maize during unseasonable rains in rural areas of Kenya resulted in the storage of wet maize under damp condition, which resulted to high level of aflatoxin contamination (Azziz-Baumgartner et al., 2005) The traditional method of field drying of crops after physiological maturity not only fail to reduce grain moisture to safe levels, but also results in increased mould incidence, insect damage and mycotoxin levels (Kaaya et al., 2005). The practise of spreading crops on bare ground to sundry brings them in direct contact with soil fungal inoculum. In the Guinea farming communities, groundnuts are dried on bare floor in the open, resulting in increased mould growth and aflatoxin production (Turner et al., 2005).

Short history of health effects due to mycotoxin:

Oral exposure due to consumption of contaminated diet is the main route of entry of mycotoxins, while speculations exist that other potential routes such as skin contact with mould infested substrates and inhalation of spores could lead to mycotoxicoses (Bennett and Klich, 2003; Jarvis and Miller, 2005). The toxicological effect of mycotoxins particularly aflatoxins (the most toxic of the group) could be acute or chronic depending on intake levels, , duration of exposure, toxin types, the defense mechanisms of exposed individuals and many poorly understood synergistic interactions (Bennett and Klich, 2003). Acute toxicity arises from ingestion of high levels of toxins resulting in liver damage, jaundice and hepatitis as was reported in Kenya in 1981, 2001, 2004 and 2005 (Ngindu et al., 1982; Probst et al., 2007). The1981 episode involved 20 hospitalised cases of acute aflatoxicosis with 60% mortality, with aflatoxin contamination levels up to 12,000µg/kg in the maize based food (Ngindu et al., 1982). In 2004, an outbreak of jaundice with a total of 317 recognised cases, and 125 mortality occurred in Makueni and Kitui, Kenya, with maize samples from the affected areas having high levels of aflatoxins, in some cases up to 8,000 µg/kg (Lewis et al., 2005). The acute toxicity of aflatoxins has led to speculations about their utilization as chemical warfare agents and evidence of the use of aflatoxins and trichothecenes as bioweapons in various part of the world was thoroughly discussed by Bennett and Klich (2003).

Chronic toxicity occurs due to long term exposure to low or moderate levels of aflatoxins and symptoms reported in Africa include growth faltering in children(Gong et al., 2002), impaired immunity and decreased resistance to infection (Turner et al., 2003; Jiang et al., 2005), and liver damage including tumors (Shephard, 2008). Aflatoxins also act synergistically with hepatiis B virus to multiply the relative risk of human hepatocellular carcinoma (McGynn and London, 2005). It is estimated that 80% of all HCC cases occur in developing countries (Wild and Hall, 2000). Tuner et al. (2007) recently reported that exposure to aflatoxins in pregnancy impact negatively on the growth of neonates in the first year of life.

Ochratoxin A (OTA) is a naturally occurring mycotoxin synthesized by several species of Aspergillus and Penicillium in grains (maize, wheat, barley, cocoa), fruit juices, spices, animal products from pigs and poultry (Al-Anati and Petzinger, 2006). The major producers of OTA are Aspergillus carbonarius, A. niger and A. ochraceus in tropical climates, and Penicillium verrucosum and P. nordicum in temperate zones (Mounjouenpou et al., 2008). OTA has nephrotoxic, teratogenic, immunosuppressive and carcinogenic

properties in many animal species, and was implicated in the etiology of Balkan endemic nephropathy and urinary tract tumours in the Balkans (Clark and Snedeker, 2006). Following studies on animals, the IARC (1993) classed OTA as possible carcinogen to humans (group 2B).

Out of 24 maize based gruels used as weaning food for children in Nigeria, four were positive for OTA at 0.142 to 6.516µg/kg (Oyelami et al., 1996). Five of the 20 samples of kenkey (fermented maize food) in Ghana had OTA at levels of 2.4-6.4µg/kg (Kpodo et al., 1996). In Nigeria, A. ochraceus and A. niger had incidence of over 50% in cocoa beans, with OTA levels of 40-60µg/kg (Aroyeun and Adegoke, 2007).

The important Fusarium spp that have been identified on African maize include Fusarium verticillioides, F. graminearum, F. subglutinans, F. pallidoroseum, F.oxysporum and F. solani (Bankole et al., 2003; Bankole and Mabekoje, 2004; Adejumo et al., 2007). However, Leslie (2005) and Leslie and Bandyopadhyay (2005) reported that the most commonly identified Fusarium spp. from African maize belongs to the Giberrella fujikoroi species complex that synthesize neither trichothecenes nor zearalenone. The authors further observed that F. verticillioides which produce extremely high levels of fumonisins constitute up to 95% of all Fusarium recovered from maize fields in Nigeria, Egypt, Kenya, Ghana, and South Africa, while Schoth et al. (2008) found that F verticillioides constituted up to 95% of Fusarium spp isolated from Zambian maize.

The major Fusarium mycotoxins are fumonisins produced by F verticillioides and its related F. proliferatum, trichothecenes and zearalenone produced by Fusarium species. F. verticillioides constitute more than half of all Fusarium spp recovered from maize in Africa, and the African strains are extremely high fumonisin producers (Leslie, 2005). Fusarium spp were found to constitute significant component of the fungi associated with root rot of cassava (Bandyopadhyay et al., 2006). Based on international data, the mean daily intake of FB1 was estimated to be 2.4µg/kg of body weight per day in SSA compared to 0.2 µg/kg for Europe, 1.0 µg/kg for Latin America and 0.7 µg/kg for Far East (Creppy, 2002). The overall daily intake of 1-10 µg/kg and 24 body weight per day was estimated for those consuming farm stored maize, and 24 µg/kg in those consuming market maize in Burkina Faso, while the proposed maximum daily intake of fumonisins recommended by JECFA was 2 µg/kg(Nikiemma et al., 2004).

Fumonisins have been implicated in a number of toxic effects in animals such as equine leucoencephalomalacia in horses, porcine pulmonary oedema and hepatic syndrome and immune suppression in swine, nephrotoxicity and liver cancer in rats (Ross et al., 1992; Concova et al., 2003). The mechanisms of fumonisins toxicity has been attributed to the inhibitory effect on sphingolipid biosynthesis, thereby interfering with foliate transport, and this accounts for findings that fumonisin induce developmental abnormalities in mouse embryo, and as such have been hypothesised to be a risk factor for human neural tube defects (Marasas et al., 2004). Significant correlations between consumption of fumonisin contaminated maize and oesophageal cancer was found in some parts of South Africa (Marasas et al., 2004) and China (Sun et al., 2007). The IARC classified fumonisins in group 2B i.e. that they are possibly carcinogenic to humans (IARC, 2002).

Depending on the substrates and environment, more than one mycotoxin may co-occur in a substrate (Bankole and Mabekoje, 2004; Adejumo et al., 2007a). Thus, it is likely that exposures of man are to mixtures of and animals are to mixtures rather than individual mycotoxins. The few studies carried out to date on the interactive effect of mixtures of mycotoxins shows that the effect may be additive or synergistic. The results obtained by Creppy et al. (2004) on in vitro testing using different cell lines showed a synergistic effect of combination of fumonisin B1 and OTA. McKean et al. (2006) found that mixtures of aflatoxin B1 and fumonisin B1 altered the toxic effect of the individual compound with a strong additive interaction.

In SSA, the most important mycotoxins are aflatoxins, fumonisins and ochratoxin A in decreasing order of importance (Bankole and Adebanjo, 2003; Bankole et al., 2006; Kpodo and Bankole, 2008; Siame and Nawa, 2008), while available data indicate that trichothecenes and zearalenone may not be of much significance in SSA (reviewed in Bankole et al., 2006). The enormous direct health risks, economic losses and implications of mycotoxin contamination in SSA have been the subject of several recent excellent reviews (Bankole and Adebanjo, 2003; Williams et al., 2004; Shephard, 2008; Coulibaly et al., 2008). Consequently, several research projects have been initiated in various parts of SSA aimed at finding culturally acceptable intervention strategies against mycotoxin contamination of food. The present paper provides an overview of findings and progress on possible strategies to mitigate mycotoxin contamination in SSA.

Management strategies against mycotoxin contamination:

Considering the huge economic and health impact of mycotoxins in SSA, it is inevitable that suitable intervention strategies be sought for their control. Consequently, several strategies are currently being investigated in different parts of Africa to manage mycotoxin contamination in foods. However, it is very important that a good testing protocol which is currently lacking in many countries of SSA be put in place (Bankole, 2007). However, it must be noted that at present, there are neither enough qualified personnel t conduct tests for mycotoxins nor adequately equipped laboratories in which tests can be carried out (Bankole, 2007). Since mycotoxin production occurs at preharvest, during harvesting and at postharvest and processing, the methods for the control can conveniently be discussed under such headings

Preharvest strategies for controlling mycotoxins:

Pre-harvest crop management practices stand as one of the best approach of avoiding or at least reducing fungal infection and subsequent production of mycotoxin. It is also highly recommended to tackle mycotoxins at preharvest because the extent of contamination f crops by toxigenic fungi in the field determines the rate at which they will deteriorate and produce mycotoxins in storage, particularly under the prevailing high ambient temperatures and relative humidities.

(a) Resistant varieties: A number of researchers in Africa are working on Aspergillus and Fusarium resistant varieties of maize and groundnuts. Ayalew et al. (1995) found considerable varietal differences in among eleven varieties tested for field resistance to Aspergillus, Fusarium and Penicillium spp. One study under development is the collaborative breeding project by the USDA Southern Regional Research Centre and the International Institute of Tropical Agriculture (IITA). The ultimate goal of their work is to breed for maize cultivars that are resistant to Aspergillus and Fusarium ear rot by combining resistance factors in maize lines from Africa with those from the US. Eighteen out of 76 inbred lines of maize from West and Central Africa accumulated aflatoxins at levels as low or lower than the best resistant lines from the U.S (Brown et al., 2001). To increase the chances of developing inbred lines with desirable agronomic traits and lesser toxins than the currently available commercial lines, the lines with the lowest toxins from Africa have been crossed with resistant genotypes from the US (Menkir et al., 2006). The promising lines obtained from such crosses have been subjected to proteome analysis with a view to identifying resistance-associated proteins and corresponding genes underlying resistance to aflatoxin production (Menkir et al., 2006). The lines are also are undergoing resistance reconfirmation trials and are being evaluated for agronomic features, while lines with consistently low levels of aflatoxins and good agronomic traits will be released to African national programs and as sources of

resistance to breeding programs(Brown et al., 2006). Afolabi et al. (2007) evaluated 103 maize inbred lines for Fusarium ear rot caused by Fusarium verticillioides: six lines 02C14585, 02C14593, 02C14603, 02C14606, 02C14624, and 02C14683 had consistently low disease severity across years and locations, while lines, 02C14624 and 02C14585, had fumonisin levels less than 5.0 µg/g. Further screenings showed that four inbred lines 02C14609, 02C14643, 02C14654, and 02C14678 have high levels of disease resistance to Fusarium stalk rot (Afolabi et al., 2008). Schjoth et al. (2008) evaluated 20 Zambian maize hybrids, and found two hybrids MM 701-1 and MM 752 to be highly resistant**.** These lines will be useful for further experiments to develop fumonisin resistant lines.

(b) Adopting sound crop management field practices: The factors that influence toxigenic fungi infection in the field include high soil and/or air temperature, drought stress, nitrogen stress, viable spores' availability, excessive plant population and conditions that aid the dispersal of conidia during silking (CAST, 2003; Hell et al., 2003). Insects vector fungi and their feeding activity damage crops that allow the fungi to gain access to crop tissues thus increasing the chances of aflatoxin contamination (Setamou et al., 1997). Good husk cover is vital in protecting maize ears from fungi and insects; the use of loose-husked maize hybrids increases the chance of insect damage and aflatoxin contamination (Caldwell et al., 2000). High incidence of the insect borer Mussidia nigrivenella significantly increased the levels of aflatoxin contamination of maize in Benin (Setamou et al., 1998).

Controlling or reducing infection by regulating the factors listed above in the field of maize and groundnut will go a long way in controlling aflatoxins. Coincidentally, the pre-harvest measures that are efficient in reducing aflatoxin levels are the same as those that will maximize plan performance and enhance yields. A. flavus infection and contamination by aflatoxins are reduced under irrigation. In Niger, the effect of irrigation to avoid drought stress and the selection of planting dates to take advantage of the period of high rainfalls and also avoiding end of season drought reduced the level of aflatoxin contamination of groundnut (Waliyar et al., 2003). Weeds compete with the growing crops for nutrients, water and sunlight, thus creating stress which results in reduction in yield and grain quality just like those from drought stressed fields. The effect of these practises such as management of insects and diseases in the field, adequate spacing of crops, weed control, proper crop rotation to avoid build-up of inoculum, proper fertilisation to avoid crop stress and timely harvesting which have been shown to decease mycotoxin substantially elsewhere (Ewards, 2004) in farmers field are under investigation in Benin using the farmers' participatory approach (Hell et al., 2008).

(c) **Biological control strategies**: The use of atoxigenic isolates of A. flavus to competitively exclude toxigenic A. flavus isolates in agricultural fields and potentially in storage, a technology that has become an adopted approach to reduce aflatoxin contamination of maize, peanut and cotton seed in the US (Chang and Hua, 2007; Dorner, 2008). is now under investigation by the African Agricultural Technology Foundation, in Nairobi, Kenya and the International Institute of Tropical Agriculture (IITA) in Nigeria. The principles of using atoxigenic strains of A. flavus to limit aflatoxin production is based on their ability to modulate aflatoxin production during crop infection and their ability to displace aflatoxin producers in the crop environment, thereby reducing the rate of crop infection by toxigenic isolates(Dorner, 2004). The atoxigenic strains just like the toxigenic ones become established with growing crops in the field, and are also carried over with the harvested grains into stores where they still exert their protective effect. The technologies of using atoxigenic A. flavus as biological control agents against aflatoxin production are being developed for maize at IITA in Nigeria. Based on initial trials in which the effective atoxigenic isolates from the US proved to be ineffective at checking aflatoxin production by the African toxigenic A. flavus, Cardwell and Henry (2004) were of the view

that it is important that atoxigenic isolates are identified from different agro ecologies where they are to be applied. Eleven isolates of atoxigenic A. flavus have been obtained from major maize producing regions in different agr3332545oecologies in Nigeria (Atehnkeng et al., 2008a) and evaluated in grain competition laboratory experiments and in field studies(Atehnkeng et al., 2008b). The reduction in aflatoxin contamination ranged from 70.1% to 99.8% in grain experiments, and 93.4% to 99.3% in the field (Atehkeng et al., 2008b). These atoxigenic isolates of A. flavus have potentials as future candidates for biocontrol of aflatoxin of maize in West Africa. However, simple, cheap and efficient formulations of these biocontrol agents and their integration with other management practices still need to be investigated.

(d) Use of synthetic chemicals: Extreme fumonisin contamination was found in maize ears damaged by insects, thus field control of insects which could be by application of insecticides was recommended for the control fumonisin contamination (Avantaggio et al., 2002). Fungal infection in the field such as those of Fusarium head blight and ear rot could also be controlled by application of recommended fungicides. When synthetic chemicals and fumigants are correctly applied at the right dosage, it could also reduce mycotoxin contamination (Giga and Biscoe, 1989; Bankole, 1996). Aflatoxin contamination could be reduced by application of fungicides such as itraconazole and amphotericin B to control toxigenic A. flvus (Ni and Streett, 2005). The control of head blight of maize caused by Fusarium spp with the fungicides prochloraz, propiconazole, epoxyconazole and cyproconazole could reduce fumonisins (Haidukowski et al., 2004).

(e) Harvesting Management: Harvesting operations used may inflict mechanical damage on kernels which may predispose them to infection during storage (Fandohan et al., 2006). Thus, the harvesting procedures should be such that damage is kept to a minimum. Fumonisin levels positively and significantly correlated with the extent of damage in maize caused by the use of mechanical sellers (Fandohan et al., 2006). Crops should be timely harvested as the practise of delayed harvesting promotes fungal infection and mycotoxin contamination (Kaaya et al., 2005). Lynch et al. (1991) found that termite damage to groundnut pods increased with delayed harvesting: less than 4% damaged when harvested 70 and 90 d after sowing which increased to 15%after 110 days and 46% 125 days. Delayed harvesting resulted in significantly increased insect damage, mould incidence and aflatoxin contamination in Mayugbe district of Uganda (Kaaya et al., 2005). However, just like over mature plants in the field may accumulate high levels of aflatoxins; harvesting crops before they attain full physiological maturity may also promote fungal infection.

Postharvest and Storage Strategies

In SSA, much of the aflatoxin contamination occurs at this stage, and the strategies for management are comparatively simple and inexpensive. The major goal at this point is to create conditions that will discourage the growth of the toxigenic fungi even if they have gained entrance into the agricultural produce. It is important that the grains are rapidly dried. Since the hot and humid tropical environment has been identified as the main barrier to curbing mycotoxin contamination, research efforts are needed to identify appropriate technologies that that can be use to reduce grain moisture to safe levels immediately after harvest and also maintain the low grain moisture during storage. Drying maize with the husks removed, drying on bare ground, shelling maize by beating, heaping maize on the floor and the use of basket for storage which are commonly practiced by African farmers positively impacted on aflatoxin development (Kaaya et al., 2006). The study by Awuah and Ellis (2002) showed that protectants that efficiently reduced aflatoxin contamination of groundnut with moisture content of 12% could not sustain their efficacy with high kernel moisture content of 18.5%.

Amoako-Attah et al. (2007) found that the proportion of damaged/ mouldy groundnut pods that were rejected was 8.6% in pods dried for four weeks compared to 22.08% in the undried pods. The levels of aflatoxins in the dried pods ranged from 0-0.7µg/kg compared to 7278µg/kg in the undried pods (Amoako-Attah et al. (2007). It is important that simple devices are made that will enable the farmers to know the moisture contents of his produce going into stores, and to also be able to monitor same in stores.

(a) Adequate sanitation is critical: all old grains and residues must be removed, and the sides of storage facilities cleaned and treated with appropriate insecticides. Hell et al. (2000) observed that cleaning of the stores before loading the new harvests was correlated to reduce aflatoxin levels. Wild hosts should be removed from the vicinity of the stores so as not to allow mould infestation. Sorting out physically damaged, infected and discoloured grains from the apparently healthy ones before loading into stores has been shown to be an effective method of reducing mycotoxin contamination (Udoh et al., 2000), and this could be achieved manually or by using an electronic sorter. The widespread use of traditional storage practises by African farmers which has been found to result in considerable post harvest losses warrants investigation into finding appropriate storage technologies for different agroecological zones. Turner et al. (2005) investigated the effect of some postharvest intervention packages: thorough drying of crop by sun drying, spreading of crops on mats rather than on ground to dry, removal of visibly mouldy kernel before storage, storage in natural fibre sacks rather than in sacks, storage of sacks on wooden pallets rather than on bare floor, and the use of insecticides. It was found that while aflatoxin albumin remained rather stable postharvest, even after five months of storage in people in the intervention villages, it increased postharvest in the control villages.

(b) Use of synthetic chemicals such as insecticides: This can also be applied postharvest to control insect infestation while appropriate fungicides will help in checking mould growth in storage. Fumigants when applied at the right dosage, could also reduce mycotoxin contamination (Bankole, 1996). Bicarbonate salts which are easily available, cheap, and easy to handle present suitable alternatives to chemical fungicides to control Fusarium and Aspergillus growth in stored corn(Samapundo et al., 2007)

(c) Use of botanicals: Concerns over the environmental impact and potential health risk of synthetic chemicals have led to the development and commercial utilization of new compounds known as green chemicals (Santino et al., 2005). The antimycotoxigenic activities of a number of African plants such Morinda lucida, Azadirachta indica, Ocimum gratissimum, Cymbopogon citratus, and Aframonium danielli have been proven in in vitro laboratory assays and artificial inoculation (Bankole, 1997; Nguefack et al., 2004; Bankole et al., 2005a; Atanda et al., 2007). Aroyeun and Adegoke (2007) observed that essential oil and aqueous extract of A. danielli reduced OTA levels in spiked cocoa powder by 64 to 95%. The aqueous leaf extract of Allium sativum had 73% inhibitory activity on in vitro growth of A. flavus, and completely inhibited aflatoxin B1 production even at 0.5% concentration (Sandosskumar et al., 2007). It was further shown that the intercropping of A. sativum with peanut kernel resulted in significant reduction in the population of A. flavus in the soil, kernel infection by A flavus as well as aflatoxin contamination of kernels. However, there is still the need to investigate the efficacy of these plants in field tests and under high pathogen conditions.

Other control strategies

(a) Food processing: Food processing includes any physical, chemical or biological treatment that raw grains undergo in the formation of food products. Maize and groundnut which are the two most susceptible to

mycotoxin contamination are subjected to different processing protocols that results in many derived fermented and non fermented food products. Within the last 10 years, several studies have been carried out on the fate of mycotoxins during food processing of raw materials in SSA. Sorting out of impurities, damaged, mouldy and shrivelled seeds have been established as an efficient mycotoxin reduction procedure. The removal of screenings from maize bulk in South Africa reduced fumonisins by 29-69% (Sydenham et al., 1994). By sorting followed by winnowing of maize, Fandohan et al. (2005) achieved mean reduction of 59% in aflatoxins and 69% in fumonisins. Maize samples that had been sorted by farmers as either good quality or poor quality were found to contain fumonisin levels of 1.4 to 110µg/g and 0.2 to 3.7µg/g, respectively (Afolabi et al., 2006).

(b) Dry milling and wet milling: In the dry milling of cereals, the highest amount of mycotoxins are found in the bran and germ fractions that are less likely to be used as food (Bullerman and Bianchini, 2007), with less in maize flour and grits which are the products that enter the food chain Wet milling of maize is used in the production of 'ogi' in Nigeria, mawe in Benin. Washings or steeping of grains in water often result in the leaching of mycotoxins into the steep liquor, and the floatation of less dense grains that often have higher contamination levels. Fandohan et al. (2005) recorded 37% reduction in aflatoxins and 51% reduction in fumonisins to loss in steeping water. Soaking of muthokoi (a traditional Kenyan maize based food) in solutions of sodium hypochlorite or ammonium persulphate reduced aflatoxin content by 28-72 %(Mutungi et al., 2007). However, it should e noted that high mycotoxin levels were also found in supernatant of 'ogi' (a fermented maize based food) (Fandohan et al., 2005), and this liquid is often used to prepare herbal concoctions. Mycotoxins are more concentrated in the outer layers of grains and as such, dehulling, which is often practised in the processing of maize result in significant reduction in mycotoxins. Dehulling maize grains during traditional processing reduced aflatoxins by as much as 92% in Zimbabwe (Siwela et al., 2005) and by 46.6% in Kenyan study (Mutungi et al., 2007). Mechanical dehulling methods reduced fumonisin levels in maize by 55-67%(Fandohan et al., 2006). In Zambia, village processing techniques of dehulling, steeping, washing, drying and then grinding of maize reduced AFB1 from 900 to 150µg/kg and AFG1 from 929 to 114µg/kg (Njapau et al., 1998). For other traditional processing techniques such as fermentation, dry roasting, cooking, variable results have been reported(Kpodo et al.,. 1996; Ogunsanwo et al., 2004; Fandohan et al., 2005; Bullerman and Bianchini, 2007) and many research groups in various parts of Africa are still investigating these processes with a view to firmly establish their influence on mycotoxin levels in food. However, a novel study recently reported that some strains of Saccharomyces cerevisae(viable or non viable) isolated from fermented foods in Ghana binds considerable amount of aflatoxin B1, and that these properties should be put in consideration in the selection of starter cultures for indigenous food production (Shetty et al., 2007).

(c) Diversification of diet: Individuals can attempt to change their diets to avoid less risky foods such as maize. Bandyopadhyay et al. (2007) recommended the replacement of maize with traditional sorghum or pearl millet in marginal environments of West Africa since the latter have less risk of contamination by aflatoxins. In China, rice was used to replace corn, the major source of aflatoxin B1 as the primary staple food in high hepatocellular carcinoma areas with the resultant modest decline in liver cancer incidence (McGlynn and London, 2005).

(d) Chemoprotection/Chemisorptions based technology: Chemoprotection is based on the principle that some chemicals could either increase animals detoxification processed or prevent the production of the epoxide that causes chromosomal damage. The inclusion of mycotoxin binding agents such as calcium bentonite, zeolites, diatomites and vermiculites has been the most commonly used approach to reduce exposure of animals

to mycotoxins (Binder, 2006). Chemopreventive approach using oltipraz originally developed as antischistosomiasis drug and chlophyllin, an essential constituent of human diet have been found to block/suppress/reverse the process of carcinogenesis induced by aflatoxins (Farombi, 2006). These two drugs have also proved to be safe and effective for use in human unavoidably exposed to aflatoxins (Kensler et al., 2004). This technique using clay based technology to protect African population from mycotoxin hazards is being carried out in Ghana by the research group from Texas A&M and Noguchi Memorial Institute for Medical Research, Accra Based on experimental studies carried out so far, it has been established that that NS clay at the dose level of 0.25% can be used effectively to reduce bioavailability of aflatoxins in contaminated diets without interfering with the levels of serum vitamins A and E, and iron and zinc(Phillips et al., 2008). However, long term trial with the NS clay is still required, while economically feasible and culturally acceptable means to NS clay are still being sought to sustain the strategy (Wang et al., .2006)

(e) Vaccination against hepatitis B: Considering the socio-economic background of people in Africa, which might prevent them from easily adopting technologies to reduce aflatoxin contamination in food, hepatitis B vaccination in areas with high aflatoxin exposure will be a major preventive tactics to reduce hepatocellular carcinoma in Africa (Wild and Hall, 1999), though persons already chronically infected will not benefit from the vaccination (McGlynn and London, 2005).. The potency of aflatoxin in HBsAg+ individuals is considerably higher (about a factor of 30) than in HBsAg- individuals; thus, vaccination against hepatitis B (or protection against hepatits C), which reduces prevalence of carriers, would reduce the potency of the aflatoxins in vaccinated populations and reduce liver cancer risk (Wild and Hall, 2000). In Taiwan, the nationwide hepatitis B vaccination reduced incidence of HCC and mortality in young children by 50% (McGlynn and London, 2005).

(f) Awareness creation: Since the harmful effects of mycotoxins are not known to the African populace and many consumers in this region are unaware of their exposure to high level of mycotoxins in their staple diet (Bankole et al., 2005b; Jolly et al., 2005), different awareness programmes are being carried to inform people of the danger of consuming and commercializing mouldy products. Bankole and Adebanjo (2003) highlighted various channels that could be used to disseminate mycotoxin information. One of the major goals of the Nigerian Mycotoxin Awareness and Study Group is to created awareness of the importance of mycotoxins among the Nigerian populace. The awareness programmes will also help in increasing the rate of adoption of technologies that have been confirmed to reduce mycotoxin contamination. Coulibaly et al. (2008) recommended increased public awareness to reduce the costs (in terms of competitiveness and access to international markets of exports from Africa) and health effects due to mycotoxin contamination, and the dissemination of information on proven aflatoxin control strategies to improve food quality in SSA. Indeed, the group of experts at the Mycoglobe Conference in Accra Ghana identified communication with the farmers and consumers, government and international aid offices of the real or potential dangers of mycotoxins in their food, and the implications of the chronic long term effects of exposures to low levels of mycotoxins (Badopadhyay et al., 2008). An information campaign sponsored by Rotary International in Benin, Ghana and Togo significantly increased public awareness of the populations that were exposed to high levels of aflatoxins and stimulated more consumers to sort out and discard bad grains (James et al., 2007).

(g) Legislation: Nowadays, there are national and international legislations such as the CODEX that regulates the contamination levels of mycotoxins allowed in different foods and feeds. Several authors have emphasized the need for policy makers in Africa to establish and enforce quality standards and mycotoxin regulation (Kaaya

and Kyamuhangire, 2006, Adejumo et al., 2007). The number of countries in Africa that have existing mycotoxin regulation in 2003 survey mostly on aflatoxins was 15 covering 59% of the continent, with 10 SSA(FAO, 2004). The SSA countries are Cote d'Ivoire, Tanzania, Mauritius, Mozambique, Nigeria, Zimbabwe, Senegal, South Africa, Malawi and Kenya. It has to be pointed out that the regulations are only on book and that enforcement may be very difficult considering the fact that the subsistent African farmers consume a significant portion of their produce or are sold at the local markets (Shephard, 2008). Some countries that do not have official mycotoxin regulation figures have measures that could help in reducing mycotoxin contamination or are conscious of the problem. For instance, in Zambia, it is statutorily required that grains going into stores should not have more than 13% moisture and maize for human consumption should not have more than 2% visibly mouldy seeds (FAO/WHO/UNEP, 1987). Many West African countries such as Gambia, Ghana and Benin have taken steps to address mycotoxin contamination problem by the execution of various research projects on mycotoxins and by large scale education of the populace on the dangers of mycotoxin contaminated foods. It should be noted, however, that in countries where food supplies are limited, drastic regulatory measures to lower mycotoxin standards would lead to food shortages at higher prices.

Conclusion

The review has shown that the insufficiency of food, the warm and humid climate conducive for toxigenic fungi growth have made foods to be at high risk of mycotoxin contamination in SSA. Food quality control systems in Africa are weak raw products and street foods barely receiving any regulatory attention. The impact of mycotoxins on the people of SSA has been the subject of many well attended recent international Conferences among which are Mycotoxins in Cereals in Africa organised by AATF in June; 2004, Regional Workshop on Mycotoxins organised by International Atomic Energy Agency and National Agency for Food and Drug Administration and Control(NAFDAC) in Lagos, Nigeria in February, 2005 and Reducing the Impact of Mycotoxins in Tropical Agriculture organised by Mycoglobe in Accra, Ghana in September, 2005. Many useful recommendations aimed at resolving the mycotoxin problems were proposed at these conferences, but it will require the genuine interest of policy makers in SSA and international aid officers before these could transform to actions. Thus, any preventive control measures must be pro-poor, well focus and cost efficient. There have been so many strategies proposed by researchers that have proved effective in mycotoxin control, but it must be noted that this process must be validated in Africa to ensure their applicability. Consequently, several research projects in different part of Africa are currently addressing strategies that will prevent/minimize mycotoxins in foods. It is hoped that the findings these research projects in the sub continent will not only stay on paper but they will be conscientiously implemented.

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Radionuclide in foodstuffs: the Nigerian situation in the estimation of internal exposure from incorporated uranium and thorium.

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Abstract:

The radiological impact of nuclear radiation in the environment has been a source of concern to many researchers all over the world. This is because of the deleterious effects of radionuclides present in the various environmental samples to human health. The overall sociopolitical implications cannot be over emphasized in view of the fact that a healthy people make a healthy economy of a nation. Until now in Nigeria, little or no quantitative and qualitative data on radionuclide present in the environment are available for the required assessment and reassessment that will help in the mitigation of the above mentioned problem. In spite of the increasing application of radioactive sources in the country, little efforts have been made so far by some researcher in Nigeria in the monitoring of nuclear radiation. These efforts have been biased toward external dosimetry with the neglect of internal dosimetry needed for the comprehensive studies of the radiological risk to the internal organs. In an effort to stimulate increased research in this area, the present work is aimed at the various foodstuffs in the country which is the major pathway of radionuclide into the internal organs of the body. The distribution and retention of some radionuclides following ingestion of local food samples using deterministic models presented by the International Committee on Radiological Protection (ICRP) is discussed.

Keywords: foodstuffs, internal dose, model, radionuclide, health

Introduction

Radiological impacts of nuclear radiation in the environment become a primary source of concern because of the availability of most parent nuclides of primordial origin. In most environments, the main technologically enhanced naturally occurring radioactive materials (TENORM) are the uranium and thorium and their progenies, together with ^{40}K. These radionuclides, especially ^{238}U and ^{232}Th, may be concentrated in granites and alkaline igneous rocks (UNSCEAR, 2000). These radionuclies (^{238}U and ^{232}Th) are both radiotoxic and chemotoxic. The health hazards associated with these radionuclides stem from their ability to accumulate in human tissues. During their decay processes, there is the emission of highly penetrating gamma rays and ionized particles, thereby causing intensive damage to the tissues where they are localized.

Natural radionuclides have been found in some foodstuff in Nigeria (Olomo, 1990; Arogunjo, 2003a&b, 2004). Only recently, high concentration of natural radionuclides was reported in foodstuffs from some parts of the Jos plateau (Jibiri *et al.*, 2007). In view of the serious hazards posed to man, especially through the ingested pathway, internal contribution to the body burden cannot be neglected in order to properly access the overall radiation body burden.

In monitoring incorporation pattern of radionuclides, reliable knowledge of the daily intake from natural radionuclide sources and their metabolic behaviour are necessary. In Nigeria, the ingestion rate of these

radionuclides has not been studied as obtained in other parts of the globe. This paper is aimed at sensitizing the need to evaluate the daily intake of ^{238}U and ^{232}Th in foodstuffs and water in Nigeria. In addition, the distribution and retention of these radionuclides following ingestion of local food samples using deterministic models presented by the International Committee on Radiological Protection (ICRP, 1995) will be discussed.

Methods

In order to be able to monitor the incorporation pattern of radionuclide, reliable knowledge of the daily intake from natural radionuclide sources and their metabolic behaviour are necessary. The qualitative and quantitative determination of radionuclide activity in foodstuffs remains the most viable option available if reliable dose calculation is to be made. The various analytical methods available for such purposes are gamma spectroscopy, atomic absorption spectroscopy (AAS), atomic emission spectroscopy (AES), X-ray fluorescence, neutron activation analysis (NAA), proton activation analysis (PAA), mass spectroscopy (MS), and inductively coupled plasma mass spectroscopy (ICP-MS). Internal dose calculation following the ingestion of food require bioassay measurements involving the determination of biological substances like urine and blood as indicator following radionuclide injected, ingested, or inhaled into the body. Biokinetic models describing the distribution of radionuclide in the various organs of the body are available for the evaluation of doses delivered to the whole body.

Biokinetic modeling of radionuclide: In the assessment of the extent of human exposure to radionuclide and the related risk, data on the daily excretion in urine are required; this excretion is related to the intake, the metabolic processes governing the absorption into the systemic circulation from the gastrointestinal (GI) tract and also the distribution and retention in the body organs. Radionuclide transport in the human body can be investigated using deterministic model. This process involves model simulation of the linear transfer processes represented by sets of linear differential equations governed by first order kinetics. In order to be able to compare the measured urinary excretion rates with that predicted by the ICRP biokinetic models for most radionuclide, expected excretion rates through lifetime could be simulated using the age dependent biokinetic transfer coefficients for the six age groups given by the ICRP Publication 69 (1995). For the purpose of simulating the behaviour of the radionuclide between compartments after ingestion, the systemic model must be coupled to the gastrointestinal (GI) tract model. The ICRP age-dependent transfer rates in the GI tract and the transfer rate from the small intestine to blood could also be calculated according to ICRP Publication 69 (1995). In modelling the lifetime excretion rates of a radionuclide like uranium for example, the distribution within the internal organs of the body can be described by a compartmental model illustrated in Fig. 1. The biokinetic transfer coefficients governing the retention R of a particular radionuclide in the various compartments of the systemic and the GI tract models during the integral time course could be performed using age-dependent linear interpolation. The transfer between the various compartments follows a system of first-order kinetics. Hence, the retention of the radionuclide in the various compartments is governed by linear transfer processes represented by sets of linear differential equations.

Given the compartmental model of the GI section of Fig 1, if q(t) is the radionuclide activity ingested in a compartment at time t, the model is described by the following eqns:

$$\frac{d}{dt}q_{ST}(t) = -\lambda_{ST}q_{ST}(t) - \lambda_R q_{ST}(t) + \dot{I}(t)$$

$$\frac{d}{dt}q_{SI}(t) = -\lambda_{SI}q_{SI}(t) - \lambda_R q_{SI}(t) + \lambda_{ST}q_{ST}(t) - \lambda_B q_{SI}(t)$$

$$\frac{d}{dt}q_{ULI}(t) = -\lambda_{ULI}q_{ULI}(t) - \lambda_R q_{ULI}(t) + \lambda_{SI}q_{SI}(t)$$

$$\frac{d}{dt}q_{LLI}(t) = -\lambda_{LLI}q_{LLI}(t) - \lambda_R q_{LLI}(t) + \lambda_{ULI}q_{ULI}(t)$$

where λ_R is the radioactive decay constant of the radionuclide in question

$\lambda_B q_{ST}(t)$ is the rate of transfer of activity to the body fluid (systemic circulation)

λ_i is the biological clearance rate from the compartment i to the other

$\lambda_i q_i(t)$ is the rate of transfer of activity from the compartment i to the other

$\lambda_R q_i(t)$ is the decay rate of the radionuclide activity in the compartment i

$\dot{I}_i(t)$ is the rate of intake of the activity from outside into the compartment i at time t.

To model these multi-compartmental systems and to solve the sets of linear differential equations, different software packages are available for solving multi-compartmental systems.

The retentions of uranium in organs and tissues are as follows:

$R_{kidney}(t) = q_{14}(t) + q_{21}(t)$

$R_{skeleton}(t) = q_5(t) + q_6(t) + q_7(t) + q_8(t) + q_9(t) + q_{10}(t)$

$R_{liver}(t) = q_3(t) + q_4(t)$

$R_{othersofttissue}(t) = q_{11}(t) + q_{12}(t) + q_{13}(t)$

$R_{blood} = q_1(t) + q_2(t)$

$R_{wholebody} = q_1(t) + q_2(t) + q_3(t) + q_4(t) + q_5(t) + q_6(t) + q_7(t) + q_8(t) + q_9(t) + q_{10}(t) + q_{11}(t) + q_{12}(t) + q_{13}(t) + q_{14}(t)$

$E_{urine}(t) = q_{21}(t) \times k_{15,21}(t) + q_1(t) \times k_{15,1}(t)$

$E_{faeces}(t) = q_{24}(t) \times k_{18,24}(t)$

where $R_{organ}(t)$ is the activity of uranium in the specified organ at time t; $E_{urine}(t)$ and $E_{faeces}(t)$ are the excretion rates of uranium in urine and faeces at time t; $k_{i,j}(t)$ is the transfer rate from compartment j to compartment i at time t with i, j = 1, 2, ……. 24; $q_i(t)$ is the activity in the compartment, i at time t, shown in Fig 1.

***Daily Intake of Radionuclide*:** In the determination of radiation dose from radionuclide within the body, qualitative determination of the amount ingested or inhaled (being the two major pathways into the body) is required. The retention within the body is a function of the concentration of the amount ingested or inhaled and also the kinetics of the metabolism processes discussed above. It is therefore very expedient to have adequate knowledge of the various transfer pathways into the food chain. Fig 2 shows the suggested radionuclide incorporation pattern into the natural ecosystem. The estimated uranium daily intakes (μg) in some selected countries as compared to Nigeria are presented in Table 1. Marked variation observed in the daily intakes presented in this table is attributed to the differences in the composition of diet among the different countries and the contribution of different food categories. The report presented for Vietnam (Giang *et al*., 2001), variability within a particular country can be observed. In Nigeria, no effort has been made to identify various diet compositions and the contribution of food categories to the daily intakes of radionuclide.

Conclusion

In view of the complex structural flow chat of the potential sources and transfer pathways presented in Fig 2, quantitative and qualitative determination of radionuclide present in Nigerian foodstuffs require concerted effort by all stakeholders in the field of radiation and health physics. Little efforts have been made by some authors in Nigeria in the determination of radionuclide present in foodstuffs. The essential data needed to obtain the needed daily intake of radionuclide in Nigerian foodstuffs are very sparse and in most cases not available. Adequate knowledge of the rate of consumption of the various foodstuffs in the country is required in order to effectively estimate their daily intake. Baseline data of the daily intake of radionuclides in Nigeria will serves as reference for future assessment strategy in the event of gross contamination in view of the increasing technological advancement in the various facets of the economy. This will lead to improved quality of life and life expectancy in Nigeria since the deleterious effects of such ingested radionuclide would have been mitigated early enough by the appropriate safety regulations that would have been put in place by the regulatory body in the country.

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Table 1. Uranium daily intake in other part of the world as compared to Nigeria.

Country	Total intake (µg)	References
Italy	3.9	Galletti *et al*. (2003)
Central Poland	1.8	Pietrzak-flis *et al*. (2001)
Ukraine	0.6	Shiraishi *et al*. (1997)
Yokohama Japan	0.1	Kuwahara *et al*. (1997)
Vietnam	0.7 (0.09 – 2.33)	Giang *et al*. (2001)
France	1.0	UNSCEAR (2000)
Russian Federation	3.5	UNSCEAR (2000)
Nigeria	-	Present work
Worldwide	1.3	UNSCEAR (2000)

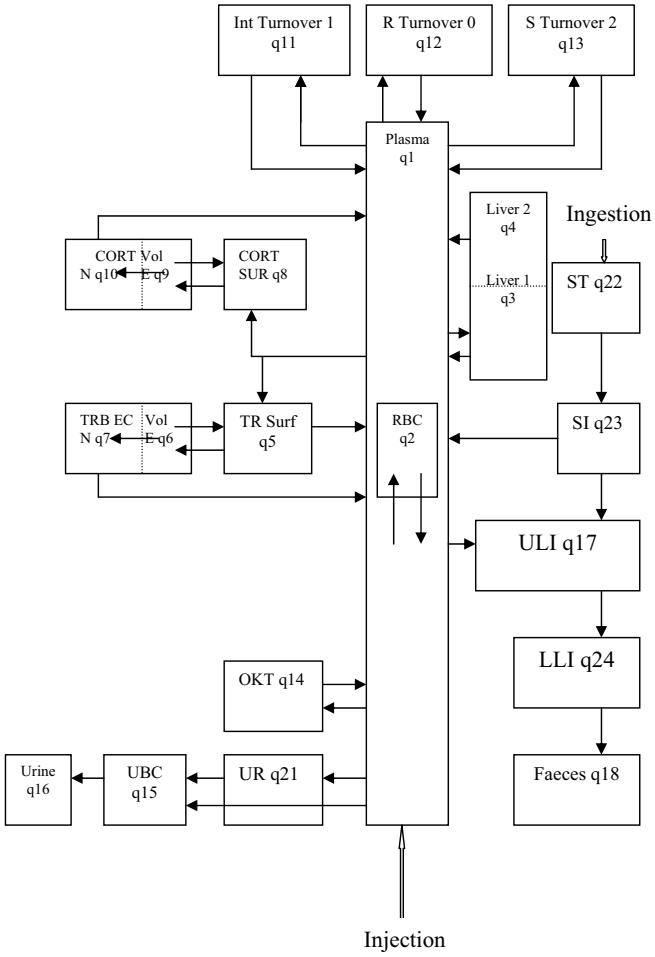

Fig 1: Compartmental model showing the distribution of radionuclide.

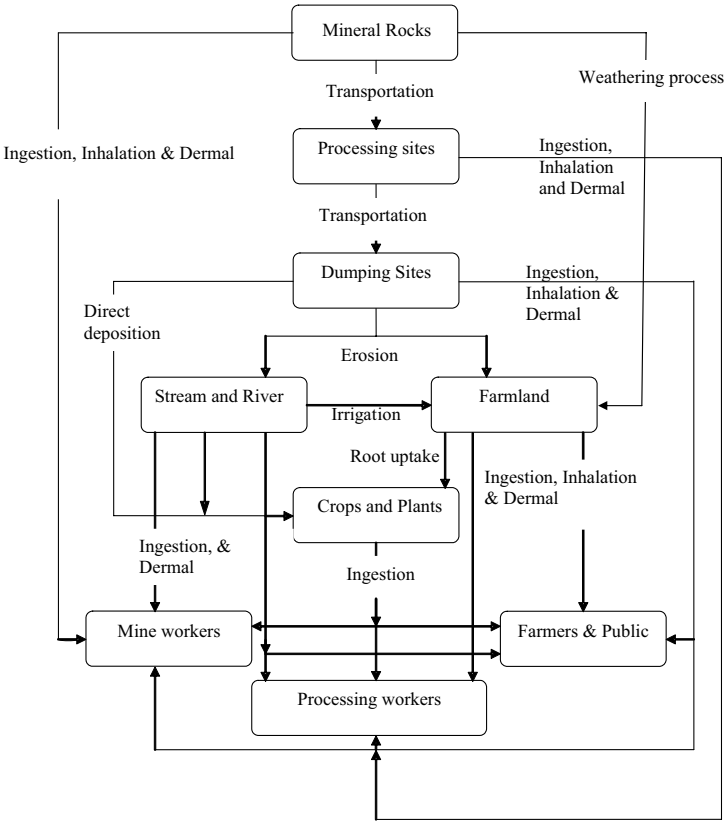

Fig 2: Radionuclide incorporation pattern into the natural ecosystem and man

Source Apportionment of Respirable Fraction of Airborne Particulates in Lagos, Nigeria.

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Abstract

To have a clear picture of air pollution from different sources and their respective contributions to the total environmental pollution load, and consequently understanding the health implications and abatement strategies, apportionment of the sources impacting the receptor is necessary. The relative contributions of the different sources to the respirable fraction ($PM_{2.5}$) of the air particulates in Lagos, Nigeria were apportioned using the chemical mass balance (CMB) model. The inputs to the model were the measured elemental concentrations and the identified sources of the air particulates impacting the receptor sites. The contributions of the major sources and associated standard errors are as follows; soil (27.93 ± 10.90%), automobile (70.12 ± 13.16%), marine (1.13 ± 0.46%), residual oil combustion (0.47 ± 0.04%), and biomass/residential wood combustion (0.34 ± 0.06%). The non availability of representative source profiles resulted in the non- apportionment of about 35% of the measured concentrations to their respective sources. The need to develop local profiles for better source apportionment studies is emphasized.

Key Words: Respirable, CMB model, source profile, automobile, residual oil combustion

Introduction

Air pollution is considered a global problem as primary pollutants may not only be capable of causing problems within the immediate vicinity but also serve as precursors for secondary pollutants, which may have impacts across the globe. In Nigeria, the capability of national, state and local governments to maintain urban infrastructure has been very low leading to numerous air pollution and other environmental problems which include improper urban waste disposal, contamination of water resources, e.g. Lagoon, and others. In order to control urban air pollution, authorities must design strategies to reduce emission of airborne particulate matter. Receptor modeling of air pollutants is very important in air quality management. The reason is that once the sources of harmful/undesirable elements impacting a receptor are identified and quantified, their release into the atmosphere can be controlled. The traditional dispersion modeling is often inadequate to deal with modern complex air basins. Dispersion model and a number of Receptor models like Factor Analysis (FA) and Cluster Analysis (CA) have been successfully applied in helping air pollution authorities to establish the most effective air pollution control strategy. These models are used in the regulatory framework, where they are increasing the reliability of aerosols source apportionment.

Receptor modeling identifies and quantifies contributions from various sources by measuring airborne particulates and their individual components at a receptor (sampling) site. It is based on the principle of conservation of mass and assumes that the concentration $C_{X(T)}$ of a given element measured at a receptor site is the sum total of the contributions from all the sources affecting that site (linear addition) (Watson, 1984): For example consider lead (Pb), then

$$C_{Pb(T)} = C_{Pb(auto)} + C_{Pb(incinerator)} + C_{Pb(smelter)} + ... \quad 1$$

The quantity of an element 'x' contributed by a given source is a function of the gravimetric (ng/mg) concentration of 'x' in the emissions from that source and the mass concentration of particles from that given source per unit volume of sampled air ($\mu g/m^3$).

Thus if x = Pb:

$$C_{Pb(auto)} = a_{Pb,auto}\ f_{\text{auto}} \quad 2$$

where

$a_{Pb,auto}$ = fractional concentration of x in automotive particles and

f_{auto} = fraction of the total airborne particle mass loading due to automobile.

Having made this partition for all the sources, the linear additive property of airborne particulates at the receptor site can be extended to account for all *m* elements in *n* samples as contributions from *p* independent sources

$$x_{ij} = \sum_{k=1}^{p} a_{ik}\ f_{\text{kj}} \quad 3$$

where:

$j = 1,n$

$i = 1, m$

x_{ij} = the concentration of the i^{th} element in the j^{th} sample

a_{ik} = fractional concentration of the i^{th} element in source *k*

f_{kj} = total mass contribution of source k to the receptor

Several approaches to receptor modeling have been successfully applied. The best-known example of models is the chemical mass balance (CMB). The CMB approach to receptor modeling is well documented by Friedlander (1973), Cooper and Watson (1980) and Watson *et al*. (1997 & 1998). The basic concept of CMB is that composition patterns of emissions from various sources are different enough for their contributions to be quantified by measuring concentrations of many species collected at a receptor site. This relative apportionment of chemical species between potential sources is based on statistical comparison of the chemical profiles of each source with the chemical profile of ambient particles. For this reason, information on the number of sources acting on the receptor and their profiles are necessary for the CMB model procedure. It is a pure source and ambient data reconciliation statistical package (Olise, 2004).

There have been several source apportionment studies involving the use of CMB and other receptor models. Few of the foreign studies bothered on inhalable and respirable fractions of the particulate matter while there has been no reported work on such particulate fractions in Nigeria. Harrison *et al*. (1997) reported receptor model study of airborne particulates at three sites in Birmingham, UK using principal component factor analysis coupled with regression analysis of the factor loading with other pollutants and meteorological variables to establish contributions. Four sources of particles that accounted for 82% of the total measured particle mass were identified; these were motor vehicle (45.4%), secondary particles (16.6%), road dust (12.7%) and di-icing

salt (7.5%). Chow *et al*. (1995) investigated the contribution of sources of airborne particulates in San Jose, California CMB. The study gave about 45% of the total PM_{10} load to residential wood burning.

In a similar study comprising six sites in Santa Barbara, California, Chow *et al*. (1996) identified marine, motor vehicle, geological material, oil combustion and construction activities as the major contributing sources, with each of the major sources having varying effects at each site. However motor vehicle, marine and geological sources appear to have the most pronounced effect on all the sites. Similar studies were carried out in Rhubidoux (Chow *et al.,* 1992a) and at San Joaquin Valley (Chow *et al.*, 1992b). The few studies carried out on the contribution of different sources to total urban air quality in Nigeria bothered on the total suspended particulate (TSP) matter. Ogunsola (1995) apportioned over 85% of Pb, Br and Zn (maker elements for vehicular emissions) metals in Lagos and Ile-Ife to vehicular emissions. Oluyemi (1997) reported source-receptor relations for Lagos airborne particulates based on samples collected at about 12m, a height considered non-sensitive to assessing contributions from line and area sources such as road traffic and residential. The study identified three major sources at each of the three sites- soil, marine and vehicular traffic with some minor sources such as incineration, regional sulphate and unidentified industrial sources. The CMB model identified entrained soil as the major contributor at each of the sites in Lagos, accounting for 39.1-54.2% of the TSP load. This was followed by marine contribution (25.8-29.4%) and regional sulphate (5-7%) while each of the other sources contributed less than 4%. Olisemeke, (2002) in the source apportionment study of Niger Delta (Warri and its environs), Nigeria identified six major sources of TSP and CMB model was used to apportion contributions to the identified sources as 50 ± 6.39% (soil), 27 ± 2.43% (transportation), 4 ± 0.91% (biomass/residential wood combustions), 5 ± 0.14% (marine), 13 ± 1.93% (residual oil combustion) and 1 ± 0.33% (construction & demolition).

Source apportionment studies in Nigeria have been lacking in a very important aspect. This is the non-availability of representative source profiles for all source categories and even the total absence of profiles for certain source types. For instance, Oluyemi (1997) was unable to account for 10-20% of the contributing sources in the CMB calculations. This was due to non-availability of accurate elemental source signatures for some industrial and other sources such as metal smelting, paint industry and wood combustion which should have been included in the CMB programme to calculate the relative contributions of such sources. Olisemeke, (2002) reported a non-apportionment of about 20% of the TSP load for lack of representative source profiles and a total non-availability of source profile for metal works, which was one of the identified sources. These shortcomings led to underestimation/overestimation of contributions from different source types in one hand and total darkness on the contributions from sources for which profiles are not known.

In an earlier work, (Olise, 2004), the elemental concentrations of the particulates were subjected to statistical analyses (Enrichment Factor, Inter-elemental Correlation, Factor Analysis and Cluster Analysis) to identify the possible sources of the airborne particulate matter impacting the receptor sites. The study identified entrained soil, automobile, industry, metal works, biomass and residential fuel combustion as the sources of particulate in Lagos. In this work, the CMB receptor model is used to apportion contribution of each of the sources to the respirable ($PM_{2.5}$) fractions of the airborne particulate load, making use of the earlier work results.

Materials and Methods

The source contribution estimates were performed using the CMB version 8.0 analysis software modified by Watson *et al.* (1997). The decision on the choice of sources to include in the CMB calculations required the consideration of the results of factor, cluster and inter-elemental correlation analyses (Olise, 2004). Source compositions (i.e. the fractional amount of the species in the emissions from each source-type) and the receptor concentrations (characterized elements), with appropriate uncertainty estimates; served as input data to the CMB model.

The analysis was repeated a number of times to arrive at the combination of source profiles, which gave the best fits, reflecting reasonable percentage of source apportionment in the CMB calculations. The output consisted of the amount contributed by each source-type to each chemical species. Marine Source was included in the calculations because of its possible contribution to one of the receptor sites in the marine area. Metal works and industry were not included because the source profiles were not available. As such only 65.4% of the measured elemental concentrations were apportioned.

The major challenges in the CMB modeling still remained the availability of credible and precise source profiles and the identification of the primary sources to be included in the model calculations. The Watson *et al.* (1998) outlined seven-step protocol for the application and validation of CMB result was, however, applied. Three different performance measures were used to evaluate the reliability of the source contribution estimates obtained from the CMB calculations. These were T statistics (TSTAT), which is the ratio of the source contribution estimate (SCE) to its standard error (STD ERR); R-square (R-SQUARE), which is the Variance in ambient species concentrations explained by the calculated species concentrations; and the ratio of the calculated to the measured elemental concentrations (C/M). A high TSTAT suggests a nonzero SCE and a low R-SQUARE (<0.8) indicates that the selected source profiles have not accounted for the variance in the selected receptor concentrations.

Results and Discussion

Figure 1 shows the CMB calculated source contribution estimates and standard errors are as follows: entrained soil (27.98±10.90%), automobile (70.13±13.16%), marine (1.13±0.46%), residual oil combustion (0.47±0.04%) and biomass/residential fuel combustion (0.34±0.06%). Despite their typically dominant coarse grain-size distribution, mineral and marine aerosols were clearly observed in $PM_{2.5}$ (respirable fraction). Multi-linear regression analysis (MLRA) was applied to the data, showing that traffic was the main source of the respirable fractions at all the sites investigated. These source contribution estimates re-affirm the reported larger contribution of automobiles to the respirable fractions of the particulate matter (Sharma and Patil, 1991; Pope *et al.,* 1995). The reason for the large contributions from traffic sources might not be unconnected with the high traffic density, regular traffic jams and poor vehicle and road conditions.

Consequently, despite location and possible metrological variability throughout Lagos, the same main $PM_{2.5}$ emission sources were identified at all the study sites and the differences between the relative contributions of each of these sources for all the sites were less than 5%. This consistency would make $PM_{2.5}$ as a useful parameter for health studies and environmental policy-making, owing to the fact that it is not as subject to influence as other parameters such as PM_{10} (inhalable, but not respirable fraction).

Table 1 shows the CMB elemental source contribution estimates ($\mu g/m^3$) revealing the difference between the calculated and the measured concentrations. The CMB calculations underestimated the

concentrations of K, Ti, Cr and Pb while Ca, Ni and Br were overestimated. However, the concentrations of V, Mn, Fe, Cu and Zn were computed correctly. The underestimation problem could be traced to the non-inclusion of a major source of an element in the calculations. The concentrations of such elements in the source profiles used for the CMB calculations may be different from the concentrations of the elements in the actual sources impacting the receptor (Watson *et. al.,* 1998). This could also account for the overestimation of some elements. We noted that only 65.4% of the measured elemental concentrations were apportioned because of the non-inclusion of metal works and industry source profiles in the CMB calculations. This level of percentage mass apportioned may also be attributed to low measured masses and missing data points (Watson *et al.,* 1997).

The validation of CMB result is shown in Table 2. The CMB results show that for most elements there was good agreement between the calculated and measured concentrations (Table 1). It showed that the CMB results were valid. The optimum ratio of the model-calculated to the measured species concentrations was between 0.8 and 1.2 (Watson *et al.*, 1998). The TSTAT values were all above the critical value (≥ 2) and the R square value obtained was 0.80. Where calculated values were outside this range, it would have been due to the non-inclusion of major source profiles and/or the use of non-representative source profiles.

Conclusion and Recommendation

The relative contributions of the different sources to the respirable fraction of the air particulate load in Lagos were apportioned using the CMB model. The contributions of the major sources showed that automobile was the major source of the particulate load. This major source together with others is to be given adequate attention in the urban air pollution abatement planning programme.

The uncertainties in the results of source apportionment were primarily a function of the data set used in the calculations. This is because CMB algorithm compares the composition profile of ambient particles with those of the sources to reach a unique solution to the CMB equations. Another source of uncertainty is the source profiles used for the CMB modeling. The source profiles were imported from literature (USEPA, 2000). These imported profiles may not be representative of the actual compositions of sources at the receptor sites. There was no profile for metal works and industry leading to its non-inclusion in the CMB calculations. As such about 35% of measured mass of the respirable fraction of the particulate matter was not apportioned to their respective sources. In view of these, it is important to develop local profiles for better source apportionment studies. With this a more reliable picture of air pollution from different sources and their respective contributions to the total pollution levels in our environment as well as its consequent health implications would be better understood.

Table 1: Elemental source contribution estimates (μg/m^3)

Elements	Soil	Auto-mobile	Marine	Biom. Comb.	Oil Comb.	Meas.	Error	Calc.	Error	C/M	Error
K	0.155	0.004	0.452	0.162	0.006	5.480	1.060	4.264	0.367	0.780	0.160
Ca	0.459	0.035	0.561	0.275	0.010	4.410	1.340	5.911	0.429	1.340	0.420
Ti	0.129	Nd	nd	0.091	0.006	1.580	1.010	0.357	0.101	0.230	0.160
V	0.016	Nd	nd	0.012	0.725	0.830	0.010	0.625	0.061	0.750	0.070
Cr	0.008	0.007	nd	0.018	0.003	1.550	0.330	0.058	0.021	0.040	0.020
Mn	0.059	0.679	nd	0.044	0.006	0.740	0.010	0.583	0.142	0.790	0.190
Fe	0.613	0.110	nd	0.362	0.038	4.060	0.520	4.562	0.795	1.120	0.240
Ni	0.109	0.819	nd	0.968	14.437	0.040	0.010	0.653	0.102	16.330	4.820
Cu	0.008	0.010	nd	1.136	0.001	1.050	0.240	1.213	0.011	1.160	0.260
Zn	0.067	0.081	nd	0.477	0.128	1.490	0.220	1.121	0.071	0.750	0.120
Br	0.019	2.233	0.154	0.016	0.001	0.230	0.010	0.557	0.149	2.420	0.660
Pb	0.027	0.461	nd	0.030	nd	3.200	0.510	1.658	0.448	0.520	0.160

nd = not detected

Table 2: Validation of CMB results

Sources	T STAT Critical (≥ 2)
Soil	2.56
Automobile	5.33
Marine	2.49
Biomass	5.67
Oil combustion	11.15
R Square Critical (≥ 0.8)	0.80

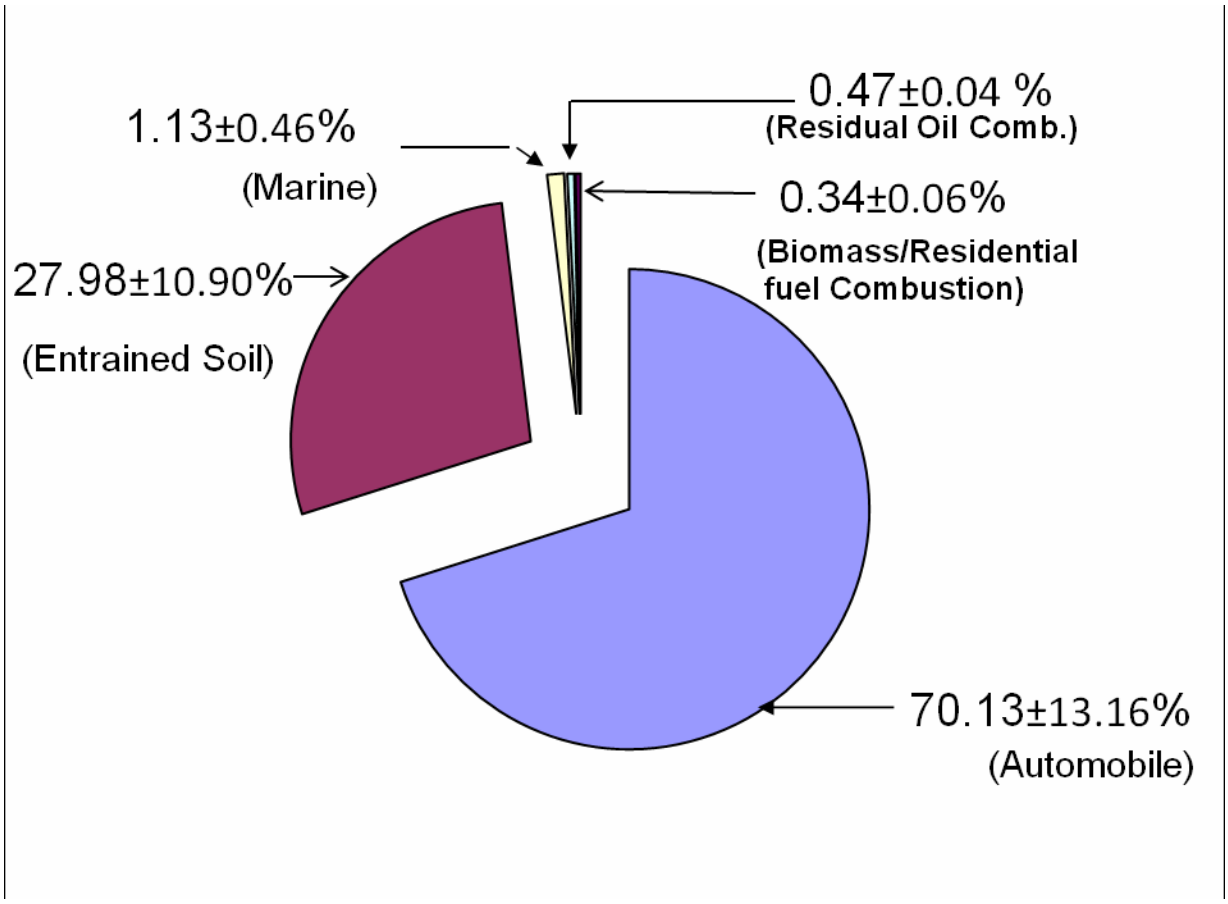

Figure 1: Percentage Contribution of Apportioned Sources

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Conversion of abattoir wastes into livestock feed: Evaluation of sun-dried wheat offal blood meal as an alternative feedstuff for broiler chickens

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Abstract
The study was conducted to determine the chemical composition of sun-dried wheat offal blood meal (SDWBM) and its effect on the performance of broiler chickens (Anak-2000 strain). Fresh blood prevented from coagulation, mixed with wheat offal, was sun-dried, ground, mixed again with blood and ground into a meal after drying again. The crude protein, fat, fiber, ash, NDF, ADF and gross energy contents of SDWBM were, 428.0, 12.5, 39.0, 80.0, 325.0, 70.0 g/kg diet and 15.80 kJg^{-1}, respectively. It contained adequate amount of all essential amino acids for growing broiler chickens. In a feeding trial, starter (14-35 d) and finisher phases (35-49 d), eighty 14-day-old commercial broiler chicks were randomly allocated to four dietary treatments in a completely randomized block design. The dietary treatments (isoproteic and isoenergetic, and fed *ad libitum*) consisted of the control diet, which contained fishmeal (starter diet only), groundnut cake and soybean meal as the main protein sources, and three other diets, which contained varying levels of SDWBM (50, 100 and 150 g SDWBM/kg diet or 5, 10 and 15%). The starter dietary treatments did not have significant impact ($P>0.05$) on feed intake, body weight gain, and feed conversion efficiency but the 0 g SDWBM/kg diet was inferior ($P<0.05$) to 50, 100 and 150 g SDWBM/kg diets for feed cost per unit weight gain. Finisher diets had no impact on feed cost per unit weight gain and feed efficiency. However, birds fed 0 g SDWBM/kg diet consumed more feed ($P<0.05$) than those on other diets while birds fed 150 g SDWBM/kg diet had the least body weight gain. Data for the whole period (14-49 d) indicated that the dietary treatments had no effect ($P>0.05$) on feed intake, feed efficiency and body weight gain. However, all the diets were similar in carcass yield but for the 0 g SDWBM/kg diet, which was inferior ($P<0.05$). The 100 g SDWBM/kg diet was similar ($P>0.05$) to the 50 and 150 g SDWBM/kg diets but superior ($P<0.05$) to the SDWBM free diet in feed cost per unit weight gain. Mortality was unaffected by dietary treatments for all periods. The study indicates that dietary SDWBM up to 150 g/kg diet had a positive effect on broiler performance and can totally replace more expensive fishmeal economically.

Key words: alternative feedstuff, blood meal, wheat offal, fishmeal

Introduction

In Nigeria, post harvest losses in the slaughter of cattle for beef and other animal products occur mainly as blood and intestinal contents, which are veritable sources of nutrients for animal production. Estimated quantity of blood meal wasted in Nigeria could be about 3,000 metric tons annually from about 2 million cattle slaughtered (Makinde, 2006). Adequate technology for properly processing blood into blood meal is unavailable because of high cost and inappropriateness of the application to the existing abattoir structure in the country, which exists as small-scattered units (Babatunde, 1988; Makinde, 2006)

Therefore, there is the need for simple, appropriate and adaptable technologies or procedures that will aid in the conversion of such wastes as blood into useful products. Using crop by-product materials as carriers for blood in the production of a vegetable-carried blood meal (Sonaiya, 1988) may provide the potential for increased supply of probably more affordable alternative animal feed ingredients given the current trend of increasingly high prices for grains. Cuperlovic *et al.* (1978) had earlier tested an oven-dried mixture of wheat offal and blood on pigs with encouraging results. However, there is limited research with poultry using the same material.

Wheat offal is a by-product of milling processes, most preferred and utilized conventionally in livestock feeds in Nigeria (Babatunde *et al.*, 2002). Wheat offal contains about 15- 17% crude protein and 9-11% crude fiber (Donkoh, 2003; Makinde, 2006). Blood contains about 80-90% crude protein high in the essential amino acids, especially lysine (NRC, 1994). Moreover, blood meal does not suffer from the disadvantages of anti-nutritional factors, such as tannins, glucosinolates, lectins and trypsin inhibiting factors found in plant proteins.

Therefore, mixing blood with wheat offal in the production of wheat offal blood meal may offer a simple method for obtaining a high quality alternative feedstuff for livestock. Makinde and Sonaiya (2007) have reported optimum mixing ratios for wheat offal with blood.

Expected advantages are that the wheat offal will serve as an absorbent for blood providing an increase in the surface area for quicker drying, and the blood will increase the quality of wheat offal. Nevertheless, blood is sensitive to heat damage during uncontrolled mechanical drying due to reactions between lysine and reducing sugars (NRC, 1994), which may reduce the availability of essential amino acids. However, sun drying offers a cheaper, less logistically problematic and probably less deleterious alternative (Azad, 2008). Therefore, the objective of this study was to evaluate sun-dried wheat offal blood meal (SDWBM) as an alternative feedstuff for broiler chickens.

Materials and Methods

Preparation of SDWBM

Wheat offal (Eagle Flour Mills, Ibadan, Nigeria) was mixed with fresh blood (prevented from coagulating for at least 6 hours by mixing with18 g common salt/liter blood) collected from several slaughtered cattle at a commercial abattoir according to the method of Makinde and Sonaiya (2007). This mixture was sun-dried for between 3-4 h, ground, mixed again with blood and ground into a meal after drying again.

Determination of chemical composition

Chemical composition (proximate analyses) of wheat offal and SDWBM were determined using standard procedures of AOAC (1990). A further partitioning of the crude fiber fraction (Van Soest *et al.*, 1991) was accomplished by digestion with neutral detergent (3 % Sodium lauryl sulfate, pH 7) and acid detergent (49.04g sulphuric acid and 20 g cetyl-trimethylammonium bromide per liter) to obtain neutral detergent fiber (NDF) and acid detergent fiber (ADF) fractions, respectively. Amino acid composition of SDWBM was determined following acid hydrolysis using a Technicon® Sequential Multisample Amino Acid Analyzer (TSM-1, model DNA 0209, Swords Co., Dublin, Ireland; reproducibility, ±3%) at the Zoology Department, University of Jos, Jos. Between 30-50mg of the defatted sample was weighed into glass ampoule. Seven milliliters of 6 N HCl was added and oxygen was expelled by passing nitrogen into the ampoule (this was to avoid or reduce possible oxidation of sulphur amino acids during hydrolysis). The glass ampoule was then sealed with bunsen burner flame and put in an oven preset at $105^0C \pm 5^0C$ for 22 hours. The gross energy content of the vegetable-carried meals was determined by oxygen bomb calorimeter (Gallenkamp Ballistic Bomb Calorimeter, Cambridge Instrument Co. Ltd, England).

The concentrations of calcium, iron, zinc magnesium, manganese and copper were determined according the methods of AOAC (1990). Two grams of sample was ashed in crucible at 600^oC in a Gallenkamp muffle furnace for 3 h, cooled to room temperature in a desiccator, extracted in the crucible with 5ml 6 N hydrochloric acid (HCl) for 30 min, filtered with ash-free filter paper into a 100ml volumetric flask, and made to 100ml with distilled water. The concentration (in parts per million, ppm) of each element was determined by atomic absorption spectrophotometer (ALPHA 4 AAS, Chemtech Analytical Ltd., Bedford, England). Phosphorus was estimated using the stannous-chloride method. Ammonium molybdate and stannous chloride were added to 5 ml of the filtrate, left for 20 minutes and absorbance read on UV spectrophotometer (Cecil CE 3041, 3000 series, Cecil Instruments, Cambridge, England) at 660 nm.

Experimental procedure and management of birds

The experiment was divided into two phases, starter and finisher phases. Eighty14-day-old commercial broiler chicks (Anak-2000 strain) were randomly allocated to four dietary treatments (Table 1) in a completely randomized block design. Each treatment was replicated four times with five birds per replicate. The dietary treatments consisted of the control diet, which contained fishmeal (starter diet only), groundnut cake and soybean meal as the main protein sources, and three other diets, which contained varying levels of SDWBM at 50, 100, and 150 g/kg diet. Two control diets were formulated, one for the starter phase containing no SDWBM but fishmeal at 30 g/kg diet, and the other for the finisher phase with no fishmeal or SDWBM or any other animal protein source. The test diets for the starter phase were formulated to be isocaloric and isonitrogenous containing 12.6 MJ ME/kg and 220 g/kg crude protein (PTF, 1992), and the finisher phase formulated to contain 12.34 MJ ME/kg and 180 g/kg crude protein (PTF, 1992). The starter diet was fed for 3 weeks, and the finisher diet for 2 weeks. The birds were confined in 20 floor pens (each measuring 1.52 m^2) which provided a floor space of 0.3 m^2 per bird. The pens were in a poultry house constructed from wood and wire gauze, with asbestos roof and concrete floor. Pens were covered with wood shavings for bedding. Plastic water drinkers and suspended metallic conical feeders were used to provide drink and feed, respectively, and were cleaned daily.

Birds were fed ad libitum with free access to water. Newcastle disease vaccine (NDV), infectious bursal disease vaccine (IBDV), coccidiostat (Embazin-Forte®: Sulfaquinoxaline-Diaveridine-Vitamin K complex), antibiotic (Keproceryl®: water-soluble mix of the antibiotics - oxytetracycline, erythromycin, and streptomycin with fat- and water-soluble vitamins), and a B-vitamin complex solution (Biovit®) as antistress were used to maintain chicks in good health. The coccidiostat, antibiotic, and B-vitamins drug were administered via the drinking water.

All five chickens in each pen were weighed individually at the beginning of the experiment, then weekly, and at the end of the experiment. Feed consumption per pen was recorded weekly after the total feed given per week was corrected for feed left over. Average daily gain (ADG), average daily feed intake (ADFI), feed conversion ratio (FCR), were calculated from the data obtained. Records of mortality kept and all dead chickens were sent to the Veterinary Unit of the Teaching and Research Farm for post-mortem examination. At the end of the experiment, three birds were selected randomly from each pen, starved of feed for 24 hours to empty their crops, killed by cutting the jugular vein, exsaguinated, defeathered and eviscerated. Carcass yield calculated as dressed weight per unit live weight excluded all the organs, head, feathers, neck and shanks. Economics of production were evaluated in terms of feed cost/kg feed, feed cost/kg gain, cost of production/kg gain, and benefit/kg gain.

Statistical analysis

Data were analyzed as completely randomized block design using the General Linear Models procedure of SAS® (2000) for analysis of variance (ANOVA). The effects of the four dietary treatments (0, 50, 100, and 150 g SDWBM/kg diet) were tested on broiler performance at both starter and finisher phases, and overall. The four replicates per treatment were considered as blocks in order to increase the precision of the experiment. Differences between means were resolved by Duncan's multiple range test of the SAS® statistical package. Statistical significance was established when probability was less than 5% level of significance.

Results and Discussion

Table 2 shows the chemical composition of wheat offal, sun-dried wheat offal blood meal, local blood meal, and vat-dried blood meal. According to Jurgens (1978), in the National Research Council (NRC) nomenclature, forages and roughages are feeds containing averagely more than 180 g/kg crude fiber (CF) on a dry matter basis. Protein supplements contain 200 g/kg or more of crude protein (CP) and those with less than 200 g/kg crude protein are energy feeds. On application to the chemical analyses data from this study (Table 2), SDWBM could not be classified as forages or roughages because the CF content (calculated on dry matter basis) was 42 g/kg. In contrast, sun-dried wheat offal blood meal could be classified as a protein supplement (465 g/kg CP on dry matter basis). These results indicate the potentials of SDWBM as a protein supplement in livestock feeding and that adding blood to wheat offal substantially improved its nutrient status. For example, CP content of wheat offal improved from about 180 g/kg (Table 3) to 430 g/kg after addition of blood. The observed tendency for SDWBM was increase in CP and decrease in CF contents.

The crude protein content of SDWBM compared to local blood meal (LBM) and vat-dried blood meal (VBM) was a little more than half (Table 2). This is obviously due to the dilution effect of wheat offal on the protein content of blood because products derived from vegetable sources have lower protein content than those derived from animal sources. However, the crude protein content alone does not determine the quality of a protein supplement but the content, balance and digestibility of its amino acids (NRC, 1994; Morris, 2004). Blood meal is recognised for its very high leucine and low isoleucine contents, and this may lead to leucine-isoleucine antagonisms especially in diets where blood meal is the sole protein source, and used at high levels (D'Mello and Lewis, 1970; NRC, 1994). Based on the NRC (1994) amino acid requirements for broiler chickens (0-8 weeks of age) the optimum leucine-isoleucine ratio was calculated as 1.5. Comparison of the leucine-isoleucine ratios for SDWBM against LBM and VBM indicate a lower tendency for antagonisms. Specifically, the leucine-isoleucine ratio of SDWBM is 2.8 versus 8.6 for LBM, and 12.0 for VBM. Therefore, though LBM and VBM contain greater quantities of most of the essential amino acids than the vegetable carried blood meals (Table 2), the higher leucine-isoleucine ratios may lower their protein quality compared with SDWBM. However, VBM contained greater quantities of mineral elements than SDWBM, which was a poor source. Further, SDWBM contained adequate amount of all essential amino acids for growing broiler chickens when compared with the NRC (1994) total amino acid requirements for broiler chickens (0-8 weeks of age).

The energy content in terms of gross energy (GE) of SDWBM was slightly lower than that from wheat offal (WO) (Table2). This could be due to lower nitrogen free extract (NFE) and ether extract (EE) values obtained for SDWBM compared with wheat offal. Ether extract and NFE are lipid and carbohydrate sources in diets. Morris (2004) reported that dietary energy concentration increases due to an increase in the lipid content and carbohydrates are chief sources of dietary energy (NRC, 1994). The results from the chemical evaluation of SDWBM appear to suggest that the processing technique was adequate in providing a potentially high quality protein source.

The general performance of the broilers fed diets with graded levels of SDWBM at the starter phase (days 14-35), finisher phase (days 35-49), and overall (days 14-49) is shown in Table 3. Mortalities recorded were not significantly different between treatments ($P>0.05$). One mortality case recorded during the starter phase (for the control diet) was the only one for the overall experimental period (days 14-49). Post-mortem autopsy indicated no specific cause for death that can be attributable to the diet.

In general, the incremental levels of SDWBM did not improve (P>0.05) the performance of broiler chickens in terms of average final body weights (AFBW), average daily body weight gain (ADG) or feed conversion ratio (FCR). However, only in the finisher phase, birds fed the SDWBM diets consumed significantly less feed (P<0.05) compared with the control. This could be due to marginal decreases in the fibrousness of the finisher diet as the level of the SDWBM was increased (Table 1). It has been reported that increasing fiber content results in nutrient dilution (Onifade and Babatunde, 1998), lower bulk (Sundu *et al.*, 2005) and energy densities (Donkoh *et al.*, 1991) of the diets and thus, increase in feed consumption for adequate nutrients for satisfactory growth.

It is noteworthy and economically important that the general trend (starter and finisher phases, and overall) was that feed cost per kg (FC/kg), feed cost per kg live weight gain (FC/kg gain), and cost of production per kg live weight gain (CP/kg gain) declined when SDWBM totally replaced fishmeal or as the dietary concentration increased. In the starter phase the control was inferior (P<0.05) to 50, 100 and 150 g SDWBM/kg diets for feed cost per unit weight gain as well as the 100 g SDWBM/kg diet overall. The most expensive diets that contained varying amounts of SDWBM were cheaper than the control (starter - N53. 60 vs. 60.79; finisher - N53. 68 vs. 54.06; overall – N47.67 vs. 57.43). This is due to the wide disparity in cost between SDWBM and fishmeal. At the time of this study, the cost of SDWBM fed to broilers was very much lower than the cost of fishmeal (N34.41 vs. N250/kg, respectively). This is similar to the finding of Donkoh *et al.*, (2003) that a blend of blood and ground maize-cob diet was more economical than the control diet with fishmeal.

Overall, profit or benefit per bird was highest for birds on the 100 g SDWBM/kg diet, and higher profits were obtained for all the other SDWBM diets compared to the control. This may be attributed to heavier final body weights and/or lower FC/kg gain for all SDWBM diets versus control. Moreover, all the SDWBM diets were superior (P<0.05) in carcass yield compared with the control.

Conclusion

The study shows that sun-dried wheat offal blood meal is a high quality protein source. In addition, broiler chickens can satisfactorily utilize dietary SDWBM economically in fishmeal free diets. The 100 g SDWBM/kg diet is the dietary level of SDWBM that will optimize profit.

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Table 1. Gross and nutrient composition of experimental broiler starter and finisher diets

	SDWBM[1] (g/kg diet)							
	Starter				Finisher			
Ingredients	0	50	100	150	0	50	100	150
Maize	589.4	603	579.7	568.7	614.2	635.3	653.5	670.5
Soya bean meal	160	110	108.6	101.5	158	98	95	68.3
Groundnut cake	145	202	165	123.5	70	84	43.8	29.5
Fishmeal	30	0	0	0	0	0	0	0
SDWBM	0	50	100	150	0	50	100	150
Wheat offal	40.6	0	0	0	122.8	97.7	72.7	46.7
Palm oil	0	0	11.7	21.3	0	0	0	0
Bone meal	27	27	27	27	27	27	27	27
Premix[3]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Methionine	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Calculated composition[3]								
ME in kcal/kg	3000.52	3000.37	3000.19	3000.27	2950.2	2950.07	2950.98	2950.28
%CP	22.19	22.06	22.05	22.04	18.02	18.05	18.00	18.10
%CF	3.32	3.23	3.29	3.32	3.65	3.46	3.36	3.23
%Ca	1.26	1.08	1.08	1.08	1.07	1.06	1.06	1.06
%P	0.96	0.75	0.76	0.76	0.79	0.74	0.73	0.71
%Lysine	1.15	1.08	1.16	1.22	0.97	0.95	1.01	1.05
%Methionine	0.48	0.45	0.45	0.45	0.42	0.41	0.41	0.41
Cost of diet (₦/kg)	60.79	53.5	53.53	53.6	54.06	53.08	53.74	53.68

[1]SDWBM = sun-dried wheat offal blood meal.
[2]Provides per kg of diet: Vitamin A, 12,500 IU; Vitamin D, 2,500 IU; Vitamin E, 40 mg; Vitamin K, 2 mg; Vitamin B1, 3 mg; Vitamin B2, 5.5 mg; Niacin 55 mg; Calcium pantothenate, 11.5 mg; Vitamin B 6, 5mg; Vitamin B 12, 0.025 mg; Choline chloride, 500 mg; Folic acid, 1 mg; Biotin, 0.08 mg; Manganese, 120 mg; Iron, 100 mg; Zinc, 80 mg; Copper, 8.5 mg; Iodine, 1.5 mg; Cobalt, 0.3 mg; Selenium, 0.12 mg; Anti-oxidant, 120 mg.
[3]ME = metabolizable energy; CP = crude protein; CF = crude fiber; Ca = calcium; P = phosphorous (total).

Table 2. Chemical composition of wheat offal, sun-dried wheat offal blood meal, local blood meal, and vat-dried blood meal[1]

Composition (g/kg)	Wheat offal	SDWBM[2]	Local blood meal	Vat dried[3] blood meal
Dry Matter	896.3	921.5	882	920
GE, kJ/g	16.95	15.80	NA	21.80
Crude protein	176	428.2	756	771
Arginine	NA	18.2	33.5	33.4
Histidine	NA	16	41.3	50.6
Isoleucine	NA	13	10.3	9.1
Leucine	NA	36.8	89	109.9
Lysine	NA	22.8	57.8	70.4
Methionine	NA	6.6	10.5	9.9
Phenylalanine	NA	18.2	18.2	53.4
Threonine	NA	18.4	35.4	40.5
Valine	NA	13	31	70.5
Alanine	NA	12.6	24.6	NA
Aspartic acid	NA	35	75.9	NA
Cystine	NA	8.4	6.1	NA
Glutamic acid	NA	60.8	122.6	NA
Glycine	NA	12.9	35.7	45.9
Proline	NA	22.4	23.3	NA
Serine	NA	16.9	26.5	31.4
Tyrosine	NA	10.7	26.3	20.7
Tryptophan	NA	NA	NA	NA
Crude fiber	103.5	38.9	14.9	5.5
NDF[4]	501	325	NA	136
ADF[5]	164	70	NA	18
Hemicellulose	337	255	NA	118
Ether extract	27.8	12.5	42.8	16
NFE	544.7	361.9	23.8	NA
Ash	44.3	80	44.5	NA
Ca, mg/kg	NA	0.16	NA	3700
P, mg/kg	NA	6.3	NA	2700
Mg, mg/kg	NA	38	NA	1100
Fe, mg/kg	NA	25.4	NA	1,922.00
Mn, mg/kg	NA	2.26	NA	6.0
Cu, mg/kg	NA	2.35	NA	11
Zn, mg/kg	NA	0	NA	38

[1]Values are means of duplicate samples; NA = Not analysed.

[2]SDWBM = sun-dried wheat offal blood meal.

[3]Values obtained from from NRC (1994) and NRC (1998).

[4]NDF = neutral detergent fiber.

[5]ADF = neutral detergent fiber.

Table 3. Live performance (14-35, 35-49, and 14-49 d) of broiler chickens fed diets with graded levels of sun-dried wheat offal blood meal

	Starter (day 14-35)					Finisher (day 35-49)					Overall (day 14-49)				
	Levels of SDWBM[1] (g/kg diet)					Levels of SDWBM (g/kg diet)					Levels of SDWBM (g/kg diet)				
Parameters	0	50	100	150	SE[2]	0	50	100	150	SE	0	50	100	150	SE
AIB (g/bird)[3]	227.25	217.35	212.3	226		948.18	906.7	959.85	975.45		227.25	217.35	212.3	226	
AFBW (g/bird)[4]	948.18	906.7	959.85	975.45	9.51	1639.16	1623.6	1679.2	1594.25	16.80	1639.16	1623.6	1679.2	1594.25	16.80
ADG (g/bird)[5]	34.33	32.83	35.6	35.89	0.44	49.36	51.21	51.38	44.2	0.90	40.34	40.18	41.91	39.22	0.45
ADFI (g/bird)[6]	81.2	78.65	78	77.2	0.50	163.808^{a}	151.38^{b}	150.85^{b}	147.40^{b}	1.24	110.82	107.74	107.15	105.26	0.74
FCR[7]	2.37	2.41	2.2	2.16	0.03	3.32	2.96	2.95	3.35	0.06	2.75	2.68	2.56	2.7	0.03
Carcass yield (%)	-	-	-	-		-	-	-	-		62.01^{b}	66.12^{a}	66.32^{a}	67.94^{a}	0.39
Mortality (no.)	1	0	0	0		0	0	0	0		1	0	0	0	
FC/kg (₦)[8]	60.79	53.5	53.53	53.6		54.06	53.08	53.74	53.68		57.43	53.29	53.64	47.67	
FC/kg gain (₦)	143.88^{a}	128.87^{b}	117.53^{b}	115.85^{b}	1.82	179.75	157.18	158.51	180.02	2.69	157.83^{a}	142.97^{ab}	137.43^{b}	144.69^{ab}	1.63
CP/kg gain[9] (₦)	-	-	-	-		-	-	-	-		341.83^{a}	326.97^{ab}	321.43^{b}	328.69^{ab}	1.63
Benefit/kg[10]gain (₦)	-	-	-	-		-	-	-	-		58.17^{b}	73.03^{ab}	78.57^{a}	71.31^{ab}	1.63

^{ab}Means on the same row with the same superscripts are not significantly different (P>0.05)

[1]SDWBM = sun-dried wheat offal blood meal.

[2]SE= standard error of means

[3]AIB = average initial body weight

[4]AFBW = average final body weight

[5]ADG = average daily gain

[6]ADFI = average daily feed intake

[7]FCR = feed conversion ratio (g feed/g gain)

[8]FC = feed cost (₦=Naira)

[9]CP = cost of production/kg gain(₦)= FC/kg gain + Total common costs for 49 days (brooded chicks; drugs; equipment; wood shavings; transportation; poultry house repair and maintainnance; labour and miscellaneous-10% of total common costs)

[10] Benefit/kg gain (₦) = price of broiler/kg (₦) when study was conducted (i.e. ₦400.00) minus cost of production/kg gain (₦); 1 US$ = N140.

Role of selected pathogens in declining crop production in Nigeria

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Abstract
The effects of simultaneous infections of *Meloidogyne incognita* and *cowpea mosaic virus* on cowpea were investigated in greenhouse and field studies. *Cowpea mosaic virus* was introduced into cowpea test plants by mechanical inoculation of homogenized crude extracts from infected leaves while freshly hatched eggs of *M. incognita* in water suspension were introduced around the base of test plants. In greenhouse trials simultaneous inoculation of test plants with both the nematode and the viruses resulted in more severe symptoms, and consequently higher soil population density of nematodes and correspondingly lower grain yield when compared with inoculations with each pathogen alone, with nematodes exerting a more devastating effects than the virus. A similar trend was observed in yield of cowpea for cultivars of cowpea susceptible to both pathogens or to nematode alone, under field conditions. There was also a significant interaction (P = 0.05) between inoculation treatments and cultivars. The results of this study suggest that breeding for combined resistance to both pathogens in cowpea should be given great attention.

Introduction

Plant–parasitic nematodes are considered as serious pests of many commercially economic crops. Although nematode problems occur worldwide, the most evident damage occurs in warm areas where higher temperatures and longer growing seasons induce more nematode generations and consequently increased populations. Based on extensive survey data (Sasser and Freckman, 1987; Koenning *et al*., 1999), it has been estimated that overall yield loss averages 12.3% annually; this figure approaches 20% for some crops. In monetary terms the world – wide figure certainly exceeds $US100 billion annually (Siddiqui *et al.*, 2004).

Impacts of interactions between plant stresses are not uncommon. Nematode interactions with fungi, bacteria and viruses have been documented to synergistically elicit certain diseases in some species (Sipes *et al*., 2002). For example, *Meloidogyne* and *Fusarium* together can exacerbrate wilts of cotton and tobacco (Starr *et al*., 1989; Lamondia, 1992; Devay *et al*., 1997), and *Criconemella* and *Pseudomonas syringae* pv. *syringae* cause short life of peach trees (Nyczpir, 1990) while simultaneous or successive inoculation of *soybean mosaic potyvirus* and *Meloidogyne incognita* was reported to result in severe symptoms as well as reduced yield of soybean (Iheukwumere *et al*., 1996) *Meloidogyne incognita* race 2 is the major root – knot nematode in Southwestern Nigeria (Amosu, 1974). In preliminary survey, mixed infection of root knot and cowpea mosaic virus were frequently observed in major cowpea growing areas in Southwestern Nigeria (Adekunle unpublished). This study was therefore designed to investigate the effects of *cowpea mosaic virus* on root knot infection in four cultivars of cowpea widely cultivated in Nigeria.

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Materials and Methods

Cultures and inoculum

Cowpea leaves infected with a strain of cowpea mosaic virus (CMV) (SB isolate) which is widely found in cowpea growing areas of Nigeria were obtained from Virology Unit of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The most widely occurring race of root – knot nematode (RKN) in Western Nigeria, *Meloidogyne incognita* race 2, was obtained from roots of *Celosia argentea L.*, a highly susceptible host plant. The identity was confirmed using perineal patterns as described by Eisenback *et al*. (1981). The nematode culture was multiplied by inoculating roots of 2 – week – old celosia plants cv. TLV8, from which eggs were extracted after 9 weeks (Hussey and Barker, 1973).

Greenhouse Study

To study interaction between cowpea mosaic virus and *M. incognita* race 2, one hundred and twenty eight 100–mm diameter plastic pots, each containing 2.0 kg steam sterilized topsoil were used. The four cowpea cultivars used in this study were: Ife Brown (susceptible to RKN and CMV, IFOB/01/94B (susceptible to RKN, but resistant to CMV), IT81D – 975 (resistant to RKN but susceptible to CMV) and IT86D – 721 (resistant to RKN but susceptible to CMV). Four seeds of each cultivar were sown in plastic pots containing sterilized soil. Seedlings were later thinned to one per pot, seven days after emergence. Treatments applied to potted plants 11days after germination were:

(i) mechanical inoculation of primary leaves with crude CMV sap
(ii) inoculation of plant roots with 8,000 eggs of RKN per plant
(iii) inoculation of plant roots with 12,000 eggs of RKN per plant
(iv) inoculation of plant roots with 16,000 eggs of RKN per plant
(v) simultaneous inoculation with crude CMV sap and 8,000 eggs of RKN per plant
(vi) simultaneous inoculation with crude CMV sap and 12,000 eggs of RKN per plant.
(vii) simultaneous inoculation with crude CMV sap and 16,000 eggs of RKN per plant
(viii) uninoculated control plants.

Cowpea leaves infected with (CMV) (SB isolate) were homogenized in 0.01M pH 7.0 phosphate buffer in the ratio of 1:10 (w/v) and used in mechanically inoculating carborundum (600 mesh) – dusted leaves of 2wk – old cowpea in the greenhouse (28 ± 3^{o}C), using standard procedures (Walkey, 1991). Freshly extracted eggs of RKN were placed in depressions near roots of cowpea seedlings and covered with soil. The levels of nematode inoculation are those that would normally initiate root – knot infection in a susceptible plant. The pots were arranged on greenhouse benches in Randomized Complete Block Design at 28 ± 3^{o}C. Plots were spaced 45cm × 45cm and were watered every other day. The plants were inspected at intervals of three days for symptom development. Mature pods were harvested at weekly intervals from six weeks after planting and this continued till all the pods were harvested. The pods were threshed and the grains were weighed. The experiment was terminated about 65 days after planting. At termination of experiment, cowpea plants in each pot were carefully uprooted and the roots were rated for galling using rating scale described by Taylor and Sasser (1978), where 0 = No galls

or egg masses, 1 = 1 – 2 galls or egg masses, 2 = 3 – 10 galls or eggs masses, 3 = 11 – 30 galls or egg masses, 4 = 31 – 100 galls or egg masses and 5 = More than 100 galls or egg masses. To estimate nematode population, 200 ml properly mixed soil samples were collected from each pot; nematodes were extracted from soil using the method of Whitehead and Hemming (1965) and were counted under a stereomicroscope (WILD HEERBRUGG,United Kingdom) at ×250.

Field Study

An experimental site was selected at the Teaching and Research farm of Obafemi Awolowo University, Ile-Ife in the tropical rainforest zone of Nigeria ($7^{o}28^{1}$N, $4^{o}33^{1}$E at 224 m above sea level). The piece of land was naturally free of plant parasitic nematodes. In the late raining season the site was ploughed and harrowed and seeds of four cultivars of cowpea planted at a spacing of 50 cm x 60 cm. The experimental design was a split plot consisting of four blocks (78m × 3.6m each), each of which was divided into four main plots each assigned to one of four cultivars of cowpea used in the greenhouse study. Each main plot was further divided into eight subplots (2m × 3.6m each) in which the following treatments were randomized;

(i) mechanical inoculation of primary leaves with crude CMV sap
(ii) inoculation of plant roots with 8,000 eggs of RKN per plant
(iii) inoculation of plant roots with 12,000 eggs of RKN
(iv) inoculation of plant roots with 16,000 eggs per plant
(v) simultaneous inoculation with crude CMV sap and 8,000 eggs of RKN per plant.
(vi) simultaneous inoculation with crude CMV sap and 12,000 eggs of RKN per plant
(vii) simultaneous inoculation with crude CMV sap and 16,000 eggs of RKN per plant
(viii) uninoculated control plants.

All treatments were administered in the field when cowpea plants, were eleven days old. Mechanical inoculation of cowpea leaves with CMV and inoculation of roots of cowpea with eggs of *M. incognita* were as described. There were six rows per plot. The cowpea plants were rain-fed. Insect pests were controlled by spraying the cowpea plants uniformly with monocrotophos formulated as Nuvacron 40 WSC (Ceiber Geigy, United Kingdom) at the rate of 0.2 kg a.i / ha weekly, from three to six weeks after planting. Mature pods were harvested at weekly intervals from each subplot from six weeks after planting and this continued till and the pods were harvested sixty five days after planting. For each subplot, pods were harvested from the four middle rows, while the first and sixth rows were not harvested to eliminate border effects. Pods were threshed and the grains were weighed.

All data were subjected to analysis of variance test (ANOVA) and treatment means were separated using The Least Significant Difference (LSD) (Gomez and Gomez, 1984)

Results

Greenhouse Study

Inoculation of cowpea with *cowpea mosaic virus* and variable *M. incognita* inoculum levels had significant effects on soil nematode population at harvest (Table 1). Nematode densities were higher in nematode – susceptible Ife

Brown and IFOB/01/94B cultivars compared to nematode resistant cultivars IT86D – 721 and IT81D – 975. In Ife Brown cultivar, a significantly higher number of nematodes were recovered from soil when virus and nematodes were simultaneously inoculated than when nematodes alone were inoculated; while in IFOB/01/94B a significantly lower number of nematodes were found in soil when virus and nematodes were inoculated together than in inoculation of nematodes alone. In the nematode – resistant IT86D–721, significantly higher nematode number was found in mixed infection than in nematode alone inoculation. The effect of single pathogen and mixed infection on root gall index of cowpea was not significant for all the four cultivars of cowpea (Table 2). Simultaneous inoculation of cowpea with virus and nematodes resulted in more severe viral symptoms and fewer pods and consequently lower grain weight per plant than in inoculation with nematodes alone (Table 3). This was more pronounced in the nematode – susceptible Ife Brown and IFOB/01/94B cultivars than in nematode resistant IT86D–721 and IT81D – 975. In all four cultivars of cowpea grain weight per plant was significantly higher in uninoculated plants than inoculated plants.

Field Study

In Table 4 is presented effects of interaction between *M. incognita* and *cowpea mosaic virus* on grain weight (tons/ha). Simultaneous inoculation of virus with nematode resulted in significantly lower grain weight than nematode inoculation alone in nematode susceptible Ife Brown and IFOB/01/94B cultivars of cowpea (Table 4). However, there was no significant difference in grain yield in virus + 8,000 eggs and virus + 12,000 eggs of nematodes for both cowpea cultivars. In nematode resistant IT86D–721 and IT81D–975 cultivars of cowpea, there was no significant difference in grain yield among treatments. The grain yield recorded in uninoculated plants was significantly higher than that recorded in each of the inoculated plants (Table 4). Similarly, more severe viral symptoms were observed with simultaneous inoculation of nematode and virus in nematode–susceptible cultivars of cowpea than in nematode – resistant cultivars.

Discussion

Under greenhouse conditions, simultaneous inoculation of cowpea plants with *cowpea mosaic virus* and *M. incognita* inoculum resulted in higher soil population density of juveniles of the nematode cowpea cultivar susceptible to both virus and nematode while in the cultivar susceptible to nematode but resistant to the virus the contrary was noted. In the cultivars resistant to nematode but susceptible to the virus, a higher nematode population density was recorded in mixed inoculation of virus and nematode than nematode alone inoculation. Also simultaneous inoculation of virus and nematode resulted in lower grain yield of cowpea than inoculation of single pathogen. Similar trend was observed in yield of cowpea for Ife Brown and IFOB/01/94B cultivars under field conditions. This indicates that simultaneous inoculation of both the pathogens had a more devastating effect on cowpea than did single pathogen inoculation. This was especially so for cultivar of cowpea that was susceptible to both virus and nematode or susceptible to nematode but resistant to the virus. This also suggests that in the current study the nematode had more negative effect on cowpea than the virus. Our findings agree with those of Iheukwumere *et al*. (1996) who reported that in all four soybean cultivars they tested, simultaneous or successive inoculation with both *soybean mosaic potyvirus* and *M. incognita* resulted in more severe symptoms

and, therefore, reduced yield and yield components when compared with inoculations with each pathogen alone. They further noted that this was more variable under field than greenhouse conditions.

Increased pathogenicity of *M. incognita* as observed in this study, when in multi – pathogen infection with *tobacco ring spot virus* has also been demonstrated for soybean (Rhyder and Crittenden, 1962). This observation has similarly been reported in maize and tobacco when they were infected by species of *Meloidogyne* and a *mosaic virus* (Bird, 1969; Khurana *et al*., 1970). Comparative grain yield were recorded in the two nematode resistant cultivars susceptible to the virus for both single pathogen and multi – pathogen infection. This implies, that multi – pathogen infection did not have significant effect in cultivars that are non – host of nematodes in comparison to single pathogen infection. Similar findings were reported by Mclaughlin *et al*. (1993) who evaluated the responses of selected clones of white clover (*Trifolium repens*) to simultaneous infection by the southern root – knot nematode (*M. incognita*) and *peanut stunt virus* (PSV). They noted that reductions in root growth of plants infected with both *M. incognita* and PSV were greater than in plants infected by either pathogen alone. In related studies Sipes *et al*. (2002) who investigated interactions between *Rotylenchulus reniformis* and *Pineapple mealybug wilt associated virus* – 1 (PMWaV-1) pineapple reported that under greenhouse conditions, no effect of PMWaV-1 on pineapple growth or nematode was observed. In the field however, nematodes reduced the average fruit weight, whereas PMWaV-1 infection did not. Also, they noted that the fewest fruits were produced in plots with PMWaV-1 infected plants that were nematode infected. Our results showed a greater effect of *M. incognita* on cowpea than CMV infection. This confirmed the findings of Iheukwumere *et al*. (1996) on soybean infected with *soybean mosaic potyvirus* and *M. incognita*. In the current study, there was a significant interaction between inoculation treatments and cowpea. This suggests that a greater attention should be placed on breeding for combined resistance to both the pathogens in cowpeas, rather than focusing on breading for resistance to each of nematode and virus.

Conclusion

Simultaneous infections of *Meloidogyne incognita* and *cowpea mosaic virus* on cowpea in greenhouse and field trials resulted in more severe symptoms and lower grain yield in comparison with infection with each pathogen alone, with the nematode exerting more devastating effects than the virus.

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Table 1 Effects of interaction between *Meloidogyne incognita* and *cowpea mosaic virus* on soil nematode population in potted plants (Number/200ml soil)

Treatment	**Cowpea cultivar**			
	Ife Brown (x10)	IFOB/01/94B (x10)	IT86D – 721	IT81D – 975
Virus only	-	-	-	-
8,000 eggs of nematode	206.0	234.0	9.0	4.0
12,000 eggs of nematode	229.0	241.0	12.0	6.0
16,000 eggs of nematode	283.0	289.0	10.0	11.0
Virus + 8,000 eggs of nematode	213.0	243.0	15.0	7.0
Virus + 12,000 eggs of nematode	242.0	232.0	11.0	11.0
Virus + 16,000 eggs of nematode	297.0	283.0	17.0	12.0
Uninoculated control	-	-	-	-
L.S.D. (P = 0.05)	4.0	3.0	1.3	1.1

Each value is a mean of four replicates.

Table 2 Effects of interaction between *Meloidogyne incognita* and *cowpea mosaic virus* on root galling of cowpea

Treatment	**Cowpea cultivar** **Gall index**			
	Ife Brown	IFOB/01/94B	IT86D – 721	IT81D – 975
Virus alone	1.0	1.0	1.0	1.0
8,000 eggs of nematode	2.1	2.2	1.1	1.0
12,000 eggs of nematode	2.2	2.2	1.1	1.0
16,000 eggs of nematode	2.3	2.2	1.0	1.0
Virus + 8,000 eggs of nematode	2.1	2.2	1.0	1.0
Virus + 12,000 eggs of nematode	2.3	2.2	1.0	1.1
Virus + 16,000 eggs of nematode	2.3	2.3	1.1	1.2
Uninoculated control	1.0	1.0	1.0	1.0
L.S.D. (P = 0.05)	0.15	0.21	0.14	0.10

Each value is a mean of four replicates of /n+1 transformed data

Table 3 Effects of interaction between *Meloidogyne incognita* and cowpea mosaic virus on grain weight of cowpea/plant (g) under greenhouse conditions

Treatment	**Cowpea cultivar**			
	Ife Brown	IFOB/01/94B	IT86D – 721	IT81D – 975
Virus alone	3.7	4.1	4.5	4.2
8,000 eggs of nematode	3.1	2.8	3.8	3.9
12,000 eggs of nematode	2.9	2.7	3.9	4.1
16,000 eggs of nematode	2.2	1.6	3.7	4.1
Virus + 8,000 eggs of nematode	1.8	2.6	2.9	3.9
Virus + 12,000 eggs of nematode	1.1	2.6	3.1	3.6
Virus + 16,000 eggs of nematode	0.6	2.2	3.2	4.1
Uninoculated control	4.5	4.8	5.4	5.6
L.S.D. (P = 0.05)	0.26	0.32	0.43	0.43

Each value is a mean of four replicates

Table 4 Effects of Interaction between *Meloidogyne incognita* and cowpea mosaic virus on grain weight (tons/ha) under field conditions.

Treatment	Cowpea cultivar Grain weight (tons / ha)			
	Ife Brown	IFOB/01/94B	IT86D – 721	IT81D – 975
Virus alone	1.0	1.1	1.2	1.2
8,000 eggs of nematode	0.8	1.0	1.1	1.3
12,000 eggs of nematode	0.8	0.9	1.0	1.2
16,000 eggs of nematode	0.6	0.7	1.1	1.0
Virus + 8,000 eggs of nematode	0.3	0.5	1.0	1.1
Virus + 12,000 eggs of nematode	0.3	0.5	0.9	1.2
Virus + 16,000 eggs of nematode	0.3	0.2	1.1	1.0
Uninoculated control	1.6	1.4	1.8	1.7
L.S.D. (P = 0.05)	0.29	0.30	0.30	0.30

Each value is a mean of four replicates

Hot water treatment for the control of some post-harvest rot pathogens of sweet potato (*Ipomea batatas* l.)

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Abstract

Botryodiplodia theobromae, *Fusarium oxysporum*, *Penicillium* sp., *Aspergillus oryzae,* and *Trichoderma viride* associated with post harvest storage rot of red and white types of sweet potatoes (*Ipomea batatas*) were isolated from rot infected tubers. The incidence of three of them namely, *Botryodiplodia theobromae, Aspergillus oryzae* and *Trichoderma viride* together with the effect of heat application as a form of control were investigated in this study. After ten days of inoculation, *Botryodiplodia theobromae* was found to be the most aggressive and virulent, followed by *Trichoderma viride* while *Aspergillus oryzae* was found to be moderately pathogenic when aseptically inoculated into two healthy sweet potato root-tubers studied. The mycelial dry weight of the test pathogens increased gradually with incubation period in stationary liquid media used (i.e. Starch-Yeast-Extract and Carboxy-Methyl-Cellulose). The white sweet potato was found to be more resistant to infection than the red sweet potato. Post-harvest treatment of these tubers at 60ºC for 25minutes was the most effective and it significantly reduced natural fungal population on the root-tuber surfaces, caused no surface injuries to the root-tubers and did not affect the taste or quality parameters.

Keywords: Heat, Post-harvest, Pathogenic Control, Inoculation, Rot disease.

Introduction

Production of sweet potato is done in all states of the country, particularly in the South Western and Eastern part of Nigeria (Tewe *et al*., 2003). Potato is an important crop which ranked fourth in the world's food production for human nutrition (Rowe, 1993). In South Africa, potatoes have a higher status, being the third most impotant food source after maize and wheat (Anonymous, 2002). Potato(*Solanum tuberosum* L.) tubers contain about 18% carbohydrates, 2.2% protein, 0.1% of fat, 0.43% potassium, 0.06% phosphorus, 0.04% chlorine, 0.03% sulphur, 0.03% magnesium, 0.02% calcium, 0.005% sodium and 0.001% iron, as well as the vitamins which are ascorbic acid, niacin, retinol, riboflavin and thiamine (Truter, 2005). Sweet potato *(Ipomea batatas)* on the other hand contains Amylose, Amylopectin, vitamin A, C, B_1 (thiamin), Tannins Phytin, Oxalate, Ash, Ether Extract and crude fibre (Tewe *et al.,* 2003). Most potatoes are used for human consumption, although approximately 50% of the European stock is utilised as fodder, with as much as 25% of the ware potatoes being diverted to cattle feed because of defects (Hooker, 1983; Truter, 2005). However, in some countries especially in Africa, it has a higher status being the third most important food source after maize and wheat (Anonymous, 2002).

Despite being rich in various nutrients, potatoes are ill-adapted for an exclusive diet owing to the low protein content and the fact that they contain toxic glycoalkaloids (Van Rensburg, 2003). Studies have shown that extracts

of healthy potatoes could be teratogenic due to the presence of solanine (Jelinek *et al*., 1976). The levels of solanine are usually increased when these tubers are attacked by pathogens especially by non-compatible fungi pathogens such as *Phytophthora infestans* (Mont) de Bary (Kadis *et al*., 1972). Also of significance is the susceptibility of potato tubers to infection by mycotoxigenic fungi and the fungal organisms such as *Fusarium* species which are associated with dry rot disease of potato tubers are capable of producing mycotoxins (Marasas *et al*., 1993). *Fusarium oxysporum* is known to be a major cause of dry and stem-end rot disease of potato tubers and it has been reported to produce fumonisin (Theron, 1999; Abbas *et al*., 1995; Seo *et al*., 1996).

The African farmers are faced with several constraints in the production of food and cash crops. Some of these constraints are poor soils, poor farm practices, use of local varieties, land tenure and damages by diseases and pests (FAO, 2000). The potatoes like many other crops are attacked by various pathogens which cause diseases in them. Such pathogens are fungi, bacteria and viruses. However, non-pathogenic diseases called disorderliness could result from the effects of physical factors such as deficiencies, excesses and improper balance of micro and macro elements, drought, extreme weather conditions (excessive moisture and temperature), improper light condition etc (Manners, 1993). The greatest of these constraints is that of post-harvest spoilage of farm produce. Out of the several tons harvested, just a fraction is utilized while most of the amount is lost to post harvest diseases especially rot diseases (Salami and Popoola, 2007). These pathogens cause great losses and reduction in the value of these crops but with a good system of control, this can be eradicated. The fungi associated with post –harvest sweet potato rot are *Caratocystis fimbriata* (black rot), *Monilochaetes infuscan* (Scurf), *Botryodiplodia theobromae* (Java black rot), *Macrophomina phaseoli* (charcoal rot), *Fusarium oxysporum* (surface rot), *Fusarium Solani* (Root rot), *Diaporthe batatstis* (Dry rot), *Rhizopus stolonifer* and *Rhizopus oryzae* (Rhizopus soft rot) (Rowe, 1993; Theron, 1999; Cilliers, 2003). These organisms have been found to have great effect on the storage and management of potatoes. Published information shows that many of the developing world's poorest producers and undernourished households are highly dependent on root-tubers. These form major, if not the principal, source of their food, nutrition and cash income (Alexandratos, 1995; Anonymous, 2004). Hence, this study sets out to investigate the control effect of heat application on the incidence of some post-harvest rot pathogens of sweet potato tubers.

Materials and Methods

Survey and Collection of Sample

Both healthy and diseased samples were collected from local markets in Ibadan, Southwestern part of Nigeria. All infected tubers were inspected for rotted areas and were stored in clean polyethylene bags. All samples were brought to the Laboratory for further analysis. Diseased samples were surface sterilized with 1% sodium hypochlorite solution for 1 minute, rinsed in five successive changes of sterile distilled water and then blotted dry. These tubers were cut aseptically from healthy region to necrotic region. Discs of about 4mm diameter were made from the advancing edge of the rot as well as from the middle of lesions and plated on potato PDA and MEA. These were incubated at room temperature i.e. 28$\pm$2°C for the growth of organisms. The organisms were to grow for 96 hours after which they were sub-cultured in order to obtain pure colonies of their cultures. The pure fungi cultures were placed on slants in MacCartney bottles and stored in a refrigerator for further use. Fungi species

were identified with the aid of a compound microscope, by reference to compendium of soil fungi (Domsch *et al*., 1980; Barnett and Hunter, 1972), in comparison with identified species of the same genera in the microbial collection of the Department of Botany and Microbiology, University of Ibadan. All fungi isolates were tested for their ability to induce rot in healthy tubers so as to establish the Koch's postulate. The healthy tuber surfaces were swabbed with cotton wool, soaked in 1% sodium hypochlorite and washed thrice with sterilized tap water. Holes were dug using sterilized 5mm cork borer and the plug was pulled out, 3mm mycelial discs of the test pathogen were placed at the bottom of each hole. Portions of the plugs were cut off to compensate for mycelial disc thickness before replacing them into the holes and the wound sealed with vaseline to prevent extraneous infection. The controls consisted of sterile PDA discs of 3mm wells made on healthy tubers. The tubers were incubated in desiccators for 2,4,6,8 and 10 days respectively at 28^0C $\pm 2^0$C. All treated tubers were replicated. After a period of 10 days, the tubers were cut across by means of sterilized scalpel along the plane of inoculation and the percentage rot was assessed using this formula:

$$\frac{\text{Rotted surface Area} \times 100}{\text{Total surface Area}}$$

Culture Filtrate (In-Vitro)

Five-day-old cultures of the fungal isolates of *Botryodiplodia theobromaeI,*, *Aspergillus oryzae* and *Trichoderma viride* grown on PDA were used as inoculum for the study on enzyme synthesis. The starch – yeast – extract (SYE) medium of Barnett and Fergus (1971), was used for enzyme synthesis. It contained: Soluble starch (BDH), 5g; Yeast extract (Difco), 2g; K_2HPO_4, 1g; $MgSO_4.7H_2O$, 0.5g; distilled water, 1 litre (pH 6.8) for amylase synthesis and Carboxymethyl cellulose (CMC), 10g; K_2HPO_4, 1g; $MgSO_4..7H_2O$, 0.5g; distilled water, 1 litre (pH 6.8) for cellulase synthesis. The medium was dispensed into 150ml conical flasks in 30ml amounts per flasks and autoclaved for 15 mins at 121 ^{0}C (to sterilize). After cooling, each flask was subsequently inoculated with one disc (5mm diameter) of agar and mycelium of test organism obtained by using a sterilized cork borer. Non – inoculated flasks of the SYE and CMC basal media served as the control. Incubation was done at 30 ^{0}C for 2,4,6,8 and 10 days intervals. Mycelia mats observed at each interval were filtered by section through filtered papers previously dried to constant weight and filtrates were collected for enzyme assay. Both the filter paper and mycelia were dried at 80^0C and the weight of the mycelia was determined. Each harvest is replicated thrice and the average weight of mycelia for each was calculated. All the experiments were factorial and statistically analysed.

Determination of the thermal level

Hot Water Treatment:

The root tubers were dipped in 25 litre containers containing 20 litres of water at 28 °C, 60 °C and 100 °C respectively for 25 minutes. The water was changed several times to prevent inoculum build up. These root-tubers were subsequently and randomly divided into two sets, one set was air dried and stored in well aerated storage sheds with temperature ranging between 12°C to 18°C for 14 days, while the second set were dehydrated, boxed and sun dried for 14 days. These treatments were replicated thrice.

Results

Five fungal isolates were cultured from the rotted white and red sweet potatoes (Table 1). These are *Botryodiplodia theobromae*, *Fusarium oxysporum*, *Trichodema viride*, *Aspergillus oryzae,* and *Penicillium* specie (Table1). All fungi isolated from rotted sweet potatoes were found pathogenic at varying degrees to healthy sweet potatoes when re- inoculated into them, although *Botryodiplodia theobromae* was absent from the white sweet potato specie collected from the local market while *Penicillium* sp; *Trichodema viride* and *Aspergillus oryzae* were absent from the red sweet potato variety collected from the local market. *Botryodiplodia theobromae* was the most aggressive and virulent followed by *Trichodema viride, Fusarium oxysporum*. *Penicillium* sp, and *Aspergillus oryzae* (Fig.1) were moderately pathogenic. The white sweet potato was found to be more resistant to infection than the red sweet potato (Fig.1& Plates 1-6).

Table 1: Incidence of Pathogenic Infection on Sweet Potatoes.

Fungi	White Sweet potato	Red Sweet potato
Fusarium oxysporum	+	+
Botryodiplodia theobromae	-	+
Penicillium spp	+	-
Trichoderma viride	+	-
Aspergillus oryzae	+	-

Key + = Present
- = Absent

1: Red sweet potato inoculated with *Trichoderma viride*

2: Red sweet potato inoculated with *Aspergillus oryzae*

3: Red sweet potato inoculated with *Botryodiplodia theobromae*

4:White sweet potato inoculated with *Trichoderma viride*

5: White sweet potato inoculated with *Aspergillus oryzae*

6: White sweet potato inoculated with *Botryodiplodia theobromae*

Levels of response of the healthy red and white sweet potatoes used were found different to test pathogens isolated from rotted potato tubers when inoculated. The white sweet potato was found to be more resistant to infection than the red sweet potato (Fig.1).

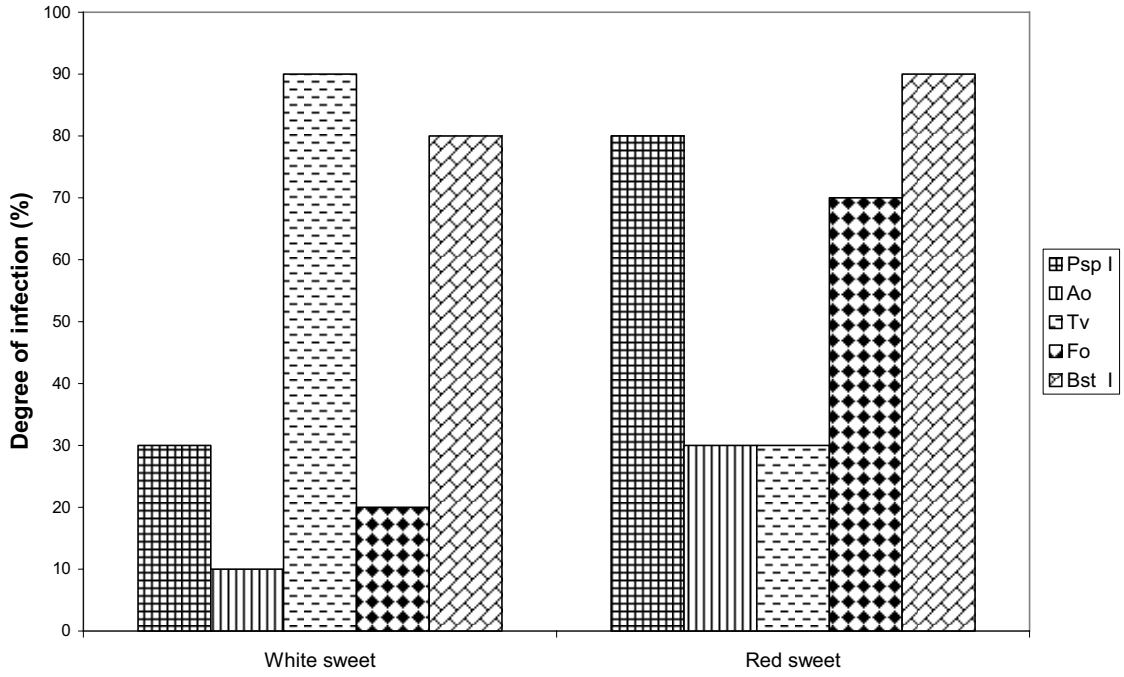

Fig.1: **Level of Susceptibility of Sweet potatoes to Different Test Pathogens**

Note:

Fo = Fusarium oxysporum,, BstI = Botryodiplodia theobromae str.I, PspI=Penicillium sp I,, Tv= Trichodema viride,, Ao = Aspergillus oryzae.

Mycelial Dry Weight of the Test Pathogens in culture filtrate (In-vitro).

The mycelial dry weight of the test pathogens increased gradually with incubation period. *Botryodiplodia theobromae* had the highest mycelial dry weights followed by *Aspergillus oryzae,*and *Trichoderma viride* in Starct-Yeast-Extract basal medium (Fig.2) while in Carboxymethyl Cellulose medium, mycelia dry weight of *Trichoderma viride* was the highest followed by that of *Botryodiplodia theobromae*, *Aspergillus oryzae* (Fig.3).

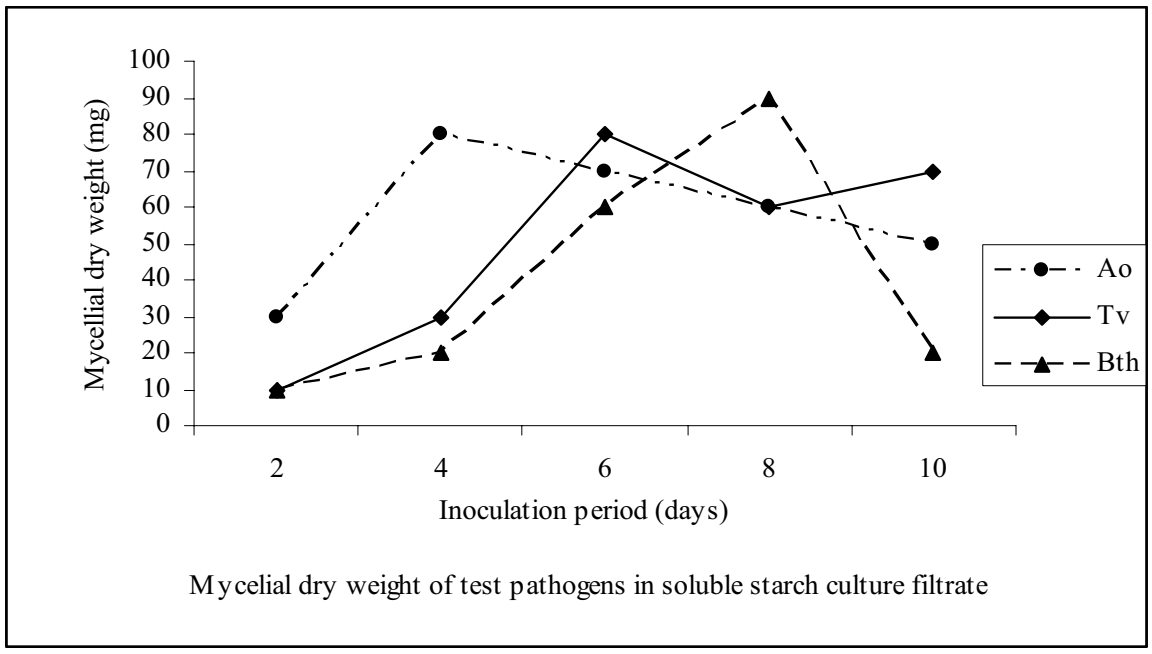

Fig.2: **Mycelial Dry Weight of the Test Pathogens in soluble starch culture filtrate (In-vitro)**.

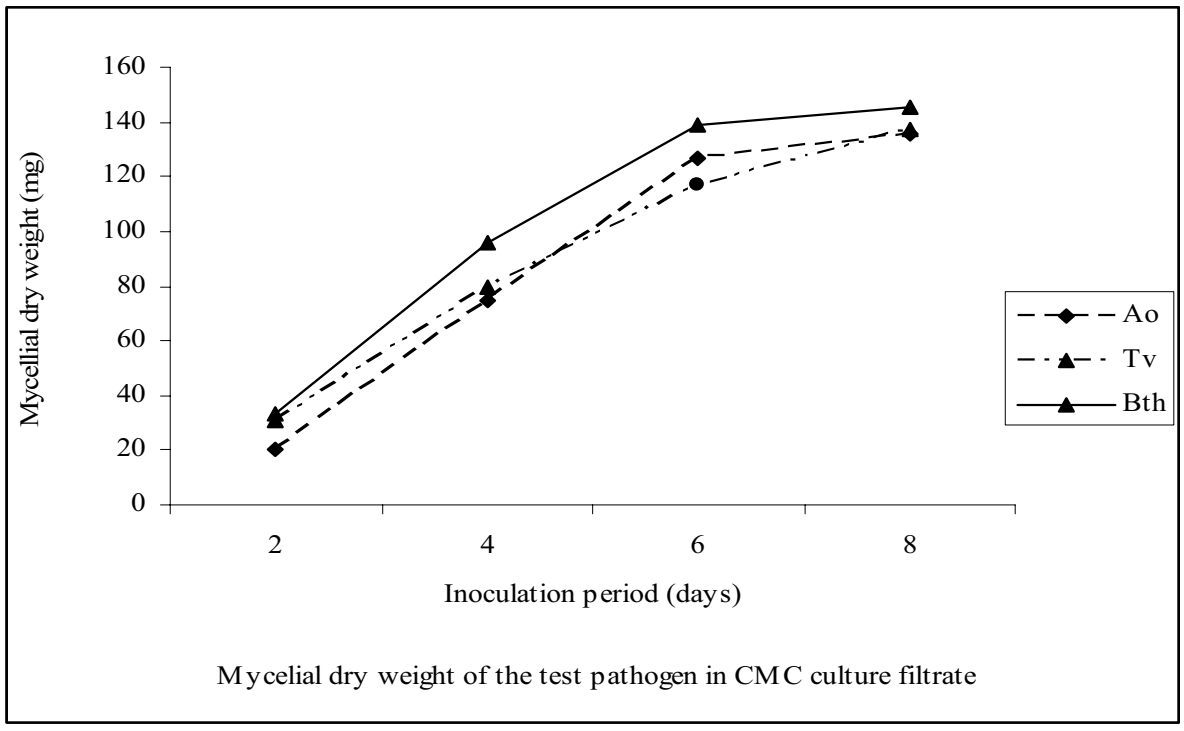

Fig.3: **Mycelial Dry Weight of the Test Pathogens in** Carboxymethyl Cellulose **culture filtrate (In-vitro)**.

Effects of Hot water treatment on root-tubers

At 28 ºC, results showed that 16%, 44%, 84% and 100% of sweet potato rotted in 8, 10, 12, and 14 days, respectively (Fig. 4), while at 60 ºC, less than 1% of sweet potato tubers were found rotted within the same period (fig. 3). At 100 ºC, all the sweet potato root-tubers rotted before the first week (Fig. 4). However, the second set of the root-tubers treated with hot water and sun dried, (Fig. 4) were found 4%, 16% and 36% rotted in 10, 12, and 14 days respectively (Fig.4).

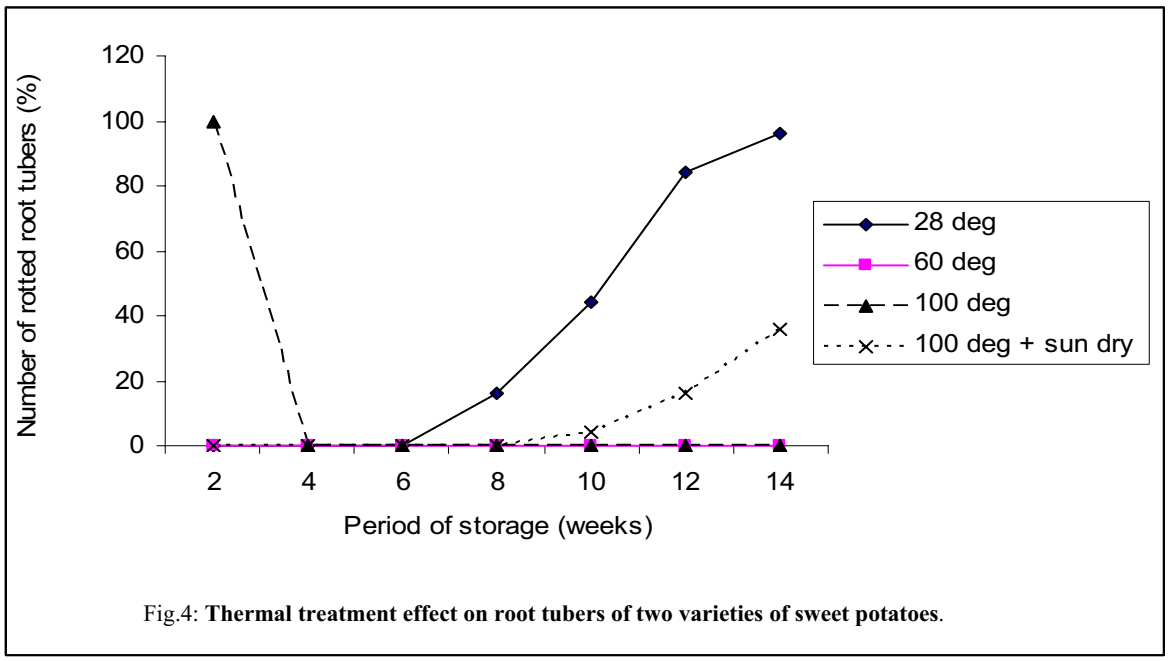

Fig.4: **Thermal treatment effect on root tubers of two varieties of sweet potatoes**.

Discussion

The need to prolong the shelf-life after harvest in order to forestall losses of crop due to rot incidence resulted in an increased use of agrochemicals (Salami and Popoola, 2007). Nevertheless, consumers' concerns with regards to pesticide residues and the fact that these widely-applied chemicals after harvest have shown some lack of control effectiveness encouraged the search for alternative methods to minimize postharvest decay (Tewe *et al*., 2003). Heat treatments to control postharvest pathogens have been tested in many crop species. The effects of the heat treatments were determined by visual analysis of the number of decayed tubers and number of lesions on each individual tuber (Salami and Popoola, 2007). Considering the number and virulence of the organisms isolated from the root tubers of the two varieties of sweet potatoes studied, the importance of plant and pathogen interaction in food production and in post harvest management cannot be over emphasized. This was found established in this study as shown by plates 1 and

2 where the tissues of the potato tubers were degraded by the fungi pathogens at different levels of degradation (Fig.1). Of all the organisms isolated from sweet potato root tubers in this study, five have been reported in the spoilage of root tubers during storage (Table 1). The ability of these pathogens to colonise a wide range of plant materials and parts, shows their ubiquity and non- host specific nature. In this study, *Fusarium oxysporum* had the highest frequency and it occurred on all potato types. This can be attributed to its non- host specific nature. This is in line with the findings of Tella (1991); Adewolu (1999); Therberge (1989) and Salami and Popoola (2007). Others like *Penicillium* sp; *Aspergillus oryzae;and Trichoderma viride;* were also found in this study to occur on the varieties of sweet potatoes while strains of *Botryodiplodia theobromae* occurred only on the red sweet potato (Table 1). These occurrences do not necessarily reflect their association with the root-tubers but rather the prevalent conditions under which they were stored. The pathogenicity test conducted showed that all the different varieties of sweet potatoes were susceptible to the fungal test pathogens used for this study with *Botryodiplodia theobromae* proving most virulent (Table 1 and Figs.1-3). The highly virulent nature of the strains of *Botryodiplodia theobromae,* was in line with studies by Onyeka (2002) and Ajiboye (2004).

Rots are typical of parenchymatous and collenchyma in nature particularly of storage tissues such as observed in sweet potatoes used in this study in which they take the form of rapidly spreading lesions. This was also observed by Onyeka (2002) and Ajiboye (2004). The rot symptoms produced by the test pathogens vary in their degree of manifestation. Infection by *Botryodiplodia theobromae* produced rot, which started initially with discolouration of the inoculated area, followed by gradual softening and subsequent degeneration of the tubers (Truter, 2005). *Fusarium oxysporum; Trichoderma viride*; and *Aspergillus oryzae* infection caused infected potato tubers to turn dry and grainy with cavities developing inside them. The affected areas appear slightly sunken and the skin wrinkles later (Plates 1-2). This is known as the dry rot. Microbial invasion of sweet potato tuber cells and tissues produced colour changes, which signifies the commencement of spoilage in this study. This is often the case when the root-tuber turns from yellow to yellowish brown or from normal pink to dark brown, at this junction, the root- tuber rapidly loses nutrients as the fungal pathogens proliferate (Rowe, 1993; Crous *et al*., 2000; Cilliers, 2003).

Subsequent to host's invasion, the non- lignified parenchymatous tissues were found in this study to be macerated due to dissolution of their cell wall and death of the cells (Cooper, 1984; Manners, 1993). This was particularly observed in this work in the infection of *Botryodiplaodia theobromae*. The growth of test pathogens on basal media, (especially with the one containing starch, yeast and Carboxymethylcellulose solutions), showed appreciable growth and enzyme synthesis. This revealed that enzyme synthesis can be induced extra-cellularly on basal media, as earlier confirmed by Lealam and Gashe (1994); Okolo *et al*., (1995); and Jordaan, (2003). Mycelium dry weight of the test pathogens in the two culture filtrates (SYE and CMC) indicates production of enzymes (especially amylase and cellulase) used by these organisms for the maceration of their host's tissues and it is largely dependent on the amount of substrate which was also

discovered by Abu *et al.* (2005). These liquid cultures were observed to enhance higher enzyme production by these organisms in the flask culture (Tipton, 2002; Popoola, 2006).

The choice of control method employed in this work gave ample consideration to the socio-economic factors affecting the farmers (Anonymous, 2002). Results from the use of the much acclaimed bio-control, have not been that successful on the field (Agrios, 1998). Thermal treatment using hot water at 60˚C into which root-tubers were blanched for 25 minutes was found to be most effective in this study. The root-tubers treated thermally this way in this work had prolonged shelf life of about 13 days without rottening. This is in line with the findings of Ranganna, *et al*. (1998); Tewe, *et al.* (2003); and Truter (2005). Physiological disorders such as sprouting and weight loss were negligible. Treatment using water at 28˚C was not as successful, with records of 28% and 60% losses of potato root-tuber rot within 4 and 6 days respectively. This was accompanied by significant weight loss. Results obtained from treatment at 100˚C showed complete spoilage in less than a week (i.e. 2 days). This may be due to the destruction of root-tuber tissues by extreme heat (Popoola, 2006). However, sun drying of the root-tubers for 4 days extended their shelf life to 9 days but with gradual changes in colour. This was in line with the works by Chu and Li (1994) and Van Vuuren and Le Roux (2004), though theirs was not up to 4 days. Thus, thermal control of stored food crops with hot water treatment done by blanching of the root-tubers in hot water at 60˚C for 25minutes was found successful with the tubers still being healthy for consumption; and it reduced the percentage of sweet potato tubers showing typical symptoms of white, dry or soft rot disease as well as reduced the number of lesions on each tuber.

Conclusion and Recommendations

Loss of food in the post harvest system is not new; it has always been a problem for mankind. Yet while so much resources have been invested to help developing countries produce more food, this has not been matched by investment in or even by awareness of the magnitude and importance of the post harvest loss problem in either developed or developing countries.. Several methods have been used and are being used to control post harvest root-tuber rot. Most are however tedious, costly and of practically little benefit to the farmers and the consumers. The control of sweet potato post harvest storage rot by thermal treatment have proven to be very effective in checking post harvest storage rot thus, prolonging their shelf life. This control method is culturally, economically and socially suitable for the farmers. However, physical damage to the root-tubers should be avoided at all cost since they serve as major entry points for pathogens. Contact between the harvested root-tubers and the soil should also be avoided, in order to prevent re-infection, since the soil is the natural reservoir for pathogen inoculums. When in storage, root-tubers should either be well spread out on wood or on clean concrete floor. The use of heated soil which is free of pathogens could be considered as an alternative to water where the latter is scarce.

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Studies on Fufu Production from Cassava Chips

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Abstract

This study investigated the utilization potential of dried cassava chips into *fufu* one of the forms in which cassava is consumed. Dried cassava chips were prepared by drying in the sun (32±2^{o}C) for 4days and in the oven at 50^{o}C. Dried cassava chips were converted into *fufu* by soaking (in water and 4day old liquor) for 1-4days at RT (27±2^{o}C), 35^{o}C and 45^{o}C. Samples were taken at 24hr intervals and examined for yield and other physicochemical properties. Sensory tests were conducted using commercially prepared *fufu* and reconstituted samples. There was no yield from chips steeped in fresh water; irrespective of the soaking temperature and also soaking fresh or dried cassava at 45^{o}C produced no yield. The total amount of water absorbed ranged between 106.5 –139.6 % for the dried chips when steeped for 6hrs. Oven dried chips absorbed higher amount of water than sun dried chips while soaking at 35^{o}C gave higher values than for samples soaked at room temperature. A maximum of 56% yield was obtained from sun dried chips soaked in old liquor irrespective of the soaking temperature while oven dried chips gave about 84% yield soaked at 35^{o}C after 72hrs. *Fufu* from oven dried chips had acceptable sensory attributes similar to those of fresh root.

Keywords: Fufu, drying, chipping, quality

Introduction

Cassava is highly perishable and cannot be stored for more than a few days after harvesting. This limits its utilization in the fresh unprocessed form (Ihekoronye and Nggody, 1985). It may be processed into chips to avoid losses. Dehydrated chips are unfermented dried products of cassava. Drying of cassava tuber is widely practiced to eliminate cyanide (Gomez and Valdivieso, 1983; Gomez *et al*., 1983) and improve the shelf life of the tuber by reducing the moisture content to a low level. Cassava can be dried naturally in the sun or artificially in the oven. As a means of eliminating cyanide, sun drying has been proven to be more efficient than oven drying at 60^{o}C (Gomez and Valdivieso, 1984). Chips are commonly used in animal feed production; however chips are used for human consumption in certain parts of Africa (Gomez and Valdivieso, 1984; Ihekoronye and Nggody, 1985). Chips can be converted into *gari* by seeding it with fresh root (Oluwole *et al*., 2004). Cassava starch and flour (*lafun*) can also be produced from chips (Famokunwa, 1994).

Cassava is consumed in a meal form as *gari, lafun* and *fufu. Fufu* is a fermented white paste made from cassava; it is ranked next to *gari* as an indigenous food in Southern Nigerian. It has attributes similar to pounded yam (a local delicacy) but its consumption is limited by the offensive odour developed during fermentation. *Fufu* is produced traditionally by soaking peeled cassava root in water and allowed to soften. It is mashed manually in water and sieved. The meal is allowed to settle, packed in cheese cloth bag and squeezed to dewater. There is a dearth of information on *fufu* production from chips. This study was

undertaken to investigate the potential use of dried cassava chips in *fufu* production. Different processing conditions for *fufu* production were studied. Physicochemical and sensory attributes of *fufu* produced from chips were also examined.

Materials and Methods

Bitter variety (*Manihot esculenta Crantz*-TMS 30572) of freshly harvested cassava roots (10-12 months old) obtained from the Teaching and Research farm on Obafemi Awolowo University campus, Ile Ife were used. The tubers had an average length of 10 ± 2cm, diameter 6.5 ± 2cm and moisture content of 67 ± 6%. Manually peeled, washed, tubers were cut into cylindrical chips of 1.5 ± 2mm thickness with a dicing machine (RG-2-8700, Hallde Sweden). Diced chips were spread thinly on hessian sack and dried in the sun (32 ± 2^{o}C, relative humidity 55%) for 4 days while some were dried in the oven (DP/DK-500/600, MRC LTD, Israel) at 50^{o}C (to a moisture content of about 7.8 ± 1%) for 15hrs. The dried cassava chips were allowed to cool, packaged in polythene bags, sealed and stored in a cupboard and used within 7 days (Oluwole et al 2004).

Water absorption capacity of the chips was determined by placing 2g of chips in 20ml water in a glass beaker at room temperature. The samples were taken out of the water at 15min interval, drained for 1min, weighed and returned to the water for the first one hour and thereafter at an hourly interval for another 5hrs (Taiwo *et al*.,1994). Fresh cassava roots and dried chips were steeped in water in a 2litre, transparent, covered plastic container at room temperature (RT, 27 ± 2^{o}C), 35^{o}C and 45^{o}C in a water bath according to the method of Oyewole and Odunfa (1992). Another set of chips were steeped in 4-day old liquor (from previous fermentation). Old liquor was used to initiate the fermentation process. At each interval of 24hrs, the fermented samples were mashed manually in fresh water and sieved to remove the fibre and unretted tuber after which the slurry was allowed to sediment. The slurry was dewatered to obtain *fufu* cake by packing the sediment into a cloth bag, squeezed slightly to obtain *fufu* cake (Ihekoronye and Ngoddy, 1985). The percentage yield of *fufu* obtained was determined based on the weight of dewatered *fufu* using the expression below according to Oluwole *et al*. (2004). The *fufu* cake (dewatered *fufu*) was thinly spread on an aluminum tray and dried in the oven (DP/DK-500/600, MRC LTD, Israel) at 50^{o}C to a moisture content of about 11± 1.5% (George *et al*., 1995).

$$\text{Percentage } \textit{fufu} \text{ yield} = \frac{\text{Weight of } \textit{fufu} \times 100}{\text{Weight of chips or Fresh peeled roots}}$$

Chemical Analysis

The pH of fermenting chips was determined using the method of Pearson (1976). pH of fermenting medium was determined after the fermented sample was removed from the medium. The total titratable acidity (TTA) in each sample was determined as a product of the titre value and 0.09, which is the lactic acid factor as described by Oluwole et al (2004). The starch content of *fufu* produced was determined using the

procedure of Mcready (1970). Cyanide level was determined in dried cassava chips and *fufu* produced from it using the method described by AOAC (1999).

Sensory Analysis

Fufu obtained from fermented dried cassava chips was reconstituted, heated in a pot with constant stirring until cooked to form smooth elastic dough. The resulting dough was subjected to organoleptic evaluation using a 12-man panel based on 5 point hedonic scale. Dried *fufu* flour was also reconstituted, cooked and subjected to sensory test. The cooked *fufu* was served with soup on a white plate. The panelists assessed the cooked samples for texture, colour, odour, and taste. Panelists rinsed their mouth with water after tasting a sample. A score of five represents excellent acceptability for the attribute under consideration and number one least acceptability. Selected samples were also compared with commercially prepared sample from fresh cassava root and dried *fufu* sample. All tests were carried out in triplicates and results presented as average readings. t-test was used for comparison and ANOVA where necessary using SPSS package (SPSS 13.0 for windows, 2004).

Result and Discussion

Water Absorption of Chips

Water absorption increased rapidly with time within the first one hour after which the increase was gradual. Water absorption value was higher in oven dried chips than sun dried chips (Fig. 1). Soaking at 35^{o}C resulted in higher water absorption in dried chips. This implies that mode of drying and temperatures of soaking are important processing factors in the rehydration of dried chips. Percentage water absorption was more than 100% of the initial weight in the chips at the end of six hours of soaking.

Yield of *Fufu* Produced from Dehydrated Cassava Chips

Steeping cassava chips in tap water produced no yield at any of the temperatures studied (RT and at 35^{o} and 45^{o}C, Table 1). There was no disintegration throughout the soaking period even when steeped longer than 96hrs. It is probable that dried chips did not posses the enzymes pectin methylesterase and pectate, which are reported to be responsible for breaking down the cell walls (Brauma *et al*., 1996). Yield was poor when fresh roots were soaked in 4day old liquor (4DOL) reaching a maximum of 26% after 96hrs. The impact of size reduction was not significant ($P>0.05$) on yield (Fig. 2a). However, fresh roots soaked in water at RT produced lower yield of *fufu* compared to samples soaked at 35^{o}C. Increasing the temperature to 45^{o}C produced no softening in the tubers. This result suggests that for optimal softening of fresh roots, steeping should be in fresh water at 35^{o}C.

Use of 4DOL as a steeping medium resulted in slow softening of sun dried chips producing a maximum yield of 56% at 96hrs. Softening set in by 24hrs of steeping in 4DOL in oven dried chips with 73.2% and 60.2% yield at 35^{o}C and RT respectively and increased with steeping time (Fig. 2b). Yield of *fufu* obtained from oven dried chips are comparable to the quantity obtained from fresh samples implying

suitability of oven dried chips for *fufu* production. At the end of steeping, oven dried chips had higher yield (80-88%) of *fufu* than sun dried (50-56%). It is probable that the different drying regimes may be responsible for these differences since continuous drying was undertaken in oven drying while intermittent drying with rest periods at night was performed for sun dried chips.

Production of high yield of *fufu* when 4DOL was used might be due to microorganisms present in the old liquor but not in tap water, which initiated fermentation in the chips. In his work on optimization of cassava fermentation for *fufu* production, Oyewole (1990) explained that Lactobacillus bacteria are involved in *fufu* production and that *B. Subtilis* showed the highest softening capability. The presence of these microorganisms in the old liquor may have facilitated softening of the chips. Other microorganisms that are also of importance in fermentation of *fufu* are *Saccharomyces cerevisiae, Lactobacillus plantarum, Lactobacillus brevis* and *Streptococcus faecalis.* (Moorthy and George, 1998).

Chemical properties of Fermenting Medium and Cassava

Drying fresh cassava roots into chips reduced the pH from 6.27 to 5.57. Oluwole et al. (2004) suggested that drying increased the concentration of acids in cassava roots. The pH change during fermentation of dehydrated chips in different media (tap water and 4DOL) at RT and 35^{o}C are shown in Fig. 3a. The pH of the soak water reduced within 72hrs from 6.56 to 4.92 at 35^{o}C and to 5.13 at RT implying an increase in acidic level of the product. The use of 4DOL for steeping dehydrated cassava chips (Fig. 3a) did not result in a significant ($P>0.05$) change in the pH of the medium. The pH values fluctuated between 4.07 and 4.64 at 35^{o}C and 4.07 to 4.5 for samples soaked at RT. The decrease in pH is desirable as some microorganisms responsible for initial starch hydrolysis cannot survive in low pH medium thus the decrease in pH helps these microbes to perform their functions (Okafor *et al.,* 1984). In addition, a low pH may not allow the growth of undesirable microorganisms which may contribute to the development of the unpleasant odour (Blanshard et al, 1994; Dougan *et al.,* 1993). There was no significant difference ($P>0.05$) in pH values of the 4DOL used to soak samples at RT and 35^{o}C meaning that temperature did not significantly affect the pH of the samples. pH of fermented cassava chips at 35^{o}C ranged between 5.57 and 4.92 when steeped in tap water. At RT it varied between 5.57 and 4.64 within 96hr (Fig. 3a). pH of the chips were higher than those of the steeping media suggesting greater acidic production in the media than in the chips (Fig. 3b). pH of cassava roots (both whole or sliced) decreased with steeping time (Fig. 3c) implying increased acidity. Variation in size and steeping temperature had no significant impact on the pH of the fresh roots. The pH of the water in which fresh roots were steeped had a sharp decline within 24hrs after which it exhibited a slow and minimal decrease in value (Fig. 3d). The final pH values of the steep water were lower than for the roots. When fresh roots were steeped in 4DOL, the pH of the medium was influenced by temperature (Fig. 3e) where samples steeped at RT had higher pH values than those steeped at 35^{o}C. Size reduction and steeping time had no significant impact on the pH of the medium.

Change in TTA values of the fermenting chips when 4DOL and tap water were used as steeping media for dehydrated chips at different temperatures are presented in Fig 4a. TTA values of the fermented

chips ranged between 0.04 and 0.05 throughout the period of fermentation in tap water (at RT and 35^{o}C) implying that organic acid was not produced when tap water was used as steeping medium since TTA measures the amount of lactic acid produced (Oluwole et al, 2004). There was no retting in the chips throughout the period of fermentation. This might be due to the absence of lactic acid bacteria in the fermenting root as high acidity in fermentation encourages the predominance of lactic acid bacteria and yeasts (Oyewole, 1990). These results agree with those of small pH changes (Fig. 3a-e). TTA values of chips soaked in 4DOL increased with steeping time reaching a maximum of 0.14% at both temperatures which shows that there was acid production in the chips soaked in the 4DOL as compared to that of chips soaked in tap water. These TTA values are similar to those reported for *gari* produced from chips (Oluwole *et al*., 2004).

TTA values for the fermenting medium in 4DOL in which chips were steeped decreased up to 48hrs of steeping, after which it began to increase (Fig. 4b). The initial high acidity recorded in 4DOL may be as a result of the acid already produced in the previous fermentation process before it was used to soak the chips. It is probable that some by-products (e.g. ethanol) are produced during fermentation leading to a reduction in TTA. In addition the chips could serve as a new substrate resulting in reduced TTA. TTA values of the tap water used for soaking chips increased gradually with soaking time but these values were significantly less than those soaked in 4DOL (Fig. 4b). This may explain why there was no retting of chips soaked in tap water. Monitoring the TTA of 4DOL (Fig. 4c) in which fresh roots were steeped showed a trend similar to those of chips soaked in 4DOL (Fig. 4b). Root size and soaking temperature were not significant (Fig.4c). However, the TTA of the tap water in which fresh roots were steeped increased with time (Fig. 4d). TTA values were higher for medium soaking sliced roots than in whole roots. Temperature of the medium did not appear to have a significant impact on the TTA of the medium.

The starch content of the raw cassava was about 70% and this value reduced slightly with steeping time but not significantly (Table 2). Starch content of *fufu* produced from chips (66.6 and 69.5%) was comparable to that of *fufu* from fresh root (60.7-70.7%). Processing factors such as steeping temperature, drying technique (fresh or dried cassava) did not significantly ($P>0.05$) affect the starch content. High starch content observed indicated *fufu* paste with good elasticity. Starch is responsible for the doughy, firm, elastic and cohesive nature of *fufu* (Moorthy, 1988).

During production of chips, drying reduced the cyanide level to about 45% of the initial value in raw cassava (67±0.4). Cyanide content of *fufu* produced reduced with steeping time and there was no significant difference in cyanide content of *fufu* produced from chips either oven or sun dried (Table 3). Final cyanide values in *fufu* obtained from chips are between 0.8 and 0.5mg HCN/100g and 1.9mg HCN/100g for fresh roots which is within the acceptable range for cassava products (SON, 1983). SON recommends 20mg HCN/kg for *gari* and cassava starch (IITA, 1989; SON, 1983; 2004; FIIRO, 2002).

Sensory Evaluation

The colour of dewatered *fufu* samples obtained from dehydrated chips were white before cooking but turned creamy white after cooking but was acceptable to the panelists. The mean score for colour ranged between 2.7 and 3.2 which was close to the mean score of *fufu* from fresh root (3.0-4.0) implying that *fufu* from chips had acceptable colour as that of fresh root. *Fufu* odour increased in intensity with steeping time but the odor of samples obtained from 96hrs of steeping at RT was not acceptable. This bad odour may be as a result of proliferation of microbes in the fermenting medium at RT which may not be so at 35^{o}C. It is probable that sustained steeping at 35^{o}C may not be conducive for the continued growth of the odour producing organisms. Texture of the *fufu* samples was coarse (did not form a smooth paste) and the coarseness increased with steeping time.

Samples having acceptable attributes tested against a commercial sample and the result are shown in Table 4. The samples were not significantly ($P>0.05$) different in color, taste and overall acceptability from one another. The odour of the commercial sample was significantly ($P<0.05$) different from the experimental samples as laboratory samples had higher values implying reduced odour. This may be attributed to lack of standardization in the traditional production *of fufu.* Some processors add hot water to the soaking medium during steeping; some pound the unsoftened roots to ensure adequate extraction of the meal while others soak beyond four days to increase the yield. These practices vary with the locality and result in different quality attributes. The odour of *fufu* samples from chips were not significantly different from that of samples from fresh roots prepared in the laboratory. The texture of *fufu* from dehydrated chips was significantly different ($P<0.05$) from other samples (had lower values compared to the commercial samples, Table 4). All *fufu* samples compared well with the commercial samples and had overall acceptability values between 3.25 and 4.07 on a scale of five being the most acceptable. *Fufu* obtained within 48-72hrs at RT and 35^{o}C had acceptable sensory attributes.

Conclusion

Fufu of acceptable quality and yield can be produced from dried chips soaked by steeping in 4 day old liquor. Yield was higher in oven dried chips than sun dried. There was greater acid production in the fermenting medium than in the roots and size or temperature had no influence on acid production. Cyanide level reduced significantly during processing to acceptable limits and starch content of the extracted *fufu* was not influenced by processing variables studied.

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Table 1 - Percentage Yield of *Fufu* Obtained from Various Cassava Samples at Different Steeping Conditions.

	Steeping Temperature										
	RT					35°C					45°C
	Steeping Time (hrs)					Steeping Time (hrs)					Steeping Time (hrs)
Sample	0	24	48	72	96	0	24	48	72	96	0 - 96
Fresh root in Tap Water	NY	NY	42.2±3.2	76.4±2.5	79.1±1.0	NY	33.2±2.3	58.7±4.8	81.4±4.0	77.81±5.6	NY
OD in 4DOL	NY	NY	60.2±5.3	82.5±2.5	88.3±1.1	NY	NY	73.2±1.8	84.0±2.9	81.55±3.1	NY
SD in 4DOL	NY	NY	NY	38±8.2	56±1.8	NY	NY	NY	27±3.1	51±7.5	NY
Oven/Sun dried chips in tap water	NY	NY	NY	NY	NY	NY	NY	NY	NY	NY	NY

NY: No Yield

RT – Room temperature - 27 ± 2°C

OD in 4DOL - Oven dried chips in 4 day old liquor

SD in 4DOL - Sun dried chips in 4 day old liquor

Table 2 - Starch Content of *Fufu* Obtained from Various Cassava Samples at Different Steeping Conditions.

	Steeping Temperature RT					Steeping Temperature 35°C				
	Steeping Time (hrs)					Steeping Time (hrs)				
Sample	0	24	48	72	96	0	24	48	72	96
Fresh root in Tap Water	70.7±13.5	NY	66.9 ±0.6	66.8 ±0.7	60.7 ±0.3	70.6 ±13.5	69.4 ±0.7	67.8 ±0.5	67.5 ±0.3	65.6 ±0.8
OD in 4DOL	69.0 ±0.2	NY	68.1 ±0.2	67.6 ±0.4	67.3 ±0.4	69.0 ±0.2	NY	66.6 ±0.6	66.2 ±0.1	66.0 ±0.2
SD in 4DOL	69.5 ±0.9	NY	NY	68.5 ±0.3	66.5 ±0.4	69.5 ±0.9	NY	NY	68.6 ±0.3	66.5 ±0.3

NY – No Yield

RT – Room temperature - 27 ± 2°C

OD in 4DOL - Oven dried chips in 4 day old liquor

SD in 4DOL - Sun dried chips in 4 day old liquor

Table 3 - Cyanide Content of *Fufu* Obtained from Various Cassava Samples at Different Steeping Conditions.

Sample	Steeping Temperature RT					Steeping Temperature 35°C				
	Steeping Time (hrs)					Steeping Time (hrs)				
	0	24	48	72	96	0	24	48	72	96
Fresh root in tap Water	6.7 ±0.4	NY	2.3±0.1	2.0 ±0.1	1.9 ±0	6.7 ±0.4	3.1 ±0	2.3±0.04	1.9±0.03	1.8 ±0.04
OD in 4DOL	1.8±0.03	NY	1.6 ±0	1.2 ±0	0.8 ±0	1.8 ±0.02	NY	1.3 ±0	0.9 ±0.1	0.6 ±0.1
SD in 4DOL	1.7±0.03	NY	NY	1.5±0.1	0.7±0.1	1.7±0.03	NY	NY	0.8 ±0.1	0.5 ±0.1

NY – No Yield

RT – Room temperature - 27 ± 2°C

OD in 4DOL - Oven dried chips in 4 day old liquor

SD in 4DOL - Sun dried chips in 4 day old liquor

Table 4 - Mean Scores for Sensory Properties of Selected Cooked *Fufu* Samples Produced from Various Processing Conditions

Sample	Colour	Odour	Texture	Taste	Overall Acceptability
967	3.83a	3.75ab	3.25ab	3.58a	3.7a
978	3.75a	3.17ab	3.00b	3.5a	3.33a
994	4.16a	4.0a	4.17a	3.92a	4.05a
999	3.17a	2.75b	3.42ab	3.33a	3.25a

Means followed by the same letter in the same column are not significantly difference.

967 ___ Sample obtained when raw cassava soaked for 72hrs at $35^{O}C$

978 ___ Sample obtained from oven dried cassava chips

999 — Commercial sample

994----Sample obtained by drying *fufu* slurry (wet extract) obtained at room temperature

Fig. 1 - Water absorption capacity of cassava chips at different hydrating temperatures

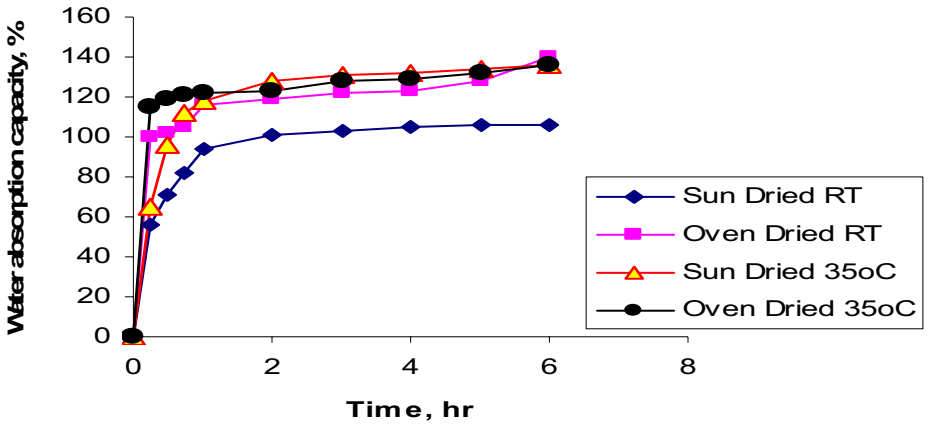
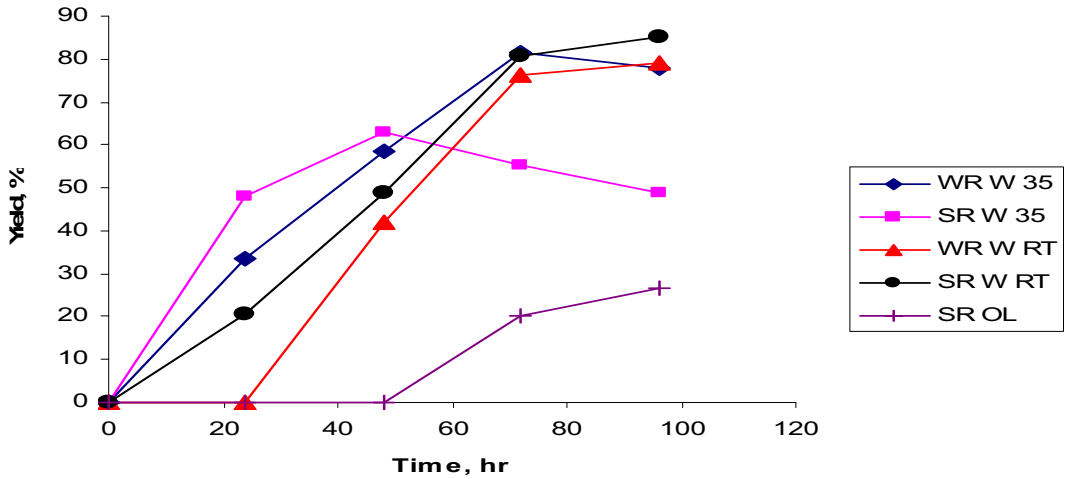
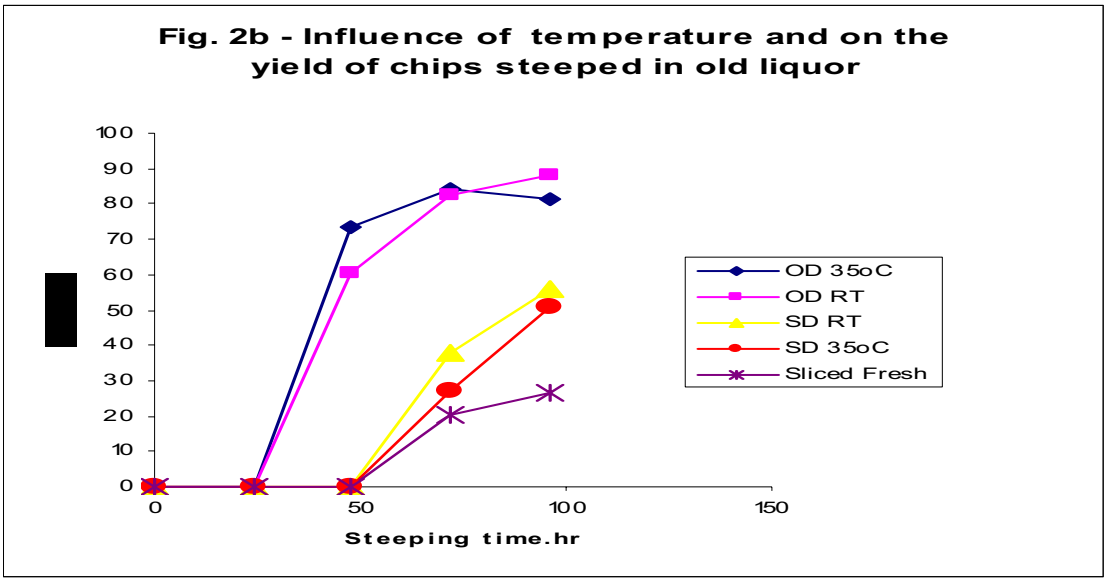


Fig. 2a - Yield of fufu at different of processing conditions





WR W 35 - Whole root steeped in water at 35°C SR W 35 _ Sliced fresh root steeped in water at 35°C WR W RT – Whole root steeped in water at room temperature SR W RT – Sliced fresh root steeped in water at room temperature SR OL – Sliced fresh root steeped in old liquor	OD 35°C – Oven dried samples steeped at 35°C OD RT – Oven dried steeped at room temperature SD RT- Sun dried steeped at room temperature SD 35°C – Sun dried steeped at 35°C

Fig. 3a - pH of steeping medium for oven dried chips at different temperatures

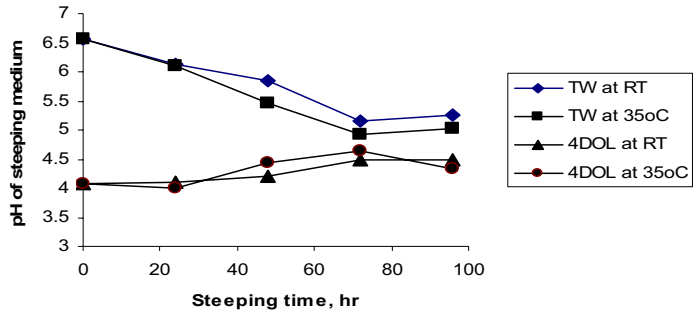


Fig. 3b - pH of cassava chips steeped at different temperatures

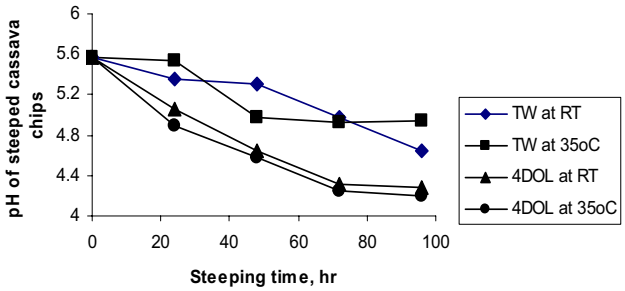


Fig. 3c - pH of fresh cassava roots steeped in water

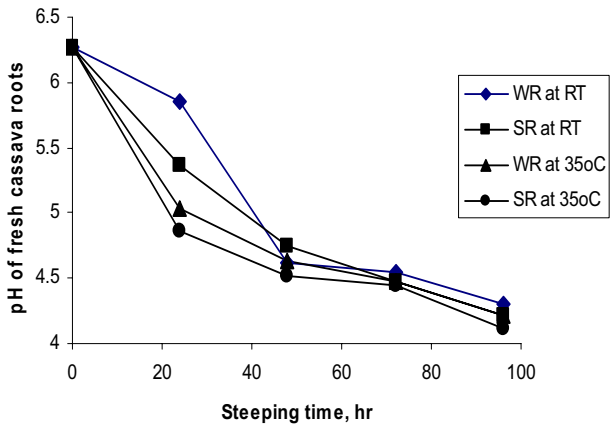


Fig. 3d- pH of steeping medium for fresh cassava roots in tap water

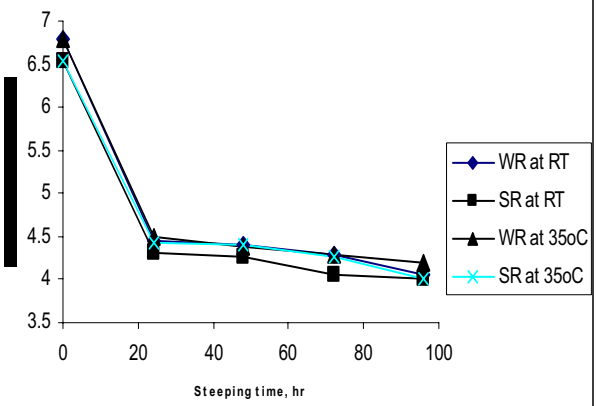


Fig. 3e -pH of steeping medium for fresh roots in 4DOL

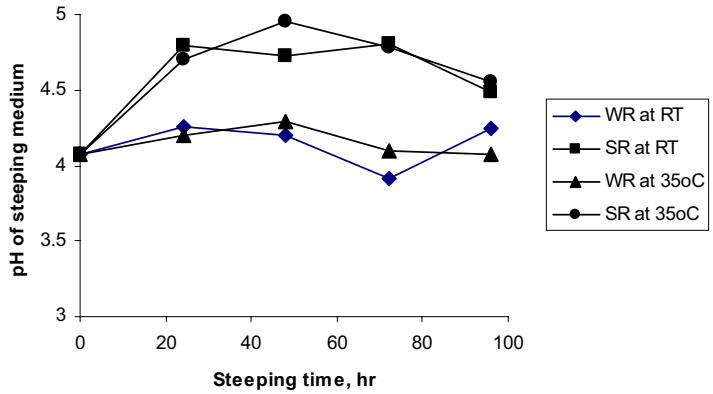


Fig. 4a - TTA values of cassava chips steeped in different media

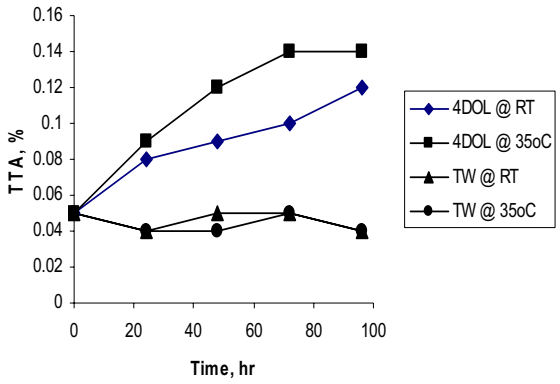


Fig. 4b - TTA values of steeping medium for cassava chips at different tempeatures

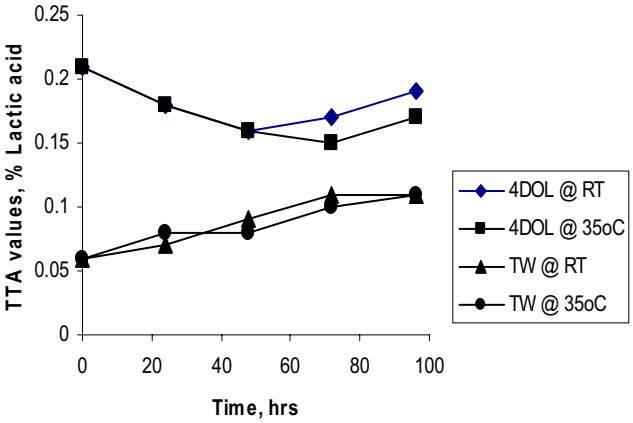


Fig. 4c - TTA values of 4DOL in which fresh roots were steeped at different temperatures

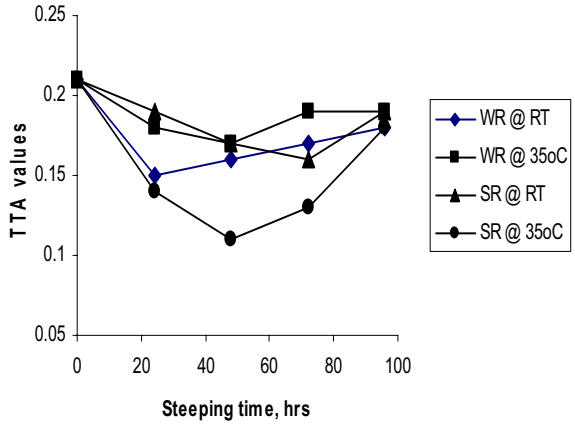
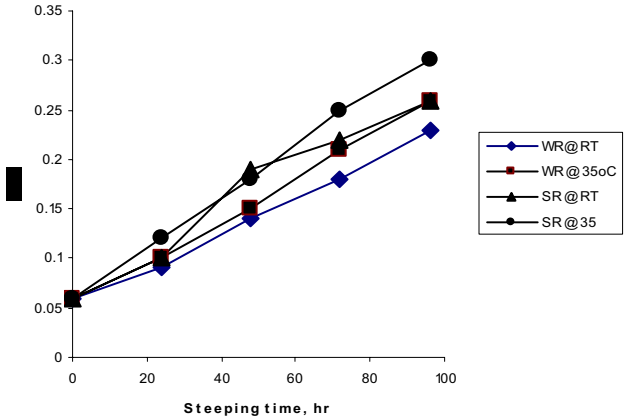


Fig. 4d - TTA values of steeping medium for fresh cassava root soaked in water



Comparative utilisation of organic acids and probiotics in starting chicks

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Abstract

Three weeks old cockerels with initial weight of 127.9 ± 6 g (Mean ± SD) were grown in floor pens for 42 days in groups of twelve. Two hundred and sixteen birds were randomly assigned to five treatments. Birds on the control diet were 72 birds while other treatments had 36 birds. A basal diet based on maize, soybean meal, groundnut cake and wheat offal was formulated to meet the nutrient requirement of starting chicks. Probiotics replaced the wheat offal in the basal diet in proportion of 0, 0.05 and 0.1% in Diets I, II and III respectively on weight basis. Probiotics preparation contained *Lactobacillus acidophilus* (0.45 x 10^{11}), *Saccharomyces cerevisae* sc-47 (1.25 x 10^{11}) and *Saccharomyces boulardii* (0.3 x 10^{11}) c.f.u. per kg. Organic acids similarly replaced the wheat offal in Diets I, IV and V in proportion of 0, 0.2 and 0.4 % respectively. Organic acids contained a blend of formic and propionic acid. Feed and water was also supplied unrestrictedly.

Starting chicken responded non-significantly ($p > 0.05$) to increasing feed additive concentration in final body weight, body weight gain, protein efficiency ratio and feed/gain ratio irrespective of the feed additive. Probiotics or organic acids at lower or upper levels of inclusion exert no influence on all performance criteria. Final body weight (g) was highest on Diet V (674) and lowest on Diet I (661), while feed/gain ratio was highest on Diet II (4.052) and lowest on Diet III (3.783). Average weekly feed intake (g) was highest on Diet V (357) and least on Diet II (334). For all response criteria a non-significant interaction occurred between feed additive and their dietary concentration. The slope of regression of body weight changes depending on weeks (g) was highest on Diet V and lowest on Diet II (84.2 vs. 75.0). Slopes ($p = 0.4797$) and y intercepts ($p = 0.1248$) were not significantly different from each other. The pooled slopes and intercepts (g) were therefore 77.4 and 6.37 respectively.

Keywords: Probiotics, organic acids**,** gut flora modulators, growth rate

Introduction

The use of gut flora modulators such as organic acids, probiotics, probiotics and essential oil from plant extracts in farm animal feeding which modulate the microflora via growth inhibition of pathogenic organism (e.g. *E coli*, *Samonella sp*., *Clostridium perfringes*) at the expense of beneficial organisms (e.g. *Lactobacillus* sp, *Bifidobacterium* sp) are on the increase due to the restriction on the use of prophylactic doses of antibiotics as growth promoter and intestinal health enhancer in the European union and the tendency of the rest of the world to follow suit due to health awareness (microbial resistance to antibiotics in human) and tendency of consumers for animal products produced through 'natural' methods with less use of chemical agents. While both organic acids and probiotics are aimed at achieving a similar end point of improvement in intestinal health, which is expected to translate to better productivity in animals, the mechanisms of action are thought to be different.

Certain direct acting modulators such as short to medium length chain organic acids such as propionic, butyric, acetic, formic, lactic, malic, tartaric and citric acids when fed as individual acid or in combination are believed to be bacteriostatic at low concentrations and bactericidal at high concentrations and efficacy varies depending on organic acids in question (Dibner

and Buttin, 2002; Leary, 2007). Antibiotic growth promoters has been used for over 50 years in the pig and poultry industry with its attendant benefits such as improved growth rate, reduced mortality and morbidity and reduced feed conversion ratio (Rosen, 1995). Organics acids have a long history of safe use in animal nutrition as feed preservatives, mould and microbial inhibitors, while probiotical strains have been used for ages in diary products and have safe history of consumption in humans. Simon (2005) defined probiotics as 'as viable micro-organisms, which after sufficient oral intake, lead to beneficial effects for the host by modifying the intestinal microbiota'. The microorganisms used in animal feed are mainly bacterial strains of Gram-positive bacteria belonging to the genera of *Lactobacillus, Enterococcus, Streptococcus, Bifidobacterium, Pediococcus* , *Bacillus* and microscopic fungi such as strains of yeasts belonging to the *Saccharomyces cerevisiae* species (Stavric and Kornegay, 1995). The use of probiotics in broiler and pigs has been reported to show some promise in terms of improvement in body weight gain and feed efficiency (Stavric and Kornegay, 1995; Jørgensen, 2004; Simon, 2005). Similarly organic acids have been reported to be beneficial in broilers and piglets (Skinner et al., 1991; Lückstädt *et al*., 2004; Lückstädt and Steiner, 2006).

Cockerels are slow growing (male layer) birds usually raised for their meat and low carcass fatness, which female lines have been selected over many generations for high egg production while the males have been less selected. They respond well to dietary nutrient supply if fed diets needed for their optimal protein deposition rates. It is however not known if slow growing animals such as cockerels could benefit from the growth promoting influence of probiotics and organic acids. It is the objective of the study to evaluate the performance of starting chicken fed either probiotics or organic acids using cockerels as a model animal for slow growing birds.

Materials and methods

Two hundred and sixteeen 3 weeks old black (Bovan Nera) cockerels with initial weight of 127.9 ± 6.5 g (Mean ± SD) were randomly assigned to five dietary treatments. Birds on the control diet had 72 birds while other treatments had 36 birds. Birds were weighed and uniformly distributed to their respective pen on weight basis. Each diet was offered to 3 pens of 12 cockerels each except for the control diet that was offered 6 pens of 12 birds each. Individual pen has a dimension of 1.5 × 1.3 m. Feed and water were also supplied unrestrictedly. Birds were individually weighed on weekly basis until the end of the experiment. Daily voluntary feed intakes were monitored.

A basal diet was formulated. The basal diet was formulated to meet the nutrient requirement of starting chicks using the NRC (1994) as a guide. The basal diet was based on maize, soybean meal, groundnut cake and wheat offal. The basal diet was fortified with synthetic amino acids to optimize amino acid balance. Amino acid and other nutrients composition of diets was calculated based on published values from NRC (1994) and NRC (1999). Table 1 shows the ingredient composition of the experimental diets. Probiotics replaced the wheat offal on weight basis in Diets I, II and III in proportion of 0, 0.05 and 0.1%. Probiotics preparation was declared to contain *Lactobacillus acidophilus* (0.45×10^{11}), *Saccharomyces cerevisae* sc-47 (1.25×10^{11}) and *Saccharomyces boulardii* (0.3×10^{11}) c.f.u. per kg by the manufacturer (Biovet-YC, Wockhardt, India). Acidifier also replaced the wheat offal in Diets I, IV and V in proportion of 0, 0.2 and 0.4 %. Acidifier contained a blend of formic and propionic acid (Biotronic SE, Biomin, Germany). Replacement was carried out on weight for weight basis. Calculated values for proximate and amino acids on as fed basis are also presented in Table 1. All ingredients with the exception of the variable ones (wheat offal and feed additives) were mixed as a single lot and later divided into seven equal parts. Wheat offal and the various feed additives were added separately in their respective proportions. Each diet was then mixed again and bagged.

Dry matter, crude protein, crude fibre and crude ash of the basal diet were performed according to the AOAC (1990) procedure. Data were subjected to routine ANOVA from General Linear Model procedures using the software package SPSS

13.0 for windows. The efficiency with which the ingested feed was used for protein deposition was described using a linear regression. A linear regression on growth of chicken [y, kg/bird] depending on weeks [x, growth over time] was calculated.

$$y = bx + a$$

where a =constant and b=slope of the regression line.

The slope quantifies the steepness of the line. It equals the change in Y for each unit change in X. The slope is the rate at which feed consumed is efficiency utilised for growth or protein accretion. Treatment averages was considered as one data point in the regression analysis. Parameters of goodness of fit were r^2 and Sy.x. The Sy.x values are the standard deviations of the residuals, which are the distances between the individual points from the calculated line. Linear regression was calculated using GraphPad Prism 4.02 (GraphPad Software Inc., San Diego, California). This experiment was conducted at the Poultry Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife.

Results

The performance characteristics of chicken fed varying levels probiotics and organic acids are shown in Table 2. Starting chicken responded non-significantly ($p > 0.05$) to increasing feed additive concentration in final body weight, body weight gain, protein efficiency ratio and feed/gain ratio irrespective of the feed additive. Probiotics or organic acids at lower or upper levels of inclusion exert no influence on all performance criteria. Final body weight (g) was highest on Diet V (674) and lowest on Diet I (661), while feed/gain ratio was highest on Diet II (4.052) and lowest on Diet III (3.783). Average weekly feed intake (g) was highest on Diet V (357) and least on Diet II (334). Protein intakes followed the same pattern as observed for feed intakes. For all response criteria, a non-significant interaction occurred between feed additive and their dietary concentrations (Table 2). The parameter estimates of the linear regression of body weight changes depending on weeks are shown in Table 3. The slope of regression of body weight changes depending on weeks (g) was highest on Diet V and lowest on Diet II (84.2 vs. 75.0). Slopes ($p = 0.4797$) and y intercepts ($p = 0.1248$) were not significantly different from each other. The pooled slopes and intercepts (g) were therefore 80.7 and 6.75 respectively. The 95% confidence interval of the slope of body weight changes overlap widely across all treatments and slopes differ significantly from zero ($p < 0.001$). Slopes and y intercept were compared using F-test. Slopes were not significantly different from each other ($p = 0.8976$). The y intercepts were likewise not significantly different ($p = 0.8540$). The pooled slopes and intercepts were therefore 0.08216 and 0.00143 respectively.

Discussion

The concentrations of probiotics used in the present study are within the range of that recommended by its manufacturer and also within the range that has been reported to elicit response in poultry (Starvic and Konegay, 1995). Probiotics supplementation in this study has no effect on final body weight gain, feed conversion ratio, feed intake and protein efficiency ratio. This is in agreement with reports on probiotics in poultry and pigs (Stavric and Kornegay, 1995; Arslan, 2004; Simon, 2005). Arslan (2004) fed *Lactobacillus bulgaricus* to two groups of rock partridges (a control and a treatment group containing 0.15% probiotics) for 12 weeks and observed no difference in live weight, feed intake and feed conversion between the two groups. Similarly, Midilli *et al*. (2008) fed 0.05% probiotics preparation containing *Bacillus licheniformis* and *Bacillus subtilis* to broiler chicken for 42 days and observed no significant improvement in final body weight, body weight gain, feed intake, feed conversion ratio, carcass weight and carcass yield. Reports on the use probiotics and its attendant benefits in

poultry have been generally inconclusive. In review of published results on the use of probiotics in poultry diet or water, Stavric and Kornegay (1995) concluded that results were generally inconsistent, while a few result indicated a beneficial effect in terms of weight gain, egg production and feed efficiency in broiler, layers and turkey, most of the results generally had no effect. They adduced the observed response to differences in concentration of probiotics added to feed (reported range in literature was 0.002 to 0.2 %), duration of treatment, diet type, age of birds and other experimental protocols. *L. acidophilus* was the strain of probiotics used in most of these experiments. A similar observation has also been made in piglets (Simon, 2005). In the review of 22 publications on the intake of probiotics by piglets, only in 3 of the studies was significant improvement in daily gain observed and improvement in feed conversion was only observed in a study. Probiotics generally reduced the incidence of diarrhoea in young piglets and this observation was consistent irrespective of the strain of microbe used (Simon, 2005).

Organic acids similarly had no growth promoting effect as in case of probiotics. The final body weight, feed intake, feed conversion ratio and protein efficiency ratio of birds fed organic acids were similar to non- treated groups. The concentrations of acidifier used in this study are within the range of those previously reported to be effective in promoting growth in young pigs and poultry (Lückstädt *et al*. 2004; Mroz 2005; Lückstädt and Steiner, 2006). Significant increase in body weight gain and less often in feed conversion has been reported from some studies with organic acids in broiler chicken fed with a blend of propionic and formic acid (Lückstädt *et al*., 2004) and fumaric acid (Patten and Waldroup, 1988; Skinner *et al*., 1991). Lückstädt *et al*. (2004) fed a blend of propionic and formic acids (3g/kg diet) to broiler chicken in a 35 days feeding trial. Weight gain of test group was significantly higher than the control group with no organic acid supplementation, but feed intake and feed conversion was unaffected. In some other studies however, no significant improvement in body weight gain or feed conversion was reported with fumaric acid (Runho *et al*., 1997) or propionic acid (Izat *et al*., 1990). Organic acids are believed to exert their influence by suppressing the proliferation of acid (pH) intolerant pathogenic microbes such as *E. coli, Samonella sp*. and *C. perfinges* in poultry (Gauthier, 2005). Improvement in growth performance usually results from enhanced intestinal health and not usually from acidification of the digestive tract. According to Dibner and Buttin (2002), some factors responsible for this variability may include, the buffering capacity of feed ingredients, presence of other antimicrobial compounds, cleanliness of the production environment and heterogeneity of gut microbiota.

The data on growth rate and feed intakes observed in this study are within the range previously reported in cockerels of similar growth phase, age and body weight (Sanwo *et al*., 2006). It was concluded that, neither probiotics nor organic acids have any growth promoting effect in cockerels based on the slope of linear regression of body weight changes depending on weeks.

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Table 1: **Gross and chemical compositions of the experimental diets (%)**

Ingredients	Diet I[1]	Diet II	Diet III	Diet IV	Diet V
Maize	50	50	50	50	50
Groundnut meal	14.9	14.9	14.9	14.9	14.9
Soybean meal	12	12	12	12	12
Wheat bran	10	9.95	9.9	9.8	9.6
Palm kernel meal	5.8	5.8	5.8	5.8	5.8
Fish meal	3.0	3.0	3.0	3.0	3.0
Oyster shell	1.5	1.5	1.5	1.5	1.5
Bone meal	2.0	2.0	2.0	2.0	2.0
Salt	2.5	2.5	2.5	2.5	2.5
DL-Methionine	1.5	1.5	1.5	1.5	1.5
L-Lysine.Hcl	1.5	1.5	1.5	1.5	1.5
Premix[2]	2.5	2.5	2.5	2.5	2.5
Probiotics	0	0.05	0.01	0	0
Acidifers	0	0	0	0.2	0.4
Calculated analyses (%)					
ME kcal/kg	2831.5	2830.9	2830.2	2828.9	2826.3
Crude protein	21.28	21.27	21.26	21.24	21.21
Crude fibre	4.550	4.545	4.541	4.532	4.515
Ether extract	3.256	3.254	3.252	3.248	3.240
Lysine	1.024	1.024	1.024	1.023	1.022
Threonine	0.702	0.701	0.701	0.701	0.699
Methionine	0.477	0.477	0.477	0.477	0.476
Tryptophan	0.210	0.210	0.210	0.210	0.209
Isoleucine	0.811	0.811	0.811	0.810	0.809
Valine	0.974	0.973	0.973	0.972	0.971
Leucine	1.638	1.638	1.637	1.637	1.635
Phenylalanine	0.968	0.968	0.968	0.967	0.966
Histidine	0.525	0.524	0.524	0.524	0.523
Arginine	1.686	1.685	1.685	1.684	1.682

[1]Analysed proximate values for the basal diet (%) were: dry matter 90.92, crude protein 21.98, crude ash 6.18, ether extract 4.4 and crude fibre 3.82.

[2]Supplied per kg diet: Vit. A, 10,000 i.u; Vit. D3, 2,000 i.u; Vit. E, 2.5 i.u; Vit. K, 2.0 mg; Riboflavin, 4.2 mg; Pantothenic acid, 5.0 mg; nicotinic acid, 20.0 mg; choline chloride, 300.0 mg; folic acid, 0.5 mg; Mn, 56.0 mg; 1, 1.0 mg; Fe, 20.0 mg; Cu, 10.0 mg; Zn, 50.0 mg; Co, 1.25 mg

Table 2: Effect of feed additive (Add) and concentration (Conc) on growth performance of cockerel chickens during 3 to 9 weeks of age (n = 6 pens of 12 birds of Diet I or n = 3 pens of 12 birds in other treatments)

						Pooled	P (ANOVA)		
Parameters	Diet I	Diet II	Diet III	Diet IV	Diet V	SEM	Add	Conc	Add x Conc
Final body weight, g/bird	661	627	662	675	674	6.70	0.6071	0.6756	0.1379
Initial body weight, g/bird	129	131	122	128	120	1.30	0.0870	0.056	0.5768
Body weight gain, g/bird	532	496	539	547	555	6.60	0.4326	0.4421	0.1786
Body weight gain, g/bird/wk	89	83	90	91	92	1.10	0.4326	0.4421	0.1786
Feed conversion ratio g/g	3.996	4.052	3.783	3.803	3.867	0.05	0.9323	0.2465	0.1052
Feed intake, g/bird	2122	2002	2037	2078	2143	28.8	0.1535	0.2401	0.4492
Feed intake, g/bird/wk	354	334	339	346	357	4.80	0.1535	0.2401	0.4492
Protein intake, g/bird/wk	75	71	72	74	76	1.00	0.1694	0.2289	0.4745
Protein efficiency ratio, g/g	1.178	1.164	1.244	1.239	1.233	0.01	0.9057	0.1612	0.1268

Means with different superscripts in the same row are significantly different (P<0.05)

Table 3: Estimated parameters for body weight changes of chicken depending on week during 3 to 9 weeks of age [n = 6 pens of 12 (Diet I) or 3 pens of 12 birds per other treatments]

	Diet I	Diet II	Diet III	Diet IV	Diet V
Best fit values					
a	0.0097 ± 0.0229	0.0184 ± 0.0251	0.0024 ± 0.0283	0.0034 ± 0.0307	-0.0034 ± 0.0250
b	0.0801 ± 0.0048	0.0750 ± 0.0056	0.0808 ± 0.0063	0.0804 ± 0.0069	0.0842 ± 0.0056
95% Confidence Intervals (range)					
a	-0.0344 - 0.0547	-0.0341 - 0.0709	-0.0568 - 0.0615	-0.0609 - 0.0677	-0.0557 - 0.0488
b	0.0701 - 0.0900	0.0632 - 0.0867	0.0676 - 0.0940	0.0660 - 0.0947	0.0724 - 0.0958
Goodness of fit					
r^2	0.9372	0.9037	0.8958	0.8781	0.9228
Sy.x	0.0436	0.0515	0.0579	0.0630	0.0512

Variation in seed yield and nutrient contents in African yam bean

(*Sphenostylis stenocarpa*)

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Abstract

Nine African yam bean accessions were evaluated for seed yield and other reproductive characters Significant differences were observed for seed yield, 100 seed weight and number of days to 50% flowering. Seed yield among the accessions ranged from 24.79 to 118.33 g per plant. Average number of seeds per pod was from 13.33 to 19.33, 100 seed weight varied between 19.69 to 28.22 g, while pod length also differed from 19.57 to 28.00 cm. The protein content of the African yam bean accessions were comparable to that of cowpea, but the concentrations of the anti-nutritional factors were significantly higher in the African yam bean accessions. Although the African yam bean accessions with low anti-nutritional factors were low yielding, they can be recombined with the high yielding accessions in developing improved varieties.

Keywords: African yam bean, evaluation, seed yield, nutrients, anti-nutrients, variation.

Introduction

African yam bean (*Sphenostylis stenocarpa* (Hochst. Ex A. Rich) Harms) is native to West and Central Africa and it is one of the underutilized grain legumes still been cultivated by some traditional farmers in certain localities mainly in the southern part of Nigeria and Benue State (middle belt). It is cultivated mainly for consumption as only about 30% of the dry grain produced is sold and also planted for soil restoration (Saka, *et al.* 2004). African yam bean is a good source of protein, fibre and carbohydrate. It is rich in minerals such as phosphorus, iron and potassium. It also contains some anti-nutrients such as trypsin inhibitor, phytate and other alkaloids (Nwokolo, 1987; Ajibade, *et al*., 2005; Fasoyiro, *et al*., 2006).

Although African yam bean (AYB) can be used to replace cowpea in most food preparations, its utility is highly limited when compared with prominent grain legumes such as cowpea, groundnut and soybean. For instance, in Nigeria, soybean and groundnut are usually processed into oil and defatted meals used as animal feeds. Soybean is also used in fortification of foods as in baby product formulation. Cowpea is widely utilized in the form of bean cake, pudding and in food fortification. African yam bean, is mainly cooked and eaten alone or with yams, maize, rice or in soup. This crop (AYB) has however found better utility in Ghana where it is usually processed into flour and used for pudding or fortified with cassava. The water drained after boiling the beans are also drunk by lactating mothers to increase milk production (Klu *et al* 2001).

However, AYB seeds take a long time to cook and contain higher levels of anti-nutritional factors (ANFs) than cowpea and soybean (Fasoyiro *et al.* 2006) which could be toxic or reduce the nutrient utilization, limiting its use in animal and human nutrition. There is also lack of awareness about the nutritional quality of AYB particularly among the urban dwellers. Another limiting factor is the low seed yield of the crop recorded by farmers despite the reported low level of pest and diseases attack (Saka *et al.* 2004).

Therefore in this study nine AYB accessions were evaluated to identify promising genotypes in terms of high seed yield, nutrients and anti-nutritional factors.

Materials and methods

Nine African yam bean accessions from the germplasm of the Institute of Agricultural Research and Training (IAR&T), Ibadan were evaluated for seed yield and other reproductive characters. The nine African yam bean accessions evaluated are SSWN32, SSWN44, SSWN48, SSWN33, SSWN50, SSWN3, SSWN35, SSWN15 and SSWN29. The seeds of each accession were planted out at the Research Farm of the Institute in Ibadan, Nigeria in June 2006. The planting was done in single row plot of 10 metres long at a spacing of 1m x 1m. There were three replicates. Two seeds were planted per stand and later thinned to one, two weeks after sowing. Manual weeding was done as at when due and no fertilizer was applied. Sherper Plus (Cypermetrin + dimethoate) brand of insecticide was applied at the rate of 50g a.i. ha^{-1} at anthesis and subsequently at two weeks interval for a total of 3 applications to control insect attack. At maturity, data were collected from five plants from each plot. The data collected were: number of days to 50% flowering, pod length, number of seeds per pod, 100 seed weight and seed yield per plant.

Proximate analysis: Dry seeds of each of the nine AYB accessions and a local cowpea cultivar were sorted, milled and stored in polythene bags at 4°C. Samples were analyzed for nitrogen content by the microkjedahl method and the crude protein was calculated by multiplying the Kjeldahl N by 6.25. The contents of crude fats, crude fibre and ash were determined by AOAC (1990) method.

Anti-nutritional factors analyses: Tannin content was determined using the method of Price *et al*., (1978), trypsin inhibitor (Kakade *et al*. 1969) and phytate content (Davies and Reid 1979). All the analyses were carried out in triplicate.

Data collected from the field and laboratory were separately analyzed using analysis of variance and Duncan multiple range test.

Results and Discussion

Significant differences were observed for seed yield per plant, 100 seed weight and number of days to 50% flowering (Table 1). Average number of days to 50% flowering ranged from 104 in NSWS50 to 118 days in NSWS15. Pod length varied between 19.57 to 28 cm with accessions NSWS6 and 15 having the longest pods. Number of seeds per pod ranged from 12 in NSWS29 to 19.33 in NSWS44. The accession NSWS50 had the biggest seeds with an average 100 seed weight of 28.22g while NSWS48 had the least. The highest variability was observed in seed yield per plant which ranged between 24.79 in NSWS35 and 118.3g in NSWS48. Similar results were reported by Togun and Egunjobi,(1997) for African yam bean

Proximate compositions of African yam bean accessions are shown in Table 2. Two accessions NSWS50 and 15 had the highest protein content of 24.07 and 24.13% respectively with NSWS32 and 35 having the lowest content of 21.79 and 21.73% respectively. Fat content also ranged from 3.93% in NSWS35 to 5.20% in NSWS50. The fibre content was from 5.20 to 8.02% while ash content also ranged between 3.71 to 7.05%. The accession NSWS33 had the highest carbohydrate content of 51.70% with NSWS44 having the lowest content of 46.83%. The results compared well with those of Edem *et al* (1990); Adeparusi, 2001 and Ajibade *et al* (2005). The protein content of the cowpea variety evaluated was 23.87% which was not significantly different from those of three of the African yam bean accessions evaluated. The cowpea variety also contained significantly lower concentrations of fat, fibre and ash, but its carbohydrate content was significantly higher than those of the African yam bean accessions.

The anti-nutritional contents of the nine accessions and cowpea are shown in Table 3. The highest concentrations of trypsin inhibitor were observed in three accessions NSWS32, 44 and 35 with the values of 32.90, 31.58 and 31.58 Tiu/mg respectively, while NSWS33 had least concentration of 19.74 Tiu/mg. Phytate content varied from 3.44 to 4.20 g/100g with NSWS32 having the highest value. Tannin content ranged between 3.95 in NSWS33 and 7.83 in NSWS3. Similar range of values for the anti-nutrients was also reported by Ajibade *et al* 2005. When compared with cowpea, the African yam bean accessions had significantly (P>05) higher concentrations of the three anti-nutritional factors evaluated than cowpea. Significantly (P>05) higher concentrations of the anti nutrients were also observed in African yam bean than cowpea, soybean and groundnut (Fasoyiro *et al* 2006). The two accessions with relatively lower concentrations of the three anti-nutritional factors are NSWS33 and 29. These two accessions are however, low yielding with average yield per plant of 31.83g and 48.23g respectively (Table 1). Availability of high yielding and nutritionally superior African yam bean accessions would enhance its acceptability and improve the protein intake and widen the food base of the populace. Improved utilization of this neglected crop will also ensure the conservation of its rich genetic resources.

Conclusion

In the present study, high yielding accessions such as NSWS48 and NSWS50 and the two accessions with relatively low concentrations of anti-nutrients (NSWS33 and NSWS29) have been identified. Rrecombination of these accessions through hybridization and selection may result in improved and nutritionally acceptable African yam bean varieties. However, screening of larger germplasm has to be carried for the identification of more desirable genotypes.

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Table 1. Seed yield and other reproductive characters of nine African yam bean accessions.

Accessions	Days to flowering	Pod length (cm)	Seeds/pod	100 seed weight (g)	Seed yield/ plant (g)
SSSWN32	114b	28.00	17.33	25.30abc	69.69b
SSSWN44	107c	23.33	19.33	21.59cd	58.62bc
SSSWN48	106c	21.00	14.33	19.69d	118.33a
SSSWN33	107c	22.33	10.67	25.19abc	31.83cd
SSSWN50	104d	20.67	18.00	28.22a	105.14a
SSSWN3	113b	19.57	13.33	25.91ab	27.91d
SSSWN35	107c	26.83	15.33	27.07ab	24.79d
SSSWN15	118a	28.00	16.07	25.96ab	39.85cd
SSSWN29	115b	23.67	12.00	23.73bc	48.23bcd
Mean	110.07	23.71	15.22	24.74	58.26

Means in the same column followed by different letters are significantly different at 0.05 probability level.

Table 2. Nutrient contents of nine African yam bean accessions and cowpea (% DM).

Accessions	Protein	Fat	Fibre	Ash	Carbohydrate
SSSWN32	21.79f	4.02f	6.29e	7.05a	48.76de
SSSWN44	22.30e	4.82b	7.59b	6.85b	46.83h
SSSWN48	22.97c	4.40d	6.40d	5.78d	49.56c
SSSWN33	22.75d	4.02f	5.02g	4.21g	51.70b
SSSWN50	24.07a	5.20a	6.04f	6.30c	47.79fg

SSSWN3	22.38e	4.72c	8.02a	4.60f	48.27ef
SSSWN35	21.73f	3.93g	7.58b	7.02a	47.55g
SSSWN15	24.13a	4.15e	6.10f	5.27e	49.58cd
SSSWN29	23.84b	3.79h	6.51c	3.71h	49.18c
COWPEA	23.87b	1.50i	3.93h	3.80h	55.93a
Mean	22.98	4.06	6.35	5.46	49.52

Means in the same column followed by different letters are significantly different at 0.05 probability level.

Table 3. Anti-nutritional factors in nine African yam bean accessions and cowpea.

Accessions	Trypsin Inhibitor (Tiu/mg)	Phytate (g/100g)	Tannin (g/100g)
SSSWN32	32.90a	4.20a	7.67a
SSSWN44	31.58b	3.86c	7.45ab
SSSWN48	26.32e	3.98bc	6.90bc
SSSWN33	19.74h	3.54d	3.95d
SSSWN50	28.29d	3.91c	6.79bc
SSSWN3	28.95c	4.08b	7.83a
SSSWN35	31.58b	3.99bc	7.78a
SSSWN15	25.66f	4.04b	6.25c
SSSWN29	21.05g	3.44d	4.15d
COWPEA	12.05i	1.65e	2.85e
Mean	25.81	3.67	6.16

Means in the same column followed by different letters are significantly different at 0.05 probability level.

Evaluation of Flamboyant seed meal as an alternative feedstuff (protein source) for rabbit feeding

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Abstract
In an 84 days feeding trial, twenty-four growing crossbred rabbits of New Zealand White, California and Chinchilla breeds of both sexes with average initial weight of 663.4 ± 18.86 g (Mean ± SEM) were randomly assigned to six dietary treatments in 2 x 3 factorial design. Dietary treatments were 2 protein sources with 3 levels of dietary supplementations each. A basal diet was based on maize, palm kernel meal, groundnut cake meal (GNC) and fishmeal diet was formulated. Flamboyant seed meal (FSM) replaced the groundnut cake meal in the basal diet on weight for weight basis in Diets I, II and III in proportion of 0, 50 and 100 g/kg. The first three diets were fortified with lysine and methionine at the rate of 1.5 g/kg for each amino acid, which are the supplemental levels needed to meet rabbit nutrient requirement for these amino acids in Diet I. Diet IV was analogous to Diet I, V to II and VI to III except in synthetic amino acid supplementation. A complete replacement of GNC by FSM was achieved. Growing rabbits responded non-significantly ($p > 0.05$) to incremental FSM intake in feed intake, weight gain, feed conversion and protein efficiency ratio and this response was independent of amino acid supplementation. A non-significant interaction occurred between protein source and amino acid supplementation for all response criteria. The amino acid supplemented diets had a comparatively better feed conversion ($p = 0.0344$) than the non-supplemented diets. Data on weekly body weight changes were pooled across each supplementation level and described using the linear regression method. The slope of regression of body weight changes (y) (g/rabbit) depending on weeks (g/week) was highest on 50g/kg FSM (Diet II and V) and lowest on 100g/kg FSM (Diet III and VI) (70.49g vs. 65.22) respectively.

Introduction
The rearing of rabbits in developing countries is a measure for producing high quality meat at a reasonable price to reduce protein deficiency and other ailments associated with insufficient protein intakes in humans. The feeding and nutrition of rabbits or any other monogastric animals requires that feed ingredients, which are potential nutrient carriers need to be supplied in adequate amount and in a definite proportion to ensure the supply of balance of nutrients. Common legumes such as soybean meal, groundnut cake and cottonseed meal are in short supply in the tropics and often not available for sustainable animal production, hence, there is an attendant high cost of these ingredients. Legumes are excellent sources of nutrients to man and animal species. *Delonix regia* L., commonly called Flamboyant is a widely grown ornamental leguminous plant, which produces 25-40 cm long pods containing large number of seeds of moderately high crude protein content (Grant *et al*., 1991). Analysis of seed samples of flamboyant in our laboratory revealed that the raw seed contained on % basis: 90.2 dry matter, 36.92 crude protein, 11.39 crude fibre and 4.17 ether extract. Flamboyant seed meal compare favourably with mechanically extracted groundnut cake meal in terms of crude protein content (NRC, 1994). The crude protein content of mechanically extracted groundnut cake meal is approximately 40% (NRC, 1994). Grant *et al*. (1991) studied the haemagglutination activity of *D. regia* seed extract in rabbit, cattle, rat and human bloods and reported that the seed extract exhibited low haemagglutinin activity and contained non-toxic

lectins. *D. regia* in spite of its potential to serve as a livestock feed and its relative abundance has remained largely unexploited and underutilized for animal nutrition. The objective of this study therefore is to assess the effect of raw flamboyant seed meal (FSM) on the growth performance in growing rabbit with or without synthetic amino acid supplementation.

Materials and methods

In 2 x 3 factorial design, twenty-four growing crossbred rabbits of New Zealand White, California and Chinchilla breeds of both sexes with average initial weight of 663.4 ± 18.86 g (Mean ± SEM) were randomly assigned to six dietary treatments. Rabbits were weighed and uniformly distributed to their respective hutches (treatments) on weight basis. Rabbits were individually housed in hutches with a dimension of 76cm x 62cm x 42cm (L x B x H) on wire screen floors. Each diet was offered to 4 hutches of individually pen rabbits at approximately 4% body weight as dry matter intake assuming 88% dry matter for the individual feed. Water was also provided unrestrictedly. Feed intake was usually adjusted upwards on weekly basis based on the weekly body weight changes. Feed intake and consequently feed conversion was calculated as hutch averages. Rabbits were individually weighed on weekly basis until the end of the experiment. Daily voluntary feed intakes were monitored.

Ripe flamboyant pods were harvested and pods were split to remove seeds. The seeds were ground in a hammer mill into a meal form through a 3 mm die. The basal diet was formulated to meet the nutrient requirement of growing rabbit (NRC, 1977). The basal diet was based on maize, palm kernel meal, groundnut cake meal (GNC) and fishmeal. Amino acid and other nutrients composition of diets were calculated based on published values from Degussa (2005) and NRC (1998). Table 1 showed the ingredient composition of the experimental diets. Flamboyant seed meal (FSM) replaced the groundnut cake meal on weight for weight basis in Diets I, II and III in proportion of 0, 50 and 100 g/kg in the basal diet. A complete replacement of GNC by FSM was achieved. The first three diets were fortified with lysine and methionine at the rate of 1.5 g/kg for each amino acid, which are the supplemental levels of these amino acids required to meet rabbit nutrient requirements guide of NRC (1977). Synthetic amino acids were supplemented into the diets as a replacement for corn bran. Diets IV to VI were the same as Diets I to III except in the supplementation of synthetic amino acids (Table 1). All ingredients with the exception of the variable ones (GNC, corn bran, FSM, lysine and methionine) was mixed as a single lot and divided into two equal parts. One part was mixed with corn bran, lysine and methionine in respective proportion. This part was further divided into three parts GNC and FSM were added accordingly. The second part also divided into three portions and corn bran, GNC and FSM were added in a manner similar to the first part. Each diet was then mixed again and bagged. The experiment lasted for 12 weeks.

Dry matter, crude protein, crude fibre, ether extract and crude ash of FSM were performed according to the AOAC (1990) procedure. Data were subjected to routine ANOVA from General Linear Model procedures using the software package SPSS 13.0 for windows. A linear regression on growth of rabbits [y, g/rabbit] depending on weeks [x, growth over time] was calculated.

$$y = a + bx$$

where a =constant and b=slope of the regression line.

Treatment averages was considered as one data point in the regression analysis. Parameter of goodness of fit were r^2 and Sy.x. The sy.x values are the standard deviations of the residuals, which are the distances between the individual points from the calculated line. Linear regression was calculated using GraphPad Prism 4.02 (GraphPad Software Inc., San Diego, California). This experiment was conducted at the Rabbit Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife.

Results and Discussions

Growing rabbits responded non-significantly ($p > 0.05$) to incremental FSM in feed intake, body weight gain and protein efficiency ratio in the 84 days of experiment and this response was independent of amino acid supplementation. Table 2 showed the growth performance characteristics of rabbits fed graded level of FSM as a replacement for GNC. Amongst the performance characteristic, only feed conversion ratio was significantly affected by dietary amino acid supplementation. The amino acid supplemented diets had a comparatively better feed conversion ($p = 0.0344$) than the non-supplemented diets and this observation was independent of the dietary protein source. The average weekly feed intake (g/rabbit) over the period was therefore 360.19 ± 9.37 (mean ± SEM). Average weekly weight gain (g/rabbit) ranged from 82.40 in Diets I to 72.14 in Diet VI. A non-significant interaction occurred between protein source and amino acid supplementation for all response criteria.

Since amino acid supplementation did not result in improved performance in most observed response criteria, data on weekly body weight changes were pooled within each graded levels and used for further calculation (Figure 1). The linear regression model explained 79 to 82% of the variation observed in weekly body weight changes. The linear model provided a good fit for the data as reflected in the parameter for goodness of fit (Table 3). The slope of regression for weekly body changes was highest for rabbits fed 50g/kg FSM (70.49g) as a partial replacement for GNC and lowest on rabbits fed 100g/kg FSM as a complete replacement for GNC (65.22g). The 95% confidence interval of the slope of body weight changes overlap widely across all treatments and slopes differ significantly from zero ($p < 0.001$). Slopes were not significantly different from each other ($p = 0.5453$). The y intercepts were likewise not significantly different ($p = 0.5818$). The pooled slopes and intercepts were therefore 68.54g and 569.54g respectively. The slope quantifies the steepness of the line. It equals the change in Y for each unit change in X. The slope of regression is the rate of gain and the efficiency with which the ingested feed is converted to lean gain. Table 3 showed the estimated parameter for body weight changes depending on weeks. The feed intakes, body weight gains and feed conversion in the present study are in good agreement with those previously reported in literature for rabbits of similar weight range (Akinfala et. al., 2003; Odeyinka et. al., 2007).

The findings of the present study are also consistent with that of Biobaku (1993). Biobaku (1993) fed raw or cooked FSM as a replacement for maize in growing rabbit diet over a period of 8 weeks and observed a non-significant difference in the growth rate irrespective of the processing method. The observation of non-toxicity of FSM in the current study even in raw form for rabbits is also consistent with the findings of Biobaku (1993), as no mortality was recorded in feeding this unconventional feedstuff over a period of 84 days. It was concluded that flamboyant seed meal could completely replace groundnut cake meal as a protein source for rabbits without compromising growth performance based on the slope of regression of body weight changes depending on weeks.

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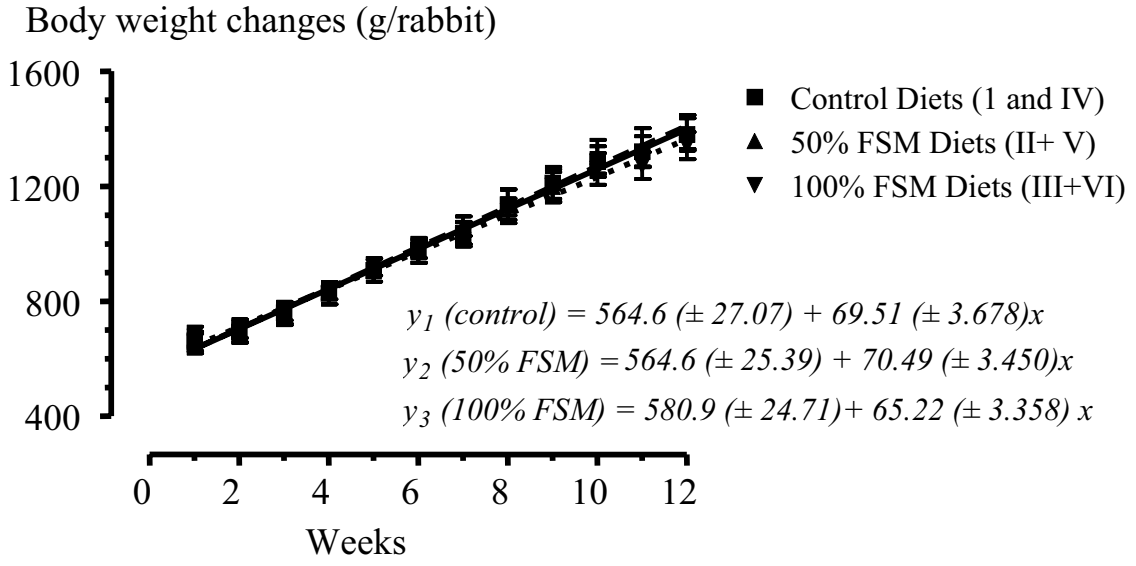

FIGURE 1: Body weight changes depending on weeks of growing rabbits fed graded levels of flamboyant seed meal (n = 4 hutches of 4 rabbits per treatment)

Table 1. Gross and chemical compositions of the experimental diets (g/kg)

	Diet I[a]	Diet II	Diet III	Diet IV	Diet V	Diet VI
Maize	130	130	130	130	130	130
Palm kernel meal	523	523	523	523	523	523
Rice bran	70.5	70.5	70.5	70.5	70.5	70.5
Cornbran	106	106	106	109	109	109
Groundnut meal	100	50	0	100	50	0
FSM	0	50	100	0	50	100
Fish meal	28	28	28	28	28	28
Biogro	12	12	12	12	12	12
Bone mael	20	20	20	20	20	20
Salt	5	5	5	5	5	5
Vitamin-premix	2.5	2.5	2.5	2.5	2.5	2.5
L-Lysine	1.5	1.5	1.5	-	-	-
DL-Methionine	1.5	1.5	1.5	-	-	-
	1000	1000	1000	1000	1000	1000
Calculated analysis (%)						
Crude protein	18.4	17.9	17.4	18.4	17.9	17.4
Metabolisable energy (kcal/kg)[b]	2546	2541	2535	2553	2548	2543
Crude fibre	13.7	13.9	14.2	13.7	14.0	14.2
Ether extract	6.4	6.6	6.8	6.4	6.6	6.8
Crude ash	3.9	3.9	3.9	3.9	3.9	3.9
Calcium	0.7248	0.7248	0.7248	0.7249	0.7249	0.7249
Phosphorus	0.3795	0.3795	0.3795	0.3808	0.3808	0.3808

[a] Amino acids values of the basal diet of Diet I %: lysine 0.7114; threonine 0.5655; methionine 0.4607; cysteine 0.2540; tryptophan 0.1417; isoleucine 0.6143; valine 0.8280; leucine 1.1677; phenylaalnine 0.7694; histidine 0.3863 and arginine 1.5541. Non-inclusion of lysine and methionine in basal Diet IV reduced the calculated value of lysine and methionine to 0.59557 and 0.31126, while other amino acid contents were relatively unaffected.

[b] Metabolisable energy of *Delonix regia* was calculated using the prediction equation of Janssen (1989): y (ME) = 29.68 x DM + 60.95 x EE – 60.87 x EE

Table 2. Performance characteristics of growing rabbits fed incremental flamboyant seed meal with or without amino acid supplementation

								P (ANOVA)	
Parameter	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI	SEM	Protein source	AA suppl.[1]	Protein source x AA suppl.
Final body weight (g/rabbit)	1630.08	1599.89	1544.09	1545.01	1569.70	1542.26	35.94	0.6345	0.8872	0.9132
Initial body weight (g/rabbit)	658.75	650.00	676.67	662.50	655.00	677.50	18.86	0.9415	0.8970	0.9992
Total weight gain (g/rabbit)	971.33	949.89	867.42	882.51	914.70	864.76	26.65	0.4739	0.6062	0.8303
Body weight gain (g/rabbit/week)	82.40	81.63	72.29	74.13	77.86	72.14	1.86	0.4739	0.6062	0.8303
Total feed intake (g/rabbit)	4461.04	4311.42	4287.67	4305.88	4189.50	4377.92	112.48	0.4974	0.9958	0.2608
Feed intake (g/rabbit/week)	371.75	359.28	357.31	358.82	349.13	364.83	9.37	0.4974	0.9958	0.2608
Feed conversion ratio (g/g)	4.49	4.42	4.93	4.86	4.48	5.06	0.10	0.4854	0.0344	0.5612
Protein intake (g/rabbit/week)	68.40	64.31	62.17	66.02	62.49	63.48	1.75	0.3698	0.8494	0.2602
Protein efficiency ratio (g/g)	1.22	1.27	1.17	1.13	1.25	1.14	0.02	0.6901	0.1141	0.6851

[1]AA suppl. denotes amino acid supplementation

Table 3. Estimated parameter of body weight changes depending on weeks of growing rabbits fed graded levels of flamboyant seed meal in 84 days (n = 8 of 8 rabbits per treatment)

Parameter		GNC Diets (I+IV)	50%FSM Diets (II+ V)	100% FSM Diets (III+VI)
	a	564.6 ± 27.07	564.6 ± 25.39	580.9 ± 24.71
	b	69.51 ± 3.678	70.49 ± 3.450	65.22 ± 3.358
95% Confidence intervals				
	a	510.7 to 618.4	514.1 to 615.1	531.7 to 630.2
	b	62.19 to 76.82	63.63 to 77.35	58.53 to 71.91
Goodness of Fit				
r^2		0.7916	0.8162	0.8214
Sy.x		124.4	116.7	106.2

The Potential of Biotechnology in Legume Processing: The African yambean (*Sphenostylis stenocarpa L.*) example.

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Abstract

The tropical African yambean (AYB), *Sphenostylis stenocarpa,* is a hardy protein rich underutilized legume of Africa. Oligosaccharides, antinutrients, and the extensive and energy consuming cooking time (4 – 6 h), among other factors, limit the food use of African yambean as an important source of protein and energy. Flatulence and diarrhoea are common after the consumption AYB, but more severe symptoms have been reported. The objective of this thesis work was to improve the nutritional value of African yambean and to promote the use by subjecting the seeds of three varieties of African yambean to non-traditional methods of processing. These methods are expected to reduce antinutrients to a low level, and processes should be less energy and time consuming than the traditional cooking procedure. Black (AYB-black), marble (AYB-marble) and white (AYB-white) African yambean varieties were examined. The proximate analyses revealed a protein content of 22 – 25 g 100 g^{-1} dry matter. This implies that if AYB was the only source of protein, an adult man need between 208 to 236 g AYB to meet the WHO daily protein requirement. Fermentation with the Lactic acid bacteria *Lactobacillus plantarum* resulted in an improvement in nutritional quality of AYB: Protein and starch contents increased by 6 – 20 and 0 – 6 %, respectively. The flatulence causing α-galactosides, and the potentially very toxic cyanogenic glycosides, were reduced by about 85 %. Fermentation was also carried out with the tempeh-fungus *Rhizopus oligosporus*. If the procedure for soybean was used, the promary nutrients remained high. The antinutrients were significantly reduced. The flatulence causing α-Galactosides were nearly completely (93 – 99 %) removed. tempeh production processes were clearly more effective than traditional cooking in improving nutritional quality. Fermentation processes thus not only can substantially improve the nutritional quality of African yambean but can also provide important economical and environmental benefits. Both processes are proposed for both household and industrial uses.

Key Words: Yambeans, *Rhizopus oligosporus*, tempeh, antinutrients, lactobacillus.

Background Information:

The term has been used in a broad sense to describe the whole range of methods, both ancient and modern, used to manipulate organic materials to reach the demands of food production. So the term could be defined as, "The application of indigenous and/or scientific knowledge to the management of (parts of) microorganisms, or of cells and tissues of higher organisms, so that these supply goods and services of use to the food industry and its consumers (Bunders *et al.,* 1996). The earliest applications of biotechnology were in the food processing and agricultural industry. The first use of biotechnology to convert a food source into another form was fermentation. It was used in this time period to produce leavened bread; although the process of fermentation was not fully understood until Louis Pasteur's work in 1857. In many parts of the world, biotechnology is still being employed

in food processing either on household or industrial scale. A prominent example is legume processing in many Asian countries. This has resulted in products such as tofu, tempeh, and others from soybean seeds and many other legumes. The same applies to many African countries were different species of legumes are processed by fermentation (Steinkraus, 2002). Recently, there have been suggestions to the effect that under-utilized, hard-to-cook legumes could be processed by some of these methods in other to enhance their use domestically and industrially. The problem of protein malnutrition persists in Africa partly because animal protein is unaffordable to the majority of the population. Interest is rising in developing countries in low-cost, protein rich plant foods as replacements for, or supplements to, the expensive and frequently scarce animal foods.

The African yambeans:

Legumes have a high potential in this respect because they are rich in protein. Many legumes are, however, underutilized. In this respect, the African yambean (*Sphenostylis stenocarpa*) deserves considerable attention. The African yambean is among the less known legumes of the humid tropics. It is cultivated in West Africa for its seeds and in East and Central Africa mainly for its tubers. In southern Nigeria, African yambean seeds were preferred to other legumes in the past because they are filling, and for unclear cultural reasons. Cowpea is now the preferred legume (Azeke *et al*., 2005). The brown and black seeds are preferred in the lowlands, the light coloured seeds in mountainous Nigeria.

Nutrient Composition of African Yambean:

The chemical composition of African yambean (AYB) has been addressed by several workers (Edem *et al*., 1990; Apata and Ologhobo, 1990; Adeyeye, 1997). A protein content of between 20 and 29% has been reported. This is lower than that of soybean (38%), but the lysine proportion in the protein is reported to be equal or higher than in soybean (Evans and Boutler, 1974; Edem *et al*., 1990; Ene-Obong and Carnovale, 1992; Agunbiade and Longe, 1999).

Limitations to the use of African yambean:

There are, however, at least two major constraints hindering a more extensive use of African yambean in the nutrition plan of Nigeria, (1) the presence of antinutrients and (2) the extremely long cooking time (6 – 8 h) required to render the beans palatable.

***Long cooking time and environmental degradation*:**

African yambean seed coats are very hard resulting in long cooking time and high energy requirement. To obtain the desired texture, Ogbonna *et al*. (2001) had to cook the African yambean seeds for as long as 8 – 10 h. Asuzu and Undie (1986) even suggested 12 – 14 h boiling in order to obtain an agreeable texture. The long cooking time implies a high requirement of cooking fuel or fire wood which in turn has a negative effect on the environment and is costly.

Health problems associated with African Yambean consumption:

The problems associated with African yambean consumption can be divided in two groups, namely acute and chronic effects. Efforts were made to find out from consumers of African yambean in Edo State (Southern Nigeria) about possible health problems associated with African yambeans. Administration of questionnaires

was not possible due to low literacy level. Questioning was therefore done orally and in groups (Azeke *et al*., 2005). At least seven groups with at least fifteen people per group were questioned in different clans. The most common method of processing was boiling in water for 6 – 8 h and adding local seasoning shortly before eating. The problems often observed by these consumers are, in order, of frequency: flatulence, stomach cramp, diarrhoea, and dizziness. Although each problem has been observed by all the groups questioned, the frequency varied. Flatulence seems to be a common symptom when the black and the brown varieties are consumed and sometimes with the white variety. Stomach cramp was also often observed with all varieties, but frequency was lower.

Biotechnological attempts to promote the utilization of African yambean:

Before now much emphasis has been given to proximate composition, protein availability and functional properties of African yambean and the effect of traditional processing (soaking, dehulling and heat treatment) (Apata and Ologhobo, 1990; Oshodi *et al*., 1995; Apata and Ologhobo, 1997; Oshodi *et al*., 1997; Nwinuka *et al*., 1997; Adeyeye *et al*., 1998; Agunbiade and Longe, 1999; Akintayo *et al*., 1999). The serious problem of long cooking time was not addressed in these reports. There are very few reports on alternative biotechnological processing methods. Njoku *et al*. (1989) investigated the effect of various pre-cooking treatments on the cooking time of African yambean. These are: soaking for 12 h in water, addition of 1% potash (potassium carbonate, K_2CO_3) or 4% NaCl. They reported the possibility of 50% reduction in cooking time in all conditions. The effects of such treatments on nutritional quality were, however, not considered. It is probable that soaking in 1% potash, an alkaline solution, allows Maillard reaction to occur during cooking rendering some essential amino acids unavailable. In other works, a vegetable milk product was prepared from a blend of spontaneously fermented African yambean and maize seeds (Nnam, 1997). Proximate and antinutrient compositions as well as sensory evaluation were reported. Antinutrients were low, protein content was about 2 % and acceptance among test panelist was modest. An alkaline fermented product was made from African yambean seeds by Ogbonna *et al*. (2001). Protein content was about 30 % with high content of calcium, phosphorus, iron, zinc and potassium. It is a major shortcoming of this process that the seeds still had to be cooked for 8 - 10 h before fermentation. This means that there was no time and energy saving. The effects of such fermentation on nutritional value were not reported. Njoku *et al*. (1991) first produced a tempeh-like product using *Rhizopus oligosporus* from African yambean. A surrogate meat pie made from this product received high acceptance among test panellist. Emphasis was on making meat pie formulations, sensory evaluation and acceptance. It is important to note that neither nutritional, quality changes accompanying fermentation nor the nutritional value of African yambean tempeh was addressed in any detail.

In the light of the existing shortcomings in the processing and food quality of African yambeans, seeds were subjected to unconventional processing methods in order to effectively reduce antinutrient contents. Another main objective was to reduce energy requirement for processing. Moreover, the application of the processes should be feasible in households and small scale industries (Azeke, 2003).

Recent Developments

Three varieties of African yambean, namely black (AYB-black), marble (AYB-marble) and white (AYB-white) yambeans, cultivated in Edo State in the Midwestern part of Nigeria, were used in this project.

Lactic acid fermentation using Lactobacillus plantarum

The fermentation procedure was essentially as described by Azeke *et al.* (2005). The seeds were washed in deionised water and soaked also in deionised water for 24 h at a bean-to-water ratio of 1 to 3. The seeds were then drained, washed several times and ground into slurry using a Warring blender. The deionised water was not boiled. Portions of 1 kg were inoculated with 10 mL suspension of *Lactobacillus plantarum* mixed-culture, mixed thoroughly and incubated at 30°C in large containers for 48 h with occasional stirring. Another batch was run simultaneously without inoculation spontaneous fermentation). Samples were taken at 0, 6, 12, 22, 28, 34 and 48 h.

"Tempeh" production using Rhizopus oligosporus

Preparation of Spore suspension: *Rhizopus oligosporus* was grown on 12 mL potato dextrose agar in petri dishes at 30°C for 7 days. Spores were harvested by adding 10 mL sterile water and scraping with a spatula. The suspension was centrifuged at 3000 rpm for 1 min and the sediment containing the spores was resuspended in 5 mL sterile water, to give suspensions containing about 10^6 spores/mL. The suspension was stored frozen at -20°C until required (usually within three days).

Traditional "tempeh" procedure: Tempeh was produced by the traditional procedure used for soybean. Dehulled bean samples were soaked overnight in deionised water, the soak water was drained off and the seeds were cooked for 30 min in boiling deionised water. The seeds were drained and allowed to cool down to room temperature. Portions of 200 g were inoculated with 5 mL spore suspension, mixed and then packed tightly in polythene bags which were previously manually perforated using a pin. The pores on the polythene bags were about 1 cm apart. The samples were kept in an incubator at 30°C and 75 % humidity for 48 h.

AZEKE'S METHOD FOR *"tempeh" PRODUCTION*.

In the modified procedure (Azeke *et al*., 2007a), acidified water was used for soaking and cooking. The pH of the sample at inoculation either delays or enhances the proliferation of accompanying microflora (Nout and Rombouts, 1990; De Reu *et al*., 1995). In order to reduce the pH at inoculation, the marble variety (AYB-marble) was subjected to two pre-fermentation treatments. The treatments are (1) soaking in 1% citric acid or citrate buffer, (pH 4.0, 4.5 and 5.0) for 24 h, draining of soak solutions, washing several times with tap water followed by cooking in deionised water 30 min and (2) soaking in 1% citric acid or citrate buffer, (pH 4.0, 4.5 and 5.0) 24 h, draining of soak solutions, washing several times with tap water followed by cooking in fresh soak solutions (20 min in buffer and 15 min in 1% citric acid).

Table 1: Change in pH after soaking and cooking in different media

Solutions	Treatments	
	Soaking and cooking[1]	Soaking and cooking[2]
	pH	
1% Citrate (pH 2.31)	5.33	3.85
pH 4.0	5.74	4.74
pH 4.5	5.94	5.12
pH 5.0	6.19	5.81
Deionised water	6.82	6.81

1. Sample pH after soaking for 24 h, soak media drained and sample cooked in fresh water for 30 min
2. Sample pH after soaking for 24 h, soak media drained and sample cooked in fresh solutions

Microbiological and chemical assay of fermented products:

The products of lactic acid and tempeh-type fermentation of African yambean seeds were subjected to standard assay procedures to determine microbial load, nutrient and anti-nutrient contents of products. Parameters determined included lactic and acetic acid production (specifically for lactic acid fermented seeds), lactic acid bacteria and other microbial growth, total protein, total lipids, ash, starch and dietary fibre (for the primary nutrients). Anti-nutrients determined included amylase and trypsin inhibitor activities, tannin, phytate, cyanogenic glycosides and the flatulence causing oligosaccharides.

EFFECT OF FERMENTATION WITH *Lactobacillus plantarum* ON MICROBIAL, AND ACID CONTENTS OF AYB SEEDS

In this experiment, lactic acid fermentation, with or without *Lactobacillus plantarum* was carried out. In the first few hours of fermentation, an increase in volume of the samples was observed probably due to gas formation. As fermentation progressed, consistency changed towards "fluid". No major colour change was observed. Generally, the lactic acid production and content (D-, L- and total) of the inoculated samples were significantly higher than the uninoculated. Significantly less ($P<0.05$) acetic acid was produced with inoculation than without inoculation. While the acetic acid concentration levelled off after 12 h fermentation of the inoculated samples, acetic acid continued to increase in the non-inoculated samples. The higher acetic acid levels of the beans slurry fermented without *Lactobacillus plantarum* suggest that the indigenous lactic acid bacteria of AYB are heterofermentative and that inoculation with *L. plantarum* (a homofermentative bacterium) had an inhibitory effect on them (Laniewska and Warminska, 1999). The pH during lactic acid fermentation dropped rapidly during the first 10 – 20 h in all varieties. This drop followed the same pattern for the inoculated and spontaneously samples (figure 1).

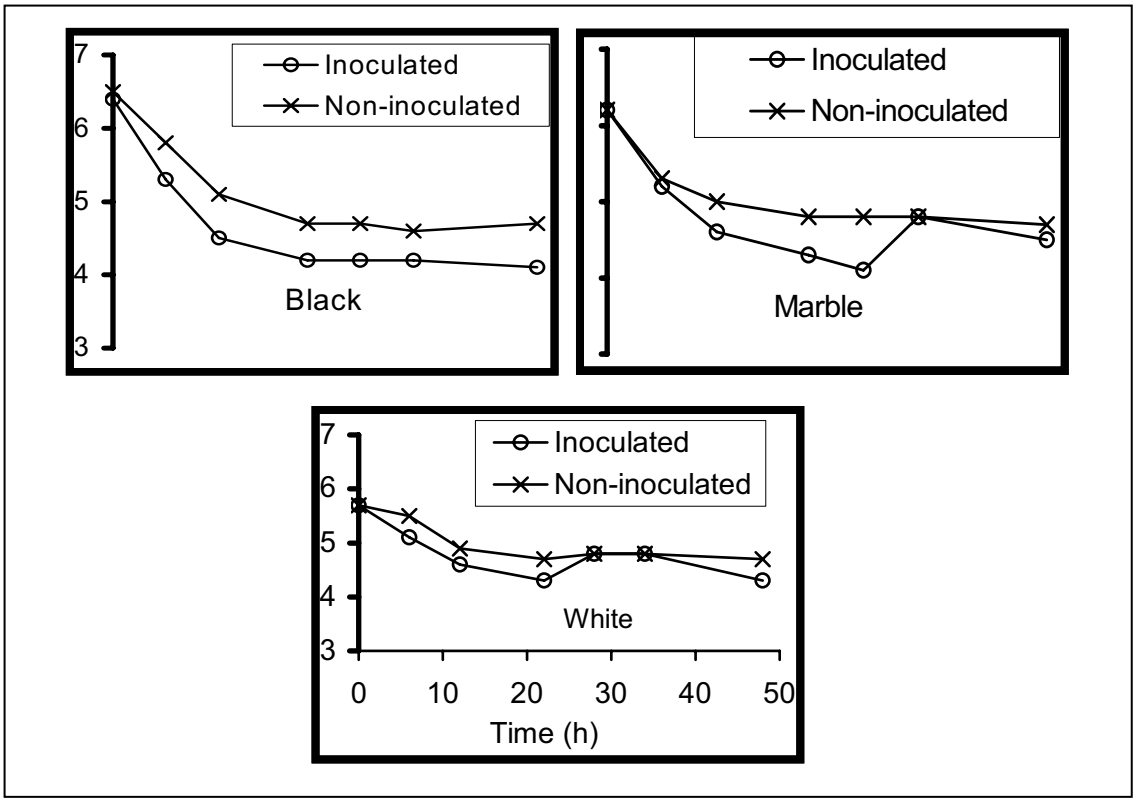

Figure 1: pH change during lactic acid fermentation of slurries of seeds three African yambean varieties.

The time course of *lactobacteria* growth during lactic acid fermentation was also determined. There was an increase in lactic acid bacteria counts in both the inoculated samples and non-inoculated samples up to 28 h of fermentation after which the lactic acid bacteria seemed to stop growing. Total bacteria count of the fermented beans is similar to the lactic acid bacteria count. This suggests that total bacteria count during fermentation is accounted for by lactic acid bacteria. The *enterobacteria* count as determined on Mckonkey agar was below detection limit throughout the fermentation period. Fungal and yeast count was also below detection limit after 12 h fermentation for all fermented samples. The samples were soaked for 24 h in water before processing, this time was long enough to initiate lactic acid fermentation which can suppress the growth of other microorganisms such as enterobacteria (Muliyowidarso *et al*., 1991). Inoculation with *L. plantarum* did not make any difference on the effect of fermentation on yeast, fungal or enterobacterial growth.

EFFECT OF FERMENTATION WITH *Lactobacillus plantarum* ON NUTRIENTS AND ANTINUTRIENTS CONTENTS OF AYB SEEDS

There was a 6 – 25 % increase in protein content as a result of lactic acid fermentation and 10 – 15 % increase due to cooking for 4 h. This increase may be accounted for by a decrease in solid matter. There was a marginal increase ($P>0.05$) in total lipid during lactic acid fermentation. Total starch and ash were also only marginally changed (0 – 6 %) by lactic acid fermentation, which, however, resulted in a significant reduction in dietary fibre. The reduction in dietary fibre was higher in samples fermented without *Lactobacillus plantarum*.

Contents of some antinutrients in samples subjected to lactic acid fermentation were determined. With exception of phytic acid, lactic acid fermentation was remarkably effective in reducing antinutrients. A mere 20 % of the original trypsin inhibitor activity remained after fermentation of the black and white African yambean seeds inoculated with *L. plantarum* or not. With the marble AYB variety, trypsin inhibitor activity was negligible after fermentation. The same pattern was observed with alpha-amylase inhibitor activity, although with a lower inactivation (50 – 60 %). No tannin was at all detected in fermented AYB-white seeds. In the other AYB varieties 50 and 60% tannin removal was achieved by lactic acid fermentation. As for phytic acid, there was a significant reduction ($P<0.05$) in the phytic acid of AYB-black. Phytic acid content either increased, as in AYB-marble or remained relatively constant as in AYB-white. Lactic acid fermentation resulted in near complete reduction of the cyanogenic glycoside content of AYB seeds. The flatulence causing α-galactoside (oligosaccharide) was nearly completely removed by lactic acid fermentation with or without *L. plantarum*. Generally, lactic acid fermentation was found to be more effective than traditional cooking in reducing most of the anti-nutrients including total α-galactoside.

Tempeh from African yambean seeds

The tempeh production processes provide a good alternative to the traditional cooking procedure for the African yambean. The most important step is the sample inoculation with spores of *Rhizopus oligosporus* and the subsequent incubation (fermentation). Unlike in lactic acid fermentation, tempeh fermentation is usually preceded by some treatments such as dehulling, soaking and cooking.

Figure 2: Tempeh produced from AYB seeds

These treatments are necessary to make the bean seeds a favourable substrate for fungal growth and fermentation. A tempeh-like product was obtained by fermentation of AYB. Visible fungal growth was observed at about 24 h incubation period and by 36 h the beans, except AYB-white, were bound together as cake with a

fungal odour. Fungal growth was evidently inhibited in AYB-white. No sporulation was observed at the end of 48 h fermentation of all varieties.

Microbial quality of tempeh

Bacterial growth was inhibited in the sample treated with 1% citric acid both in the inoculated and non-inoculated samples. Similar finding was reported by Ruiz-Teran and Owen (1996) who used 0.11M lactic acid. It appears that higher pH favoured the growth of bacteria. The results presented in this work show that there is therefore no major hygienic risk from tempeh produced from the acidified seeds. A recent report by Yee-Lean (2002) showed the antibacterial activities of sodium citrate and potassium acetate. Using appropriate media, tempeh samples were tested for the parameters shown in the table 2.

Table 2: Partial characterization of microflora of tempeh made from AYB

	1% citric acid	pH 4.0	pH 4.5	pH 5.0	Normal (water)
Spore forming	-	+	+	+	+
Enterococcus	-	-	-	-	-
L-lactic acid forming	-	-	-	-	-
D-lactic acid forming	-	+	+	+	+
Catalase activity	-	+	+	+	+
Clostridium	-	-	-	-	-
B. cereus	-	+	+	+	+
Enterobacteriaceae	-	-	-	-	-

Worth noting is the presence of *Bacillus cereus* which could pose health problems when tempeh is not properly prepared. Catalase activity and spore formation are also pointers to *Bacillus cereus*. Samson *et al*. (1987) reported the presence of *B. cereus* in 84 of 110 commercial tempeh obtained in the Netherlands. Tempeh is not consumed in its raw form but usually in the form of slices which are deep fried in oil or cut into pieces and cooked in soups and many other dishes. Generally pathogens in tempeh are killed during the preparation of foods before consumption. However, the risk of undercooking and cross-contamination still exist in the home (Samson *et al*., 1987). The pre-treatment of seeds with 1 % citric acid results in bacteria-free tempeh ensuring safety, but the absence of bacteria also means the absence of vitamin B12 formation.

The modified tempeh procedure

The bacterial load of AYB-tempeh, produced by the traditional process was high (10^9 Most Probable Number g^{-1}, MPN g^{-1}) while tempeh made by the modified process was bacteria free and of lighter colour than the other tempeh. As mentioned earlier, fungal growth on the AYB-white was inhibited in the traditional procedure. However, in the modified procedure fungal growth improved as the seeds were bound together into a cake by fungal mycelium after 48 h.

The effects of tempeh production on primary nutrient composition

Raw, dehulled, dehulled-soaked-cooked seeds and finally tempeh made from the seeds of AYB were analysed. There were no varietal differences in the response of seeds to treatments; therefore, the results shown in Table 3 are means of seeds of the three varieties. The protein contents of the three AYB varieties were not significantly affected by dehulling ($P>0.05$), while soaking and cooking of dehulled seeds led to an increase in protein concentration ($P<0.05$). Fermentation with Rhizopus resulted in slight reduction (4 - 6 %) in protein concentration. Cooking for 4 h resulted in about 10 - 14 % increase in protein concentration. The starch concentration of AYB increased slightly as result of dehulling followed by a 5 - 10 % increase after soaking and cooking. The increase in starch concentration after tempeh fermentation was probably due to a decrease in dry matter content. For the total dietary fibre, dehulling resulted in a 50 % increase, which may explain the slight increases in protein and starch. Subsequent cooking and fermentation of the dehulled seeds resulted in a gradual increase in dietary fibre content. This increase may be accounted for by the decrease in total dry matter content. The net reduction in total crude lipids during tempeh production was accounted for mainly by dehulling. The slight decrease in lipids during fermentation indicates that it was probably being used as carbon source by Rhizopus. For the ash content, dehulling, soaking and cooking resulted in a 16 - 30 % reduction, probably due to leaching. This was followed by a 4 - 10 % increase after fermentation. It has been reported that Rhizopus spp produces a variety of enzymes such as carbohydrases, lipases, proteases and other enzymes (Nout and Rombouts, 1991) the activities of which affect the contents of their substrate during fermentation. The presence of protease and lipase activities was only recently confirmed (Ruiz-Téran and Owen, 1996).

Table 3: Changes in the proximate composition (*g kg^{-1}dm*) of seeds of African yambean during tempeh production and traditional cooking

	Protein	Starch	Lipid	Ash	Dietary fibre
Raw	232.8 ± 18.0^{a}	446.6 ± 27.4^{ac}	16.4 ± 1.6^{a}	32.0 ± 3.7^{a}	151.9 ± 17.0^{cd}
Dehulled	234.3 ± 14.8^{a}	502.6 ± 9.7^{b}	14.1 ± 2.1^{a}	30.1 ± 4.6^{a}	79.1 ± 4.7^{a}
Soaked/cooked (30 min)	253.5 ± 10.3^{a}	475.5 ± 12.2^{bc}	14.8 ± 1.6^{a}	23.0 ± 2.1^{a}	111.4 ± 9.5^{b}
Tempeh (48h)	247.7 ± 15.2^{a}	468.2 ± 11.2^{bc}	14.1 ± 3.0^{a}	24.9 ± 4.6^{a}	132.3 ± 11.4^{bc}
Cooked (4h)	259.3 ± 17.6^{a}	408.3 ± 17.6^{a}	28.0 ± 1.1^{b}	28.2 ± 7.5^{a}	170.5 ± 2.9^{d}

Results are means of the three varieties samples ± standard deviation

The values in columns with different letters are significantly different from each other ($P<0.05$).

dm: dry matter

(Source: Azeke *et al.*, 2007a)

The effects of tempeh production on antinutrients composition

The effects of pre-fermentation treatments and fermentation on the content of some antinutritional factors in AYB seeds were determined. There was on the average about 50 % reduction in trypsin inhibitor activity as a result of dehulling. Trypsin inhibitors are proteins located in the endosperm. Their reduction resulting from dehulling could be due to the fact that part of the endosperm is removed during mechanical dehulling. Seed trypsin inhibitors are generally heat sensitive. After soaking and cooking, only about 2 - 17 % of the original inhibitor activity was retained. Subsequent fermentation led to a complete loss of activity. Similar result was obtained for the α-amylase inhibitor. The results for tannin have shown that tannin reductions (75 - 100 %) during AYB tempeh production were accounted for mainly by dehulling. This suggests that tannin is located in the seed coat. Dehulling is therefore recommended if low tannin is considered important. After fermentation, only 0 - 18 % of the original tannin was retained in AYB seeds.

Considering phytic acid, dehulling resulted in a small but significant increase ($P<0.05$) in the phytic acid concentration of seeds. The exception was AYB-black variety. Soaking and cooking for 30 min of the dehulled seeds of the three varieties resulted in phytic acid reductions of between 30 and 47 % for AYB seeds ($P<0.05$). However, most of the phytic acid was removed by fermentation of with *Rhizopus oligosporus*. About 60 % of phytic acid in the dehulled AYB-white was retained after fermentation. This may be due to the inhibited growth of the fungus in AYB-White. Only the processed AYB-white seeds were assayed for cyanogenic glycoside because glycosides content of the other samples was considered nutritionally negligible. Although there was a significant reduction ($P<0.05$) in the very high cyanogenic glycoside content of AYB-white as a result of dehulling, soaking and cooking, the glycosde content remained high (98 mg HCN equ. kg^{-1}) after these treatments. This may have contributed to the inhibition of fungal growth. There was no significant reduction in the glycoside due to fermentation with Rhizopus ($P>0.05$). The tempeh production process resulted in almost 100 % loss of the flatulence causing α-galactoside (table 4).

Table 4: Changes in α-galactoside content of AYB seeds* during tempeh production

AYB	Raffinose	Stachyose	Verbascose	Total RFO	% RFO reduction**
Raw	0.57 ± 0.27^{a}	2.15 ± 0.33^{a}	0.14 ± 0.02^{a}	2.85 ± 0.57^{a}	0.0
Dehulled	0.48 ± 0.22^{ab}	2.30 ± 0.40^{a}	0.16 ± 0.02^{a}	2.94 ± 0.59^{a}	+5.0
Soaked (24 h)	0.35 ± 0.17^{ab}	1.88 ± 0.21^{ab}	0.15 ± 0.01^{a}	2.38 ± 0.37^{a}	5.5
Cooked (30 min)	0.26 ± 0.10^{ab}	1.38 ± 0.08^{b}	0.14 ± 0.04^{a}	1.77 ± 0.17^{a}	33.2
Tempeh	0.02 ± 0.02^{b}	0.06 ± 0.06^{c}	0.02 ± 0.01^{b}	0.10 ± 0.08^{b}	98.3

* Results are means for three varieties ± Standard Deviation.

** % Reduction relative to the raw seeds

The values in rows with different letters are significantly different from each other ($P<0.05$).

(Source: Azeke *et al*., 2007b)

Energy requirements

Kerosene is the most important cooking fuel in Nigeria, followed by firewood. Assuming that 1 l of kerosene gives a cooking time of 1.25 h and that the fermented samples still require some form of heat treatment (30 min each) to become palatable, conservative estimates shows that kerosene requirements for lactic acid fermentation and tempeh production are only about one quarter of that required for traditional cooking. Lactic acid fermentation and tempeh production processes are therefore energy saving, economical and environmentally friendly.

Conclusion

Lactic acid fermentation with *Lactobacillus plantarum* and tempeh production using *Rhizopus oligosporus* were both found to be effective means of improving the nutritional quality of African yambean, outscoring the traditional long-time cooking. The high protein content of lactic acid fermented AYB and AYB-tempeh implies that 194 - 219 g AYB products would be enough to meet the WHO/FAO recommended daily protein intake for a 70 kg adult male. With a starch content of over 40 g 100 g^{-1}, these AYB products could be useful in the prevention of protein-energy malnutrition (PEM), which affects more than 40 % of the sub-Saharan African population. Because of the dietary fibre contents of both lactic acid fermented AYB and AYB-tempeh (13 – 15 g 100 g^{-1}), products would help to overcome problems associated with western diets such as obesity and some kinds of cancer. As a matter of fact, the fear of excessive fat intake is ruled out because the lipid content of both products was found to be negligible (0.5 – 1.6 g 100 g^{-1}). These processes are less energy intensive than traditional cooking and, if accepted, could provide the fast growing population of sub-Saharan Africa with an effective means of utilizing not only the African yambean, but also other protein-rich under- utilized legumes which abound in the African continent. These fermentation processes could be applied on legumes found in Europe in order to provide healthy nutrition and promote responsible use of resources such as land and water.

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Financial Potential of Rainwater Harvesting Technology for Agricultural Production in Osun State, Nigeria

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Abstract

The fact that agricultural production activities are at their lowest ebb during the dry season, due to lack of irrigation facilities and minimal suitable area for fadama farming, justify the consideration of Rainwater Harvesting Technology (RWH) for agricultural production. This study was conducted with the aim of providing financial viability of RHT for agricultural production in the study area. The study was conducted in two ecological zones: (i) derived savannah belt in Iwo zone and (ii) rainforest belt in Ife-Ijesa zone. These covered the villages of Obamoro and Mafikuyomi in Iwo zone, and Erin-Oke and Erin-Ijesa in Ife-Ijesa zone. The primary data used were obtained with the aid of a structured questionnaire supplemented with focus group discussion. Budgetary and investment analyses were used to assess the financial potential of RHT system. Budgetary analysis indicates that adoption of RHT will increase farmers' income. For instance, a farmer cultivating okra will earn additional ₦54, 120/ha, while the corresponding value for rice farmers is ₦69, 166/ha. Investment analysis also shows that the Net Present Values (NPV) for both crops is positive and with an Internal Rate of Return (IRR) of 37% and 49% for okra and paddy rice respectively. Benefit-cost ratios are all greater than one. These results indicate that the adoption of RHT for crop production in the study area can be profitable, since farmers will be able to pay for investments and operational costs, and yet make profits. It is therefore suggested that various tiers of government (especially in southern part of the country where irrigation system of farming is rare) should initiate and support individuals and groups willing to adopt RHT system, in order to enhance agricultural production in Nigeria. The study also suggests that the application of output price support programmes would be an effective policy option in achieving this purpose.

Keywords: Rainwater Harvesting, Technology, Agricultural Production, Financial Potential.

Introduction

Agriculture remains one of the most important sectors of the Nigerian economy. This sector is particularly important in terms of its employment generation and its contribution to Gross Domestic Product (GDP), provision of raw materials to the industrial sector, as well as its contribution to export earnings. Despite Nigeria's rich agricultural resource endowment, the agricultural sector has been growing at a very low rate. Less than 50 per cent of the country's cultivable land is under cultivation. Smallholder farmers who use rudimentary production techniques, with resultant low yields, cultivate most of this land. The smallholder farmers are constrained by many problems, including that of over-dependence on rainfall for production. Like in other countries in Sub-Sahara Africa (SSA), rainfall could generally be said to be sufficient but is often erratic.

Erratic rainfall distribution leads to yield fluctuation, thereby putting food security into jeopardy. Solar radiation is also intense and the rate of evaporation is among the highest in the world (Falkenmark and Rockstronm, 2006; Barrow, 1987 cited in SIWI, 2001). These extreme scenarios implies that a large

fraction of the water escapes unless technical and other management measures are introduced and properly used to harvest and store more of the rainfall (Mugerwa, 2007). Since a large proportion of farmers practice rain-fed agriculture under adverse climatic conditions, it is essential to employ water-conserving technologies systematically and make rainwater management an integral part of land use and crop management (UNDP, 2006; Falkenmark and Rockstronm, 2006; SIWI, 2004; Rosegrant and Cline, 2003; FAO, 2002).

Rainwater harvesting technology (RHT) is feasible for both large and small-scale farmers and has the potential to double or triple production and productivity (Botha et al., 2005; SIWI, 2004; FAO, 2002). Furthermore, it would not directly compete with other sectors for scarce blue water resources. In addition, RHTs do not require huge financial investments. Generally, the technologies are small-scale and simply require labour to dig well, canals, plant hedgerows or construct stone barriers and terraces. Some of these activities can actually be carried out during idle or less intensive agricultural seasons (Lecomte and Krishna, 1997). With these characteristics, therefore, RHTs are considered well suited for small and poor peasant households (Mugerwa, 2007). Given the fact that the construction of a moderate RHT structure (to store 20,000cm^3 of water for one hectare) had been estimated to cost ₦120, 000 in addition to ₦5,000 for its maintenance every two years in the area of study, it is imperative that economic and financial evaluation of the adoption of RHT be carried out.

Several studies have been carried out with a view to determining the potential of rainwater harvesting to improve land productivity and returns to RHTs. For example, Fox and Rockstronm (2000) examined the effect of rainwater-harvesting for supplementary irrigation of cereal crops to overcome intra-seasonal dry-spells in the Sahel. Results of the study showed that supplemental irrigation during dry-spells increased sorghum harvests by 41%. Schweigman (2003) also demonstrated that application of water and soil conservation in the Central Plateau of Burkina Faso has rehabilitated degraded land and increased cereal production.

Apart from improving agricultural productivity, RHTs have also been associated with other environmental and social benefits. For instance, Ngigi (2003) reported that construction of communal water pans to store water helped to reduce conflict over water resources among different clans in northeastern Kenya. In addition, investment in construction of water storage facilities has greatly improved crop and livestock production, thereby leading to better standard of living in the area. Sekondo *et al.* (2004) employed gross margin and investment analyses to assess the profitability of RHTs in selected semi-arid areas of Tanzania. The results of the study showed the tremendous benefit of RHT through the improvement in gross margin, as well as returns to labour. In specific terms, it was found that maize production with RHT had positive Net Present Value (NPV), Benefit to Cost ratio (B: C) of greater than one, and an Internal Rate of Return (IRR) of 57%. Similarly, paddy production with RHT had a positive NPV, B:C ratio greater than one, and an IRR of 31%. Hatibu *et al.* (2000) calculated returns to RHT on maize and onion in Hedaru and Mgwasi villages in Western Pare Lowlands of Tanzania. The results showed that annual return to water for maize production was lower than that of onion. Due to existing

potential and profitability of RHTs, most of the studies reviewed were of the opinion that rainwater harvesting should be encouraged. Hence, the objective of this study is to determine the viability of RHT in Osunt State, Nigeria.

Materials and Methods

Area of Study

The study was carried out in Osun State, Nigeria. The State has 30 Local Government Areas (LGAs) with a population of 2,203,016 and an estimated land area of 8,882.55sq.km. A wide range of crops is grown in the State, based on vegetation, soil and other agro-climatic factors. Two important vegetation regions in the State are the rain forest and the derived savannah. The rainforest is found mostly in Ife/Ijesa zone while the derived savannah (forest savannah mosaic) features partly in Iwo and Osogbo zones. In the forest region with a much higher rainfall and relative humidity, tree and arable crops are grown. On the other hand, the derived savannah region has mainly arable crops with patches of tree crops.

The mean annual rainfall is about 1000mm in the northern part (Iwo site) and 2000mm in the South (Oriade site). The rainfall distribution is bimodal with peaks in June and September. The area has two distinct seasons, the dry and rainy seasons. The dry season extends from November to March. In the rainy season, the rainfall is high and relatively adequate for the production of some crops grown in the area. However, towards the end of the rainy season, the rainfall becomes erratic and reduces to about 500mm. The dry season is from mid November to mid March. In this season, there is very little rainfall (less than 100mm). The potential evapo-transportation of the study area is very high. It ranges from 7.2mm/day in January to 6.4mm/day in June or October. Thus the soil experiences severe moisture deficit even during the rainy season. The study area therefore has potential for Rainwater Harvesting.

Data and Method of Collection

The primary data required for this study were obtained using farm business survey method supplemented with focus group discussion. The basic tools for data collection were structured questionnaires. Generally, the questionnaires were designed to capture data on input costs and revenues. The questionnaires were pre-tested to ascertain the validity of questions before final administration was made. Necessary adjustments were made accordingly to improve the questionnaires after the pre-testing exercise. A total of hundred farmers was selected, fifty each for okra and rice. Experience in relevant enterprises was a significant determinant of participation in the focus group discussion. Twenty farmers participated in the discussion in each zone.

Analytical Techniques

The appraisal of the economic performance of RHTs varies between simple yield comparison and more sophisticated risk analysis methods such as stochastic dominance analysis (Kunze, 2000). Measures of project worth computed and used in this study are budgetary analysis, payback period (PBP), net present

value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR). For the NPV and BCR the discounting rates used in this evaluation are 10% and 20%, while 10 years was employed for the time horizon.

Net return, which is the difference between gross value of output and the total cost used in the production process, can assist in improving the overall management of the farms and it generally addressed resource productivity in a given period of time. Pay back period is simply the time taken for expected profits to fully recover the initial outlay or investment; that is, the time taken for cumulative net cash flow to become zero. Pay back has its advantages as an investment criterion. It is a simple cash flow easily understood by farmers. If a business is short of cash, it is essential that investment is changed into cash as soon as possible and this method acknowledges the value of early returns and keeping liquidity. By selecting investment projects with the quickest paybacks, the time value of money is allowed to some extent. Because the method considers only the years in which cost is recovered, estimates are not based over long time periods and so tend to be more accurate than other methods in which the whole life of the asset is considered. Unfortunately, the PBP criterion has several disadvantages that limit its use for appraising long-term investments. The investment analysis (NPV), which allows costs and benefits to spread across the lifetime of the project, is a useful tool to analyze investment in RHT structures that can produce benefit for up to 10 years or more. This evaluation concentrated on two major crops that are sole cropped: (i) okra, the major crop in Iwo zone and (ii) paddy rice, the major crop in Ife-Ijesa zone

The following assumptions were made for the computation of net revenues:

(i) with supplementary water from RHT, there could be at least 30% increase in yield of okra for both seasons while rice could at least increase yield of existing cropping season by 30% and allows an additional season for upland rice;

(ii) costs and returns are the same for both early and late seasons for okra;

(iii) farmers will repay both principal and interest in 12 months;

(iv) price per unit is constant in a production year for both enterprises;

(v) operating capital is borrowed from cooperative society at the rate of 12% per annum;

(vi) the money to be invested in RHT reservoir will be obtained from cooperative societies at the rate of 12% per annum, Thus, initial investment (N134, 400) is made up of principal (N120, 000) and interest (N14, 400)

In this evaluation, with and without project situations analysis was calculated for okra as well as paddy rice production with the assumption that the without RHT cropping situation will yield existing net farm income.

Results and Discussion

Budgetary Analysis:

Table 1 shows results of budgetary analysis for the two crops; paddy rice and okra. The result shows that with RHT farmers will earn more income from the production of both crops. That is, a farmer cultivating okra will earn ₦54, 120 per hectare as additional income in addition to the existing farm income annually. Similarly, he will earn ₦69, 166 per hectare as extra from paddy rice production if he adopts RHT.

Investment analysis:

The results of investment analysis performed for rice and okra production are presented in Table 2. The payback periods show that farmers who adopt RHT technology will fully recover the initial outlay in 2 years and 2 years 7 months when rice and okra are cultivated respectively. The net present values (NPV) for both crops are positive. This indicates that the present value of benefits will exceed the discounted present values of costs. Benefit-cost ratios are all greater than one. These results imply that the adoption of RHT for crop production will be profitable in the long run as farmers will be able to pay for investment and operational costs and yet attain profit.

Sensitivity Analysis:

To test whether the above results will be stable or not (as a result of changes in market prices of inputs and outputs), sensitivity analysis was undertaken. The results of this are presented in Tables 3 and 4. For okra production, an increase in production costs by 20% will affect the viability of all the measures of project worth (Table 3). Contrariwise, a 20% decrease in product prices does not alter the viability of the measures of the project worth. The results also suggest that okra production is more sensitive to changes in input than product prices.

For paddy rice production, an increase in production costs by 20% affects the viability of the project at 20% discount rate although it does not alter viability of other measures. Similarly, a 20% decrease in product price does affect the viability of the project at 20% discount rate but does not alter viability of other measures of project worth. These results further suggest that paddy rice production is sensitive to changes in both product and input prices.

Conclusion and Recommendations

The results have demonstrated that net returns for the selected crops (okra and paddy rice) are positive. That is, farmers will be able to cover their costs and remain in a positive balance. These show that RHT is viable and has the potential to enhance farm income from okra and paddy rice production in the project sites.

With respect to investment analysis, the two crops have favourable measures of project worth (i.e. PBP is less than 3 years, NPV are positive and BCR are greater than one). Sensitivity analysis shows that when prices of inputs used in okra production are changed by 20%, the viability of the project is negatively affected, whereas 20% decrease in product price does not affect the viability of the project. However, 20%

change in input and output prices alter the viability of the project in paddy rice production at 20% discount rate. It is also demonstrated that the project is more sensitive to changes in input prices than product prices.

Based on the results of this study, it can be concluded that the recommendation of RHT for adoption by farmers should be predicated on affordable input and product prices. It can therefore be recommended that various tiers of government should initiate and support individuals and groups willing to adopt RHT system, especially in southern part of the country where irrigation system of farming is rare, in order to enhance agricultural production. In doing this, the policy makers should adopt output price support programmes, because of the problems associated with input subsidies to stimulate farm production in Nigeria. The beauty of this policy option is that both farmers and consumers gain with no net transfer to the middlemen.

Table 1: Budgetary Analysis Results

Enterprises	With RHT (₦ per ha)	Without RHT (₦ per ha)
Okra	219, 746.00	165, 626.00
Paddy	97, 802.00	28, 636.00

Table 2: Results of Investment Analysis

Enterprises	NPV (10%) (₦ per ha)	NPV (20%) (₦ per ha)	B:C ratio (10%)	PBP	IRR (%)
Okra	185, 460	82, 970	2.38	2 Years, 7 months	37
Paddy	275, 961	146, 857	3.05	2 Years	49

Table 3: Results of Sensitivity Analysis for Okra

Scenario	Performance Indicators				
	NPV (10%)	NPV (20%)	BC ratio	PBP	IRR (%)
Basic scenario	185,460.00	82,970	2.38	2 Years 7 months	37
20% increase in costs	(437.84)	(43,049.38)	0.996	61/4 years	17
20% decrease in product price	85, 897.44	15,858.61	1.64	33/4 years	23

Table 4: Results of Sensitivity Analysis for Paddy Rice

Scenario	Performance Indicators				
	NPV (10%)	**NPV (20%)**	**BC ratio**	**PBP**	**IRR (%)**
Basic scenario	275, 961.00	146, 857.95	3.05	2 Years	49
20% increase in costs	44,157.65	(19, 626.13)	1.32	7 Years 1 months	16
20% decrease in product price	56, 244.08	(4374.40)	1.42	4 Years 4 months	19

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Toxicity of Cutback (MCO) Bitumen to African catfish *Clarias gariepinus(*Burchell 1822)

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Abstract

The toxicity effects of cut back bitumen (MCO) on African catfish *(Clarias-gariepinus)* were evaluated. A 96h static bioassay was conducted to determine the LC_{50} of the bitumen to African catfish juveniles. Concentrations of the bitumen used were 0, 21, 22, 23, 24 and 25ml L^{-1} for treatments 1-6 respectively. On introduction into the experimental tanks, the bitumen spread evenly on the water surface and significantly depleted the available dissolved oxygen over time. The fish exhibited hyperexetability, cutting of their barbells and attempted to jump out of the test media and eventually mortality resulted. The percentage mortality was converted to probit response while the concentrations were converted to Log_{10} and the values were used to plot a graph from which the 96h LC_{50} value of 21.3 ml L^{-1} was red. The histological examination of gills, kidney and spleen showed pathological damages which worsened with increasing concentrations of the toxicant. The gills showed filament breakage, epithelial hyperplasia and separation of epithelial layer from the supportive tissues. Kidney indicated loss of cellular outline congested with blood clots and vacuolation resulting in rupturing of the kidney. The spleen revealed presence of vacuolation, epithelial separation and rupturing of the cells. The degree of damages done to this hardy fish by the little volume of bitumen is a pointer to what becomes of the aquatic organisms when they come in contact with large quantities of bitumen. Therefore, as Nigeria prepares for industrial and commercial production of bitumen, extreme care must be taken to prevent incidence of bitumen pollution and degradation of the water environment and mortality of aquatic organisms. Besides eating aquatic animals contaminated with bitumen have serious health implications in humans including carcinogenicity, reproductive and developmental toxicity, neurotoxicity, and acute toxicity.

Key words: Toxicity; cut back bitumen (MCO), African catfish

Introduction

Bitumen is a non-crystalline viscous material, black or dark brown, which is substantially soluble in carbon disulphide (CS_2) possessing adhesive and water-proofing qualities. It consists essentially of hydrocarbon and would typically comprise at least 80% carbon and 15% hydrogen (Petersen, 2000), the remainder being oxygen, sulphur, nitrogen and traces of various metals especially vanadium, nickel and iron (Herrington *et al*. 2006). Bitumen is a tar-like substances and it is one of the by-products of crude oil refinery, Herrington *et al.* (1994). It is a thermoplastic material; softens and becomes liquid with the application of heat and it hardens as it cools. It resists actions by most acids, alkali and salts (asphalt bitumen) (WHO, 2004).

Bitumen does occur naturally and the deposits have physical properties that are similar to that of the petroleum-derived bitumen, although the composition is different (CONCAWE, 1992) but for all intents and purposes it is petroleum on which the world relies for its supplies of bitumen today (Herrington et al. 1993). In some areas notable for their petroleum resources for example in the middle east and Nigeria semi-fluid bitumen can be found oozing out of fissures near hot springs or seeping out of the ground. The bitumen content of crude can vary between 15% and 80%, but the more normal range as a thick, sticky form of crude oil, so heavy and viscous that it will not flow unless heated or diluted with lighter hydrocarbons (CONCAWE 1992).

Cutback bitumen consists basically of bitumen that has been diluted with kerosene (Herrington *et al*. 2006) in order to make it into fluid for application, mainly in road making, paint industries and roof sealant (Speight, 1997). Cutback bitumen is also called liquid Asphalts (WHO 2004) because they are liquid at ambient temperatures. They are classified according to the time it takes them to become solid, and further according to the solvents used to liquefy them as rapid curing (RC) medium curing (MC) or slow curing (SC) cut backs. The cut back varies according to the flux or diluents; while spirit, gasoline or naphtha is commonly used for RC grade kerosene is used for MC and diesel for SC (Speight, 1997).

Environmental changes caused by the exploration of crude oil, presence of hydrocarbon and its by-products such as bitumen is detrimental to aquatic life in varying degrees (Roberts *et al*. 2001). Berka *et al*. (2001) reported that contamination of aquatic environments with liquid hydrocarbons has caused chronic water pollution with tar-like deposits. This is most damaging to surface-living aquatic animals, coastal fish farms including Salmon cages, Oyster-racks, corals, salt marshes and mangroves. It has also endangered wildlife and fisheries by damaging their livers, kidneys, hearts, gills and other vital organs as they ingest it (Martins, 1976, Svecevicius *et al*., 2003).

Nigeria is a world major producer of crude oil and petroleum products and by-products including bitumen. Recently, large quantities of bitumen were discovered in coastal swampy areas of Agbabu Ode-irele Ondo State Nigeria. The bitumen has covered some parts of the nearby river Oluwa. With time, the bitumen is expected to degrade and then form part of the food chain which would eventually be ingested by fish and other aquatic organisms and microbes. Most of them would adsorb to aquatic vegetations which form part of the food of the aquatic animals. So as Nigeria prepares for industrial and commercial production of bitumen, it is necessary to conduct some investigations on the toxicological effects of the bitumen on some major commercial fish species around the bitumen environment. This has a strong justification because pollution of waters by bitumen and its by-products is imminent. More so that published information on bitumen toxicity to aquatic organisms in Nigeria is scarce. Therefore, the present study focused on the toxicity of medium curing (MCO) cutback bitumen to African catfish (*Clarias gariepinus*) juveniles. Cutback bitumen (MCO) is bitumen diluted with kerosene, a lighter hydrocarbon.

Materials and methods

Collection and conditioning of test fish

Healthy *Clarias gariepinus* juveniles were collected life from Ondo State Agricultural Development Programme (ADP), Akure; Ondo State, Nigeria. They were acclimatized without food for 48h in glass tanks measuring 75cm x 40cm x 40cm at the Fisheries and Wildlife Laboratory of the Federal University of Technology, Akure, Ondo State. Acclimatization was conducted using tap water. Thereafter, the fish were weighed with a digital sensitive scale and the total length was measured with graduated ruler. This was followed by the stocking of ten fish of similar sizes into individual glass tanks. The average standard length per fish was 8.50cm while the average weight was 9.50g. Eighteen (18) glass tanks were used in all with a total of 180 juveniles of *Clarias gariepinus.* This means three replicates per treatment.

Toxicity test

Range finding test was carried out, and from the results obtained, different concentrations of the cutback bitumen were applied for definitive test**.** The bitumen was obtained from Bill Construction Company Okitipupa Site. Six treatments (T1-T6) were prepared with varying concentrations of bitumen as 0ml L^{-1}, 21ml L^{-1}, 22ml L^{-1}, 23ml L^{-1}, 24ml L^{-1} and 25ml L^{-1}. Each treatment was replicated thrice. Static bioassay was conducted, and observations on the behaviour of the fish to the toxicant were recorded at 30 minutes interval while mortality was observed every 24h. All the dead fish from each treatment of different concentrations were kept at -20^{o}C for histological examinations. The mortality (%) values were converted to probit response, while the concentrations were converted to logarithm (Hewlett and Plackett, 1979). The converted values were used to plot a graph of probit reponse against log-dose, and the LC_{50} of the toxicant to the fish was red from the graph.

Water quality monitoring

The dissolved oxygen ($D0_2$), temperature and pH were determined and their readings were recorded every 24h of the 96h duration of the experiment. Dissolved oxygen and temperature were measured by a combined digital oxygen-temperature meter while pH was measured by a pH meter, Mettler Toledo 320. The mean values of the parameters were tabulated.

Observations

General observations made included erratic swimming which started just few seconds after introduction of the toxicant; staining of the vomerine teeth as a result of their effort to gulp air, standing uprightly for a very long time, discolouration of their dorsal fin, staining and cutting of their barbells and severe aggressiveness which led to injuries and eventually to mortality in most cases.

Histological examination of the fish Gills, Kidney and Spleen

Histology of the vital organs of the fish like gills, kidney and spleen were examined to determine the effects of bitumen on such organs. The gills, kidney and spleen of the dead fish from each treatment concentrations were removed by dissecting the fish. The organs were then placed in 10% formalin for three (3) days after which they were cut into smaller sizes to enhance thorough dehydration. Then histological examinations involving dehydration of the organs in graded alcohol, cleaning in xylene, embedding, staining and observation under light microscope were carried out according to methods of Sheehan (1980) and Lee (1992).

Results

Mortality (%) of African catfish juveniles exposed to different concentrations of cutback bitumen showed that the fish was sensitive to concentrations from 21- 25ml L^{-1} (Table 1). The table indicated that within 96h, about 40% of the fish died in concentration of 21ml L^{-1}, while 70% died in concentration of 22ml L^{-1}, suggesting that the 96h LC_{50} of the bitumen might lie between 21 and 22ml L^{-1}. At concentrations of 23, 24 and 25ml L^{-1}, 80%, 90% and 100% of the fish died. The fact that some fish survived in concentrations of 21-24ml L^{-1} showed that though the fish were of the same genetic make up and sizes, they had different resistance to the same concentration of the toxicant. Figure 1 actually confirmed the 96h LC_{50} to be 21.3ml L^{-1}, as the mortality table indicated. The LC_{50} can also be calculated from the regression equation $Y = 29.6x - 34.312$ given by the graph of response probit against the log-dose concentration. Where Y is the response probit (% mortality), and x is the concentration.

Changes in temperature, pH and dissolved oxygen concentration of the test media following the introduction of the toxicant is presented in table 2. Average temperature ranged between 23.2 and 24.2 ^{o}C, and remained constant throughout the bioassay period (96h). Mean pH concentration at the beginning of the assay was 7.4 and dropped to about 6.8 during the toxicity test, a tendency towards acidity. While the mean initial dissolved oxygen concentration was 6.80 mg L-1 and dropped to 4.8 in 24h; 4.3 in 48h; 4.00 in 72h and 3.40 in 96h. This critical level of oxygen would have caused mortality due to asphyxiation. The least oxygen level at 96h also corresponded to the highest concentration of the toxicant, suggesting inverse relationship between oxygen concentration and increase in concentration of the toxicant and time of exposure.

On introduction of the toxicant to the test media, the fish showed different behavioural changes which are expressed in table 3. Immediately the fish came in contact with the bitumen, they swam erratically in different directions gaping for air from the beginning of the assay till the end. There was discoloration of the vomerine teeth which started after 24h of introduction of the toxicant till the end. Discoloration of the dorsal fin followed after 72h till the end. The fish were also found standing up-right from 48h till the end. Cutting of fish barbells was also noticed from 72h till the end of the assay. Generally, there was loss of reflex and increased aggressiveness among the fish after introduction of the toxicant till the end of the assay. These stressors eventually resulted in mortality of the fish.

Histological examinations

Gill

Examinations of the gills of untreated fish (control, 0 ml L^{-1} bitumen) revealed a normal gill filament consisting of primary lamellae with its arrays of delicate secondary lamellae; primary epithelium and secondary epithelium covering the primary and secondary lamellae respectively and there was no vacuolation. Gills of *Clarias ganepinus* juveniles exposed to cutback bitumen MCO exhibited varying degrees of epithelial hyperplasia among the gill filaments in varying treatments of different bitumen concentrations. There were significant changes with increased concentration of the toxicant. Gill filaments exposed to 21ml L^{-1}, showed little alteration of the filament with delicate primary lamellae dropping off. As the concentration of the bitumen increased from 23 to 25ml L^{-1}, there was extensive epithelial separation, rupture and fracture of the gill. Some of these changes are shown in Plates 1-4.

Kidney

Kidney of *Clarias ganepinus* juveniles exposed to cutback bitumen MCO also exhibited varying degrees of histological changes. Several arteries and veins exhibited coagulation and staining of blood, Slight to extensive loss of cellular outline was also noticed at various concentrations while the kidneys of the untreated (control) experimental fish remained normal. At concentration of 21ml L^{-1}, there was slight loss of cellular outline with thick blood clot. As the concentration of the bitumen increased, there was big size of blood clot with big size vacuolation (figures not shown).

Spleen

There were different degrees of histological changes in the spleen depending on the concentrations of the toxicant. Spleen of the fish exposed to 21 ml L^{-1} of MCO showed no visible changes. However, with increase in concentration of the bitumen to 23ml L^{-1}, vacuolation occurred in the spleen. With further increase of MCO to 25 ml L^{-1}, there was vacuolation and rupturing of the cells with blood clot (not shown in the figures).

Discussion

Changes in behavioural pattern observed during the experiment showed a sensitive indicator of physiological stress in fish subjected to varying concentrations of the toxicant. These were characterized by high rate of swerving movements and general state of restlessness. Davis (1973) reported that organisms exposed to chemicals usually exhibit increased rate of opercular movements. Drummond *et al*. (1973) reported that Brook trout *Salvelinus fontinalis* increased their activities up to 4-6 times that of the control during the first 8-hours of the exposure to copper solutions. Stress and hyperactivities were observed in African catfish and *Heterobranchus bidorsalis* fingerlings exposed to different concentrations of potassium permanganate (Salami and Nwanna, 1995). Similar changes in behavioural patterns had been reported by White (1980), Ajao (1985) and Nwanna *et al*. (2004).

In agreement with observations that organisms of the same size and age can show differences in tolerance to the same concentrations of certain toxicants (Salami and Nwanna,1995), results from the present study showed that African catfish juveniles showed differences in tolerance to the same concentrations of bitumen. Chen and Lei (1990) also observed that juveniles and adolescent of *Penaeus monodon* showed differences in their tolerance to ammonia and nitrate solutions. Heit and Fingermann (1977) observed that females of the cray fishes, *Procambarus clarki* and *Faxonella clypeata* were much more tolerant of mercury than the males. Thus, it is possible that the difference in tolerance of the test fish is as a result of the differences in the male: female composition.

Fish mortality recorded in the present study might have resulted from the alteration in the physico-chemical parameters of the test media especially the dissolved oxygen which dropped significantly with increasing bitumen concentration and exposure time; beyond the critical level for the survival and well-being of most fresh water fishes (Boyd, 1981, 1990). CITGO (1999) reported that in stagnant and slow-flowing waterways, the hydrocarbon layer can cover a significant surface area and can limit oxygen transfer resulting in anaerobic environment and consequently mortality. A number of toxicants become more toxic at low oxygen concentration because of an increase in respiratory rate caused by increase in concentration of the toxicant and exposure time. Thomas and Rice (1975) suggested that increased opercular movement of pink salmon fry exposed to fraction of crude oil may be caused by decreased efficiency in oxygen uptake or transport. These observations are in agreement with the report of Eileen *et al*. (1991) that fish mortality were affected by temperature, dissolved oxygen concentration, pH and exposure time as well. Lioyd (1961) reported an inverse relationship between increased mortality in rainbow trout and reduction in dissolved oxygen concentration due to exposure to toxicants. This is in line with the results of the present study. Nwanna *et al*. (2008) also attributed mortality in Nile tilapia fingerlings exposed to palm oil mill effluent to oxygen sag with concentration and the time of exposure. White (1980) similarly observed gasping for air and breathing difficulties in Atlantic herring *Clupea herengus* intoxicated with *dinoflagellate* toxins as a result of oxygen tension. In Mitchell (1984) the swimming performance of striped bass was reduced by the reduction in oxygen uptake. The pH of the test media showed a decreasing trend towards acidity. This is an indication that much more concentrations of the bitumen could turn the water into acidic media which would lead to quicker and massive killing of aquatic organisms. Boyd (1981) described pH of 4 as the acid death point for most of the fresh water fish species.

The histological degenerative changes observed in the gills, kidney and spleen of the fish exposed to cutback bitumen is in consonance with the reports of other authors. Nwanna *et al*. (2003) reported such changes in African catfish and Nile tilapia fingerlings exposed to ichthyotoxic plant, *Parkia clappertoniana*. In Jegede *et al*. (2007) toxic concentration of common salt (NaCl) led to similar changes in the gills and kidney of African catfish fingerlings. Linden (1978), Kuhnhold (1972), Mironov (1967) and Wilson (1976) had observed deformity and various abnormalities in fish larvae exposed to crude oil and oil products. Similarly, Onuoha and Nwadukwe (1990) described spinal flesures of larvae as the effect of liquid petroleum refinery effluent on the hatchability of African catfish eggs.

Conclusion

The study has provided a base-line data on the toxicity of cutback bitumen (MCO) to African catfish juveniles. Bitumen spill can result in serious economic loses on the aquatic organisms and the communities who depend on the resources for their livelihood. Also affected are the aesthetic value and tourism potentials of the polluted environment. Consumption of organisms contaminated with bitumen also has critical health implications in humans including carcinogenicity, reproductive and developmental toxicity, neurotoxicity, and acute toxicity. Therefore, as Nigeria prepares for industrial and commercial production of bitumen, efforts must be made to avoid the incidence of environmental bitumen pollution. We also recommend environmental impact assessment of bitumen on the aquatic biodiversity. This will help in planning for the safe tolerable and allowable limit of bitumen in Nigerian aquatic environment.

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Table 1: Mortality of African catfish juveniles exposed to different concentrations of cutback bitumen

	TIME							
	24 h		48 h		72 h		96 h	
Concentration ml L^{-1}	M[1]	S[2]	M	S	M	S	M	S
0ml L^{-1}	-	10	-	10	-	10	-	10
21ml L^{-1}	-	10	1	9	2	7	1	6
22ml L^{-1}	2	8	3	5	1	4	1	3
23ml L^{-1}	2	8	4	4	2	2	-	2
24ml L^{-1}	3	7	5	2	-	2	1	1
25ml L^{-1}	3	7	5	2	1	1	1	0

[1] is mortality
[2] is survival

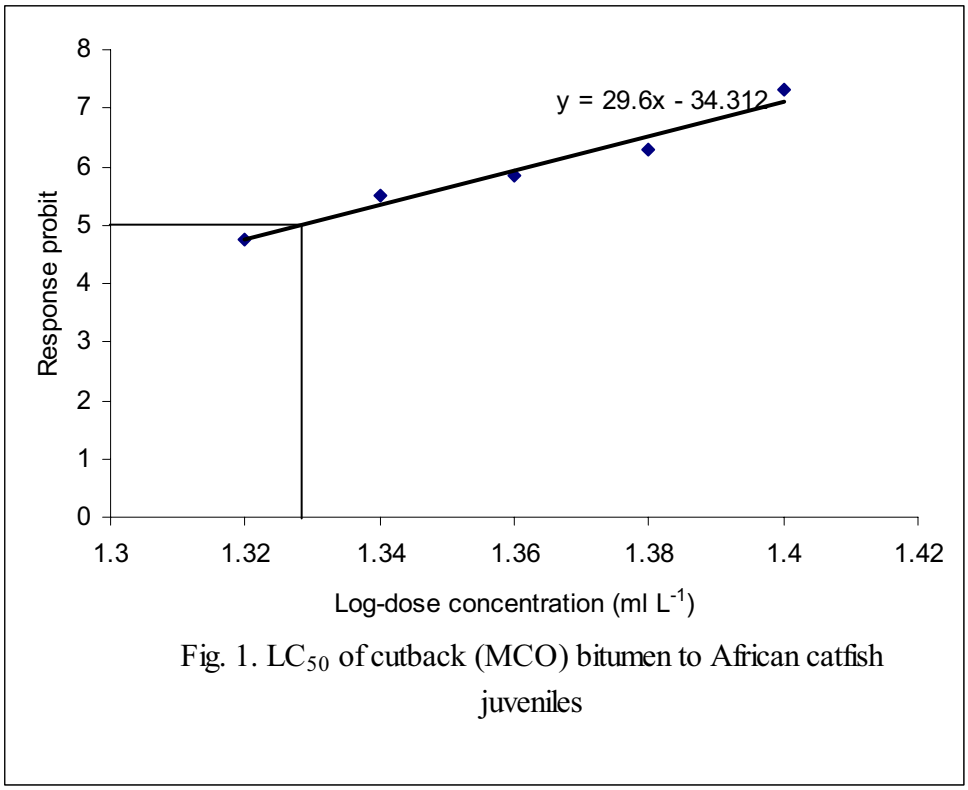

Fig. 1. LC_{50} of cutback (MCO) bitumen to African catfish juveniles

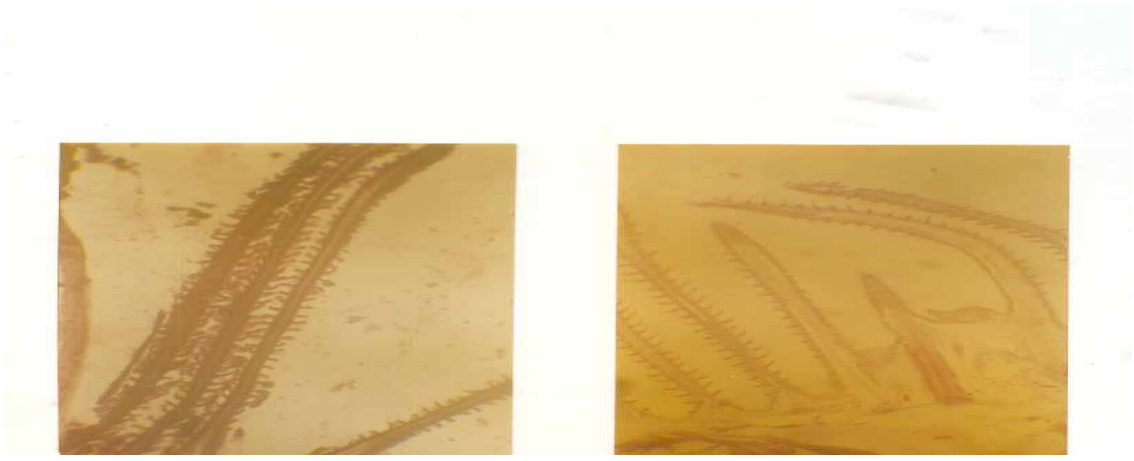

PLATE 1

Control Experiment (0.00ml L^{-1}) of untreated gill of *Clarias gariepinus*

PLATE 2

Gill filament of *Clarias gariepinus* exposed to 21ml L^{-1} of MCO bitumen showing little alteration of the gill filament with delicate primary lamellae dropping of

PLATE 3

Gill filament of *Clarias gariepinus* exposed to 23ml L^{-1} of MCO bitumen bitumen showing extensive epithelial and fracture of the gill

PLATE 4

Gill filament of *Clarias gariepinus* exposed to 25ml L^{-1} of MCO showing the ruptured gill separation

Table 2. Water quality parameters monitored during the toxicity test

	Temperature (°C)				pH				Dissolved oxygen (mg L^{-1})			
	24h	48h	72h	96h	24h	48h	72h	96h	24h	48h	72h	96h
Control	23.2± 0.3	24.1± 0.7	23.6±0.7	24.0±0.5	7.2 ± 0.01	7.3 ± 0.01	7.4 ± 0.03	7.5 ± 0.03	6.8 ± 0.02	6.0 ± 0.00	5.8 ± 0.01	5.3 ± 0.00
T1	23.2± 0.6	24.1± 0.6	23.6±0.6	24.0±0.4	6.9 ± 0.05	6.80 ± 0.02	6.9 ± 0.01	7.0 ± 0.05	6.2 ± 0.01	5.6 ± 0.04	5.3 ± 0.04	5.1 ± 0.00
T2	23.2± 0.5	24.1± 0.8	23.6±0.2	24.0±0.2	6.9 ± 0.01	6.80 ± 0.03	6.9 ± 0.01	6.9 ± 0.04	5.3 ± 0.00	5.0 ± 0.02	4.8 ± 0.01	4.3 ± 0.00
T3	23.2± 0.4	24.1± 0.8	23.6±0.1	24.0±0.3	6.8 ±0.02	6.80 ± 0.04	6.8 ± 0.03	6.9 ± 0.01	5.2 ± 0.01	4.6 ± 0.02	4.3 ± 0.01	4.0 ± 0.03
T4	23.2± 0.5	24.1± 0.0	23.6±0.3	24.0±0.4	6.7 ± 0.02	6.80 ± 0.04	6.8 ± 0.08	6.8 ± 0.02	4.9 ± 0.01	4.2 ± 0.00	3.9 ± 0.03	3.5 ± 0.00
T5	23.2± 0.4	24.2± 0.3	23.6±0.4	24.0±0.4	6.6 ± 0.01	6.80 ± 0.04	6.7 ± 0.05	6.8 ± 0.03	4.8 ± 0.00	4.3 ± 0.02	4.0 ± 0.01	3.4 ± 0.01

Table 3: Behavioural changes and body features of *Clarias gariepinus* juveniles exposed to different concentrations (21ml L^{-1} - 25ml L^{-1}) of cutback bitumen

Period	24 hours						48 hours						72 hours						96 hours					
Conc. ml L^{-1}	21	22	23	24	25	0	21	22	23	24	25	0	21	22	23	24	25	0	21	22	23	24	25	0
Erratic Swimming	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-
Discoloration of vomerine teeth	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-
Discoloration of dorsal fin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+	+	+	-
Standing upright for a long time	-	-	-	-	-	-	-	+	-	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-
Cutting of their barbells	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-	+	+	+	-	+	-
Aggressiveness/loss of reflex	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-
Mortality	-	-	-	-	+	-	-	+	+	+	+	-	-	+	+	+	+	-	+	+	+	+	+	-

Key:
+ = Present
- = Not present

Water hyacinth (*Eichhornia crassipes (*Mart.) Solms : A sustainable protein source for fish feed in Nigeria.

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Abstract

Chemical control of water hyacinth leads to deterioration in water quality; and may eliminate both targeted and non-targeted species; while mechanical control is labour and capital intensive. Harnessing of the weed into fish feeds will complement and reduce the capital involvement in mechanical control through profits that will accrue from the multiplier effect of using the weed in low -cost fish feed. Therefore the effect of replacing soybean meal with water hyacinth (*Eichhornia crassipes*) meal on the growth and nutrient utilization of Nile tilapia ((*Oroechromis niloticus*) fingerlings was evaluated. Four isoproteic diets were prepared to contain graded levels of water hyacinth meal (WHM) in replacement for 0, 25, 50 and 75% of soybean meal (SM). The diets were fed triplicate groups of Nile tilapia in in-indoor glass tanks for 70 days. Results showed that final mean weight, percentage weight gain, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and productive protein value (PPV) of fish fed diet with either (100% SM + 0% WHM) or (25% WHM + 75% SM) were statistically the same but better than in fish fed diets with more than 25% WHM. There was a consistent decrease in final mean weight (15.8-12.3g), percentage weight gain (63.7-34.4), SGR, PER (2.29-1.43) and PPV (0.34-0.14) of the fish with increase in WHM. The study suggests that WHM can replace up to 25% soybean meal in the diets of Nile tilapia. Currently, 1 ton of SM costs 100 thousands Naira; so the financial implication is that 4000 Naira per ton of SM will be saved by replacing 25% of SM with WHM. Further researches are on-going to determine the most effective processing method that will drastically reduce the fibre content of WHM, so as to make it more digestible by fishes. This will increase the level of its incorporation into diets and further reduce the unit cost of feed and fish production.

Key words: Alternative feed ingredient, water hyacinth meal, Nile tilapia

Introduction

Water hyacinth (*Eichhornia crassipies*) invaded the coastal waters of Nigeria in 1984 and rapidly spread inland to major rivers and streams (Akinyemiju, 1987), because the plant can thrive well in low water quality environment such as pH 4.4-9.9; phosphate 0.46-6.4 mg L^{-1}; nitrate 0.03-1.6 mg L^{-1} and ammonia level of 0.21-7.98 mg L^{-1} (Balasooriya *et al*., 1984). Akinyemiju *et al*. (1992) reported its invasion in some parts of Lagos Lagoon, Badagry Creek, Ere, and Yelwa in Ogun State, Delta State and the Niger River; while Daddy (2000) reported the appearance of the weed in Kainji Lake and River Dole Kaina in Kebbi State. Thyagarajan (1984) reported that water hyacinth has phenomenal growth rate of about 15% biomass production per day. The weed has negative socio-economic effects on fisheries activity, inland water ways transportation, water supplies, irrigation agriculture, hydro-power productions, environment and health of the people of the surrounding community (Thompson 1991, Obot *et al*., 1995; Ayeni *et al.,* 2002). In an attempt to control the weed in Nigeria, mechanical weed control was applied because it has the least

adverse effect on the environment, although it is also tedious and capital intensive. Ofoezie and Akinyemiju (2002) also evaluated the use of herbicides to control the weed and reported that chemical control of the weed had negative significant effect on some major water quality variables such as transparency, dissolved oxygen concentration, conductivity, Na^{+}, K^{+}, Mg^{++} Ca^{++}, Cl^{-1} and SO_4^{3-}. To date control of the weed is still a big problem and the Federal Government of Nigeria is spending a lot of money towards this dimension. For instance, in 1988, the Government awarded a contract in the tune of 60 million Naira for mechanical control, fabrication and installation of water hyacinth barrier along the coastal waters (Nigerian Guardian Newspaper 2001, Sotolu Per. com). Also in 2001, the Government disbursed 18 million Naira to Epe local government in Lagos for the control of the weed (Nigerian Guardian Newspaper 2001, Sotolu Per. com). Many more contracts in millions of Naira are still being awarded to control the weed.

There is also a realization that the weed is nutritious and could be harnesses into animal and fish feeds. Edewor (1988) observed that water hyacinth has a high photosynthetic fixation efficiency of 1.52%; while NAS (1976) reported that water hyacinth removed 80% of nitrogenous compounds and 40% of phosphorus compounds within two days. These are indications of high nutrient load in water hyacinth. WHO (1973) and FAO (1971) described water hyacinth as a good source of high quality protein and other nutrients such as vitamins. As the search for the most cost-effective and environmentally friendly methods of controlling the weed continues, we are of the opinion that mechanical control is still the best option. More so that some costs can be recovered when mechanically-removed plants are harnessed into the production of low-cost fish feeds. Our preliminary investigation showed that water hyacinth in Nigerian waters contains about 24% crude protein which qualifies it as a potential protein feed in animal diets (NRC 1993).

Soybean meal is a conventional plant protein used in fish feed. But the price is on the increase because it is imported, not readily available and it is also used in human and live-stock feeds. Therefore the need for other readily available and less expensive alternative plant protein feed ingredients to reduce the unit cost of fish production, since fish feed alone constitutes over 60% of the operating cost of fish culture (Nwanna 2002). This will promote mass production of fish that will be affordable to more people. Therefore the present study focused on how to reduce the unit cost of producing Nile tilapia (*Oreochromis niloticus)* a major aquaculture species in Nigeria, by reducing feed production cost, by reducing the quantity of soybean meal while increasing the quantity of water hyacinth meal in the diets. The results revealed the best combination ratios of soybean meal and water hyacinth meal that gave maximum production and profit.

Materials and Methods

Fresh samples of water hyacinth (*Eichhornia crassipes*) were collected from Awba Dam located in the University of Ibadan, Ibadan, Nigeria. The aquatic weed was transferred to the Laboratory for immediate processing to dry meal to ensure optimum proximate composition values. The weed was dried in an electric oven at 60^{o}C for 48h and then milled into a rough powder by the Thomas Wiley miller and subsequently stored in air-tight closed glass bottles for use in dietary preparation. The experimental diets (Table 1) consisted of isoproteic (35% CP) rations with a progressive inclusion of water hyacinth at 0, 25, 50 and 75%. Fish meal and soybean were the main dietary protein

sources while mineral/vitamin premix was added as quoted by suppliers (Roche Nigeria Ltd.). The diets were prepared into pellet forms as previously described (Falaye and Jauncey, 1999), oven dried at 70^{o}C in a Gallenkamp oven for 18h. The dried feeds were subsequently stored in air-tight polyethylene bags and kept in a deep freezer at a temperature at 8^{o}C until used. The experimental fish Nile tilapia (*Oreochromis niloticus*) were procured from a commercial fish farm (Tropical Aquaculture Products Ltd), Moniya Ibadan Nigeria and placed in an acclimation tank in the Department of Wildlife and Fisheries Management Laboratory, University of Ibadan. From this tank, 15 fingerlings of 5.50 ±0.2g were allotted to 20-litre circular glass tanks for each of the four dietary treatments in three replicates. The fish were acclimatized for 48h prior to the commencement of the feeding trials.

Each of the experimental diets was assigned to a fish tank with the replicates and fed 5% of fish biomass per day, supplied in two equal rations daily. Diets were adjusted bi-weekly on the basis of fish weight changes during the 10-week feeding trial. Fish tank water was replenished daily from a fresh water reservoir after siphoning the waste materials, while the tanks were completely washed every three weeks to prevent accumulation of scum and degradation of water quality. Water quality monitored remained stable throughout the experimental period with average readings of temperature, dissolved oxygen and pH as 25^{o}C, 8mg l^{-1} and 6.8 respectively. Samples of the feedstuffs, experimental diets and fish carcass (initial and final) were analyzed for chemical composition according to AOAC (1990). Water quality parameters were analyzed according to APHA (1975). Moisture was estimated by oven-drying at 105 ^{o}C for 24 h. Crude protein was determined by micro-kjeldahl (N X 6.25). Crude lipid was analyzed by Soxhlet extraction with petroleum ether and residue samples were charred at 550^{o}C in a muffle furnace for 12h to estimate ash content.

Fish growth and nutrient utilization parameters assessed were specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER), productive protein value (PPV). Gross energy was calculated according to Jobling (1983) with multiplier factors of carbohydrate, 4.1 kcal g^{-1}, protein, 5.4 kcal g^{-1} and lipid, 9.5 kcal g^{-1}. SGR = 100 x ($\log_e$ final weight-$\log_e$ initial weight/culture period (days); FCR= total feed fed/total wet weight gain; Protein efficiency ratio = wet weight gain/Amount of protein fed; Productive protein value (PPV) = Protein gain in fish/Protein in feed. Fish growth and nutrient utilization data were subjected to one way analysis of variance (ANOVA). Mean differences were separated using Duncan's multiple range test (Duncan, 1955).

Results

Proximate composition of WHM (Table 1) showed that the meal has 23.5% protein, high fibre and ash and low fat contents. The protein level is high enough for the meal to be used as dietary plant protein source in animal feeds. Table 2 presents the gross and proximate composition of the experimental diets. In the diets, WHM replaced 0, 25, 50 and 75% soybean meal. This replacement resulted in changes in some chemical composition of the diets. The protein contents of the diets were almost the same confirming consistency in diets formulations. However, the fat, ash and crude fibre contents of the diets increased with increasing replacement levels of WHM, while the carbohydrate and gross energy contents of the diets decreased with increasing supplemental levels of WHM in the diets. This may be due to the fact that soybean meal has more carbohydrate than WHM and or high levels of ash and fibre in the diets, since both variables are not included in the calculation of gross energy.

All diets were accepted and actively ingested by the fish throughout the feeding trial. No pathological symptoms resulting from nutritional deficiency was observed among the experimental fish during the period. Water quality in the experimental tanks remained stable throughout the experimental period. The growth and nutrient utilization performance is presented in table 3. The table shows that the final weight gain, percentage weight gain, SGR, FCR, PER and PPV values were statistically the same in fish fed either 0% or 25% of WHM, indicating that WHM can replace up to 25% of soybean meal in the diets without compromising physiological functions. Also the indices were significantly better in fish fed diets with either 0% or 25% WHM than fish fed other diets, revealing 25% WHM as the optimum that can be included in the diets of Nile tilapia. The growth of the fish and protein retention decreased consistently with progressive increase in dietary WHM. Survival rate of the fish in all treatments was almost 100%, as the death of a fish in treatment 2 could not be attributed to dietary inadequacies.

Carcass chemical composition (Table 4) showed an increase in the protein contents of the fish compared with the initial value before feeding trial. Protein retention was statistically the same in fish fed diets containing 0%, 25% or 50% WHM in replacement for soybean meal, but higher ($P<0.05$) than in fish fed 75%WHM. Crude fibre contents of the fish were higher ($P<0.05$) than the initial value; and increased progressively in the fish as a result of dietary WHM inclusion. However, contrary to expectation, fish fed 50% WHM contained higher ($P<0.05$) fibre than the fish fed 75% WHM. Fat contents of the fish showed a decreasing trend from the initial value before the feeding trial. Also the ash contents of the fish fed the experimental diets decreased drastically in comparison with the initial value. And interestingly, ash content of the fish fed 0, 25, 50 or 75% WHM was statistically the same. Similarly, moisture contents of the fish before and after the feeding trial were statistically the same.

Discussion

The chemical analysis of the water hyacinth meal (WHM) used showed that it has crude protein of 23.5% which qualified the use as a dietary protein source (NRC 1993). The meal also had high level of fibre which might have adversely affected digestibility by Nile tilapia (*Oreochromis niloticus*). To improve the digestibility, we recommend further processing or treatment of the meal to bring the fibre content to the lowest possible level and consequently improve the digestibility. The proximate composition of the diets revealed increased levels of fat, ash and crude fibre resulting from increasing levels of WHM meal in the diets. This consequently led to reduction in carbohydrate and gross energy (calculated, Jobling 1983) content of the diets. These reductions could have affected the growth performance of the fish as inverse relationship was observed between the growth and increasing supplemental levels of WHM.

Over 95% survival of the test fish was recorded during the feeding trial. This implied that the diets were well accepted and without physiological disorders. Growth and nutrient utilization of the fish were optimum at replacement level of 25% of WHM for soybean meal and consistently declined with further increase in supplemental levels of WHM. This is evidence that that 25% of soybean meal can be saved while formulating diets for Nile tilapia. Presently, 1 ton of soybean meal costs 100 thousands Naira therefore 4000 Naira per ton of soybean meal will be saved by supplementing the diet of Nile tilapia with 25% WHM. More of this cost will be saved by further processing of the WHM to reduce the fibre content, improve digestibility and by incorporating more of the meal into the diet. As fish

feed alone constitute over 60% of the operating cost of aquaculture (Nwanna 2002), this will be a big relief to many fish farmers. Nwanna and Ajani (2005) reported 15% WHM as the optimum for inclusion in the diets of African catfish, *Clarias gariepinus*. The 25% WHM reported for Nile tilapia in the present study is reasonable because Nile tilapia feed more on plants that the African catfish. Nwanna and Ajani (2005) also reported a decreasing trend in specific growth rate and food conversion ratio of African catfish fed diets with increasing levels of WHM.

The increase in the carcass protein is expected as evidence that the fish retained some quantity of protein fed. However, inclusion of 75% WHM into the diet affected protein retention negatively and should therefore be avoided. It is expected that carcass fibre would increase with increase in the WHM supplementation, so more fibre that is contained in fish fed 50% WHM than in fish fed 75% WHM could not be immediately explained, and therefore further investigation is necessary. The declining trend observed in carcass fat is also difficult to explain because after the feeding trial, the fat content of the fish was expected to appreciate more than the initial fat content value of the fish before the feeding trial. Interestingly, better than expected, the ash contents of the fish fed the different diets were statistically similar, indicating that inclusion levels of WHM did not affect the ash contents of the fish.

Conclusion

The study revealed that water hyacinth meal could replace up to 25% of soybean meal in the diets of Nile tilapia. This translates to more profit margins through the use of water hyacinth meal than the use of soybean meal. We recommend that Nile tilapia can be cultivated in some ponds/rivers to feed directly on water hyacinth as a means of controlling the weed. Farmers can also harvest the weed, sun dry and incorporate them into their farm made fish diets. Mechanical control of water hyacinth is tedious and expensive, but if the harvested plant are harnessed into animal feed, that would assist in low-cost feed production, which would lead to production of more animal protein and recovery of some costs in form of profits accruable from the multiplier effect. Finally, we also recommend that the Federal Government of Nigeria can turn the menace of this noxious weed into economic advantage by establishing industries that will process water hyacinth into meals for animal feeds. Even if the meal is sold to fish farmers at cost less than that of soybean meal that will still help in alleviating the problems of fish farmers, as insufficiency of fish feed remains a hindrance to the development of aquaculture in Nigeria.

Table 1. Proximate composition of water hyacinth (%)

Composition	%
Moisture	39.0
Protein	23.5
Crude fibre	26.2
Fat	0.50
Ash	10.8

Table 2. Gross and proximate composition of experimental diets (g 100g^{-1} DM)

	Diets Numbers			
Ingredients	1	2	3	4
Fish meal	26.33	26.33	26.33	26.33
Soybean meal	26.33	19.75	13.16	6.58
Water hyacinth	0.00	6.58	13.76	19.75
Wheat offal	22.66	22.66	22.66	22.66
Maize	22.66	22.66	22.66	22.66
Bone meal	1.00	1.00	1.00	1.00
Vitamin premix	1.00	1.00	1.00	1.00
Proximate composition				
Moisture	6.30	6.60	5.70	8.10
Crude protein	34.97	34.86	34.76	34.81
Fat	3.88	5.02	4.96	5.06
Ash	10.16	11.26	12.04	14.07
Crude fibre	5.54	9.34	15.62	18.14
NFE[1]	39.15	32.92	26.92	19.82
GE (kcal g^{-1})[2]	386.2	371.0	345.2	317.3

1. Nitrogen free extract
2. Gross energy

Table 3: Growth performance and nutrient utilization of *O. niloticus* fed WHM based diets

	Diets			
Parameters	1	2	3	4
Ini. mean wt. (g)	5.40±0.12[a]	5.40±0.12[a]	5.40±0.12[a]	5.40±0.12[a]
Final mean wt. (g)	14.2±0.08[a]	14.1±0.07[a]	12.8±1.01[b]	12.5±0.08[c]
Mean wt. gain %	163.0±2.27[a]	161.1±2.14[a]	137.0±2.11[b]	134.5±2.18[c]
S.G.R (g day^{-1})	1.38±0.01[a]	1.37±0.03[a b]	1.23±0.03[b]	1.20±0.02[c]
FCR	1.25±0.01[a]	1.36±0.01[a b]	1.52±0.01[b]	2.09±0.01[c]
PER	2.29±0.22[a]	2.11±0.18[a]	1.89±0.19[b]	1.43±0.20[c]
PPV	0.34 ±0.00[a]	0.42 ±0.01[a]	0.29 ±0.00[b]	0.14 ±0.01[c]
Survival rate (%)*	100	95.56	100	100

*Values not analyzed statistically.
Means along the same row with similar superscripts are not different (P>0.05)

Table 4: Initial and final carcass composition of *O. niloticus* fed with WHM based diets (% dry weight)

Component	Initial composition	Final composition				S.E.M
		Diet 1	Diet 2	Diet 3	Diet 4	
Crude protein	49.40[c]	61.48[a]	63.92[a]	59.47[a]	54.04[b]	3.61
Crude fibre	0.69[c]	0.87[b]	1.03[b]	1.47[a]	0.99[b]	0.13
Fat	5.00[a]	4.32[c]	5.16[a]	4.92[b]	4.85[b]	0.15
Ash	10.87[a]	3.16[b]	3.09[b]	2.70[b]	2.12[b]	0.28
Moisture	39.04[a]	34.04[a]	30.17[a]	26.80[a]	31.44[a]	3.40

Means along the same row with similar superscripts are not different (P>0.05).

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Illegal Logging and Control and its in South West Nigeria: Impacts On Sustainable Forest Resources Management and Forest Ecosystem

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Abstract
The greatest challenge to sustainable forest management (SFM) in Nigeria today is the increasing rate of illegal logging and the weak control of this nefarious act. This is more rampant in the tropical rainforest ecosystem of south west Nigeria because of its richness in desirable tropical hardwood timber species. Government policies, institutional support in forest management and enlightenment have not succeeded in curbing these problems. This is a great challenge to sustainable forest resources management. This study was on the problems of log control and illegal felling in southwest Nigeria using Ekiti State as a case study. Four Local Government Areas (LGAs) corresponding to Zonal Forest Offices were used for the study. Primary data were collected with three sets of structured questionnaire administered on forest professionals, forest guards and log control team members in each of the selected LGAs. Sixteen questionnaires were administered on professionals, 35 on forest guards and 32 on log control team members. Information on forestry activities in the state was obtained from the State Director of Forestry with interview schedule. To be able to preserve the forest ecosystem from total collapse, all the respondents were in support of effective log control. However, 43.2% of the respondents advocated for joint forest management. Prominent among what constituted illegal logging activities are evacuation of unhammered logs, logging without permit, felling under-girth trees, flitching, and non production of Timber Inspection Certificate (TIC) and Log Evacuation certificate (LEC). The most rampant of these offences is flitching. As part of log control measure, 57% of the respondents claimed that all felling sites were usually inspected before and after felling of logs in order to minimize illegal felling. Also, an average of 40 million Nigerian Naira is generated annual as fine paid by those arrested for carrying out illegal logging activities (forest offences) in the state. Most of the respondents (53%) rated the effectiveness of log control to be very good, while 40% rated it to be very poor. The study further revealed some of the limitations to log control in the study area. These include obsolete forest laws and policies, sharp practices of log control team members, the power that be, shortage of transportation facilities, bad road network, inadequacy personnel in the log control team, encroachment, lack of provision of incentives for the team members and inadequate funding of forestry activities. To avert these problems and enhance effective log control, there is the need to strengthen the officers in charge of logging and review of the existing logging policies and edicts.

Key Words: Illegal logging, Forest laws, Log Control, Reservation, forest cadres.

Introduction

The development of forest resources management in Nigeria could be divided into three phases. These phases are the reservation phase which is between 1899 and 1930, the exploitation phase between 1930 and 1960 and the development phase from 1960 to date. The first phase was pioneered by the colonial authorities. It involved the demarcation and establishment of tracts of forest land as reserves, provision for their protection and controlling of exploitation. This began in 1899 by one Mr Thompson, a serving British Forest Officer transferred from India to Nigeria (Enabor, 1981; Adekunle, 2005 and Oyebo, 2006). During this period, only 10% out of the 25% target of the country's land area proposed for reservation was achieved due to stiff resistance by the local communities who saw this process as a way of taking over their land by the government. Ogunlade (1993) reported that one third of Nigeria´s total land area (983, 213km^2) could be classified as forest from where the 10% reservation was achieved (Oyebo, 2006). The second phase is the exploitation phase. There was an increase in logging because many Nigerian timber

species were accepted in international market after extensive testing of their samples. During the third phase, there were large scale afforestation projects and plantation establishment through Taungya system to augment wood supply from the natural forest.

Forest reserves are portion of forest estate constituted by law and gazetted by the State or Local Government. Entrance and activities such as logging, hunting, farming and collection of minor forest products these reserves are controlled by the government. Nobody is permitted to farm or settle by a way of building house in the reserve. All other woodlands apart from the 10% under reservation are regarded as free areas. The available records in the Federal Department of Forestry, Abuja show that Nigeria has a total of 1,160 constituted forest reserves covering a land area of about 1075km^2. Salami (2006) reported that most of these reserves only exist today on paper. Apart from illegal logging, other factors that have contributed to the disappearance of the natural forest ecosystem include poor rural development, encroachment, massive conversion of forest reserves to agriculture and large scale afforestation projects. Illegal logging and encroachment are the greatest threat to SFM today. The natural forest is now disappearing at an alarming rate of 3.5% (about 350,000 – 400, 000 ha) per annum (Oyebo, 2006).

The ecological (biodiversity conservation, soil fertility maintenance, home for wildlife), economical (job opportunity and source of income to man and the government), environmental (air purification, mitigation of climate, prevention of global warming and its anticipated effects, watershed management, erosion control, carbon sequestration, adaptation to climate change) and sociological (provision of goods and services for rural livelihood e.g. food and herbs for health care delivery, recreation and aesthetic values) roles of forest ecosystem to urban and rural dwellers cannot be overestimated. About 70% of Nigerian population in the rural areas depends sole on forest ecosystem for survival. The forest has the potential of providing indispensable goods and services in perpetuity if sustainable management is applied in the real sense of it. Once a forest ecosystem is destroyed, and devastated due to illegal logging and encroachment, its potentials and usefulness to mankind is lost forever. Reactivating it is usually very difficult and may not be possible.

Timber harvesting is an important economic activity in Nigeria but the increasing rate of illegal logging is a serious challenge to forest conservation and reservation. Illegal logging is the indiscriminate removal of logs from the forest without following due process highlighted in government logging and harvesting policy. The illegally logged are usually converted into planks (flinches) at the site using hand power saw machine. Flinching wastes wood and destroys the immediate forest ecosystem. Those not converted on site are transported in the night after collusion with government forest officials with the duty of log control.. Illegally harvested timber constitutes more than 50% of the value of timber legally harvested in the country today (Akande, 2006). Causes of illegal felling in southwest Nigeria are the discretionary power of governments to de-reserve forests, lack of coherent and consistent forest policy and excessive bureaucracy in harvest management, poorly defined property rights, non-transparent allocation of concessions, corrupt government officials in charge of log control, over-capacity utilization in some timber industries, use of outdated management practices and inefficient log tracking system, get-rich-quick syndrome with most Nigerians and timber touts with political god fathers. All these are challenge to SFM.

Effects of Illegal logging are environmental degradation, landscape deterioration, loss of plant and animal species (biodiversity loss) and their potential importance to man, loss of revenue to the government, global warming,

loss of economic species etc. Curbing illegal logging is a difficult challenge in the domain of forest governance and this situation is presenting real challenges to all stakeholders in forest resources management

In 1998, a summit of the Group of Eight Nations (G8) met in France and highlighted their concerns about illegal logging. Various follow-up initiatives at country and regional levels were developed at the meeting. The general consensus was that forest governance, by way of united tri-partite actions, could stem illegal logging through capacity building and improved awareness of associated impacts. The main objective of this work therefore was to examine the impacts of illegal logging on SFM and forest ecosystem.

Methodology

Description of the Study Area

Ekiti State is located in the South Western part of Nigeria. It was created out of the former Ondo State in 1996 by the Federal Government of Nigeria. The forest estate in the state is endangered because of its location as trans-savanna rainforest but due to illegal felling activities, the State forest estate has now transformed to more or less savanna rather than improved rainforest. The state lies between the latitudes 7^0N and 8^0N and longitude 5.1^0E and 5.7^0E. It covers a total of about 7,500km^2 land mass (Adekunle and Ajakaye, 2003). The vegetation of the state consists of savanna wood land and predominantly deciduous and high forest reserves. The annual temperature ranges from 22.5^0C and $25.^0$C, and annual rainfall ranges from 1,500-2000 mm. Ekiti State has sixteen Local Government Areas (LGAs) which are grouped into four forestry administrative zone (a zone has four LGAs). This study was carried out in the four Zones. The zones are Ikere, Ado Local, Ido/Osi and Ikole.

Method of Data Collection

The data collected for this project were gathered through the use of structured questionnaire, which were administered in four Forest Zonal Offices in the state. The questionnaires were administered on the three categories of workers namely the Professional Forest Officers, Technical staff and Forest Guards. The Log Controls Team members were also included in questionnaire administration. The questionnaire was administered and retrieved on the spot. This was possible because all the respondents have formal education. An interview schedule was carried out with the Director of Forestry, Ekiti State Forestry Department to gather additional information on logging activities, forest offences, the amount of money realized form logging activities, effectiveness of the log control teams, major problems of log control etc. The questionnaires were designed to collect information on the problems facing log control and forest monitoring in the state, suggestions on how to control illegal logging, forest offences committed and number of offenders apprehended, amount realized as fine for committing forest offence between year 2000 and 2006 etc. Ten professionals, 6 Technical Officers and 45 forest guards were randomly selected for questionnaire administration. Twenty-two Log control team members were also randomly selected for questionnaire administration too. So, a total of 83 forestry staff were involved for data collection. Additional information relevant to this work was obtained as secondary data from the state's records, files and annual reports.

Data Analysis

The data collected for this study were analyzed using descriptive statistics, like frequency and percentage distribution. Two-way analysis of variance was used to compare the number of forest offenders apprehended during the five year period covered by this study. Also, the presence of significant difference was verified among the various categories of forest offences. Where significant difference was discovered, means were compared using the Fishers Least Significant Difference (LSD). Also, chi square test of association was used to verify whether there is relationship between the zones and efficiency of log control. These analyses were done at 5% probability level using SPSS version 13 for windows (SPSS, 2003).

Results and Discussion

The result of this study revealed that there are 131 staff members who are foresters by training in the service of Ekiti State, Nigeria. This is made up of 16 professionals, who are university graduates of Forestry or Botany, 9 technical officers who are holders of Higher or Ordinary Nation Diploma and 106 Forest Guards as shown in Table 1. These are the officers in charge of monitoring and controlling all activities in conservation areas of the state. They are distributed into the four forest zones in the state for easy administration and effective monitoring of logging activities. These officers are charged with the duty of arresting and compounding of offences for any illegal fellers apprehended in their respective administrative zones. All the various ranks available in different cadres were covered during questionnaire administration. For the professionals, the following ranks were involved: Chief Forest Officers (Zonal Forest Officers: who are usually the overall officer in each zone), Principal forest officers, Senior Forest Officers, Forest Officers (I & II). The ranks under the technical staff are Chief Forest Superintendent, Principal Forest Superintendent (I & II), Senior Forest Superintendent, Higher Forest Superintendent, Forest and Assistant Forest Superintendent. The ranks for the forest guards are Chief Ranger, Ranger and Forester. Officer in the Log Control Team cut across all the cadres and ranks.

For the experience of the respondents on the job (Table 1), highest percentage (37%) claimed to have spent between 6 and 10 years in services. This is followed by those who have spent 1-5 years. Those who have spent more than 10 years are well versed in the act of forest monitoring and protection of conservation areas. These are sets of people who have learnt on the job and have attended several training and workshops. Only 2% claimed to have spent 21 -30 years in service. These set of people are the most experienced but they will soon retire from the civil service.

From the result, the primary assignment of the professional forestry officers is to manage all forest estate in their charge and coordinate the activities of all other categories of staff including the administrative support staff such as clerk, they are assigned to specific charges or stations. For the Technical Staff, they are in charge of conservation, silvicultural operations and plantation development. The main assignment of the forest guards is to implement forest laws at the grass root level. They are assigned with the work of patrolling the forest and pass hammering all logs legally felled from reserves and free areas. They inspect trees before felling and oversee that various communities do not encroach into the forest reserves.

There are 20 log inspection posts in the state. These posts are strategically located on high ways in the zones and the number in each zone is shown in table 1. The highest percentage (35%) of the posts is located at Ikole zone.

Each post is man by forest officials to apprehend illegally cut timber on transit. On the effectiveness of log control, 53% of the respondents claimed that this is done efficiently. This is followed by those who reported that logging activities are poorly monitored and controlled. Only 1% of the respondents agreed that it is very efficient. In general, logging is poorly supervised by forest officer due to several reasons raised by the respondents. The greatest factor promoting illegal logging is unemployment as reported by 31% of the respondents. This is followed by those who claimed that conservation areas are not properly monitored and logging is not supervised (27%). However, it was discovered that lack of efficiency of log control team is not associated with a particular zones as a non significant χ^2 test of association was obtained ($P \leq 0.05$, $df = 6$).

Logging activity as organized in Nigeria is labour intensive and it requires many professionals such as power saw operators, skidders and truck drivers. Illegal logging is now being carried out by armed and irate youths with impunity. This has led to shortage of high grade hardwood timber species in reserved and free areas. Except urgent action is taken by the government and the stakeholders, deforestation and its attended complication is imminent and this will be a great threat to SFM. SFM is a system of management that gives room for judicious exploitation and utilization of forest resources without jeopardizing the future. It is the pillar behind forest management in developed counties. SFM has been defined as the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems (Briner, 2004).

The entire respondents claimed that illegal logging activities are going on in all over the zones at an alarming rate. Illegal activities under the logging policy of southwest Nigeria include evacuation of unhammered logs by the forest guards, logging without obtaining all necessary permits from the government, felling of under-girth trees (trees with dbh less than 48 cm), trespassing and non production of Timber Inspection Certificate (TIC) and Log Evacuation Certificate (LEC). Table 2 shows the number of people arrested for committing the various logging offences between year 2002 and 2006 in the study area.

Table 1: Staff strength, experience, number of inspection posts and factors promoting illegal logging in the study area

Variables	No	%
No. of Staff according to ranks		
Professionals	16	2
Technical staff	9	7
Forest Guards (Uniform staff)	106	81
Total	131	100
Respondents experience on the job (years)		
1 – 5	29	35
6-10	30	37
10-20	22	26
21-30	2	2
Total	83	100
No of inspection post in each zone		
Ado-Ekiti	3	15
Ikole	7	35
Ikere	5	25
Ido-Osi	5	25
Total	20	100
Effectiveness of Log control		
Very efficient	1	1
Efficient	44	53
Poor	34	41
Very poor	4	4
Total	83	100
Factors promoting illegal felling		
Unemployment	26	31
Poverty	8	10
Lucrativeness of timber business	12	14
Weak forest laws and policies	15	18
Ineffectiveness of forest monitoring and log control	22	27
Total	83	100

The crime with the highest number of offenders is logging without permits represented by an average number of 564 ± 12.48 offenders. This is followed by trespassing (logging in a compartments not officially allocated to the offenders) with a mean value of 85 ± 1.64 offenders. In southwest Nigeria, forest compartments are usually allocated to concessionaires in the reserves after the payment of all appropriate levies and meet all the necessary conditions. The allottees usually renew their allocation annually. Allocations are revoked from those who could not renew or abide with the rules and regulations guiding logging activities in conservation areas. Loggers who are not lucky to obtain allocation or could not afford the cost of a compartment are those carrying out logging in another person's compartments. This is trespassing and stealing, a serious forest offence. Adekunle and Ige (2006) reported that selective logging is the major logging method in Nigeria. This entails searching and felling of economic species above the minimum girth specified by forest law. Faces of logs legally felled are always stamped and inscribed with the

government and contractor's seals (hammering). This makes tracking and arresting of illegally felled logs to be very easy.

Logging without permits was recorded as the commonest offence due to the fact that these illegal loggers are not always willing to pay the appropriate government charges and tariffs for the logs they cut. Instead of obtaining all necessary permits after the payment of prescribed fees, these set of illegal loggers prefer to commit this crime in the night. This has resulted to the loss of revenue by the government. It was discovered that the number of offenders reduced over the year. Highest number was recoded for year 2002 while the least for 2006. This is contrary to the assertion of Adetula (2008) that illegal logging has moved to a level and increasing daily. He noted further that armed gangsters had constituted themselves into a militant groups behaving like private army to carry out illegal felling. They have found illegal felling a very lucrative business and the situation had got out of control of the unarmed uniformed field staff (forest guards) that have the mandate to protect the forest. There is actually a tremendous increase in the number of illegal loggers in the study area according to all the respondents and the State Director of Forestry. But the reason for the reduction in the number of those apprehended between 2003 and 2006 in this study can be attributed to the ineffectiveness of the forest monitoring, lack of incentives and patrol vehicles for log control team, ineptitude and corruption on the part of forest guards, offender who could provide bribe or with "political god father" are easily released, lack of appropriate records of offenders and the clever way illegal loggers are now operating. Logs illegally logged are either transported in the night or processed at the site of felling (Flitching). Flitching produces waist logs and disturbs forest ecosystem (Akande, 2006).

The result of the two way analysis of variance (ANOVA) in table 3 shows that there was no significant difference ($P \geq 0.05$) in the number of offenders apprehended on yearly basis during the five-year period. But a significant difference (≤ 0.05) was recorded for offenders in the various categories of offences. The result of mean comparison with LSD also indicated that there was significant difference in the number of offenders when the categories of offence were compared. The penalty for committing any of these logging offences include fines, seizing of the logs, equipment and truck, imprisonment and withdraw of logging permit.

Table 2: Categories of offences and Number of offenders arrested between year 2002 and 2006 in the study area

Offences	Years						
	2002	2003	2004	2005	2006	Total	*Mean
Trespassing	82	72	85	89	97	425	85 ± 1.84
Illegal evacuation of unharmmered log	72	55	83	85	91	386	77 ± 2.84
Logging without permit and flitching	602	611	614	509	484	2820	564 ± 12.48
Cutting of Undergirth trees (tree with dbh ≤ 48 cm	52	46	32	21	35	186	37 ± 2.43
Non production of TIC and LEC	97	67	42	38	32	276	55 ± 5.38
Total	905	851	856	742	739	4093	
Mean	181 ± 47.18	170± 49.32	171 ± 49.43	148 ± 40.74	148 ± 38.08		

Table 3: ANOVA table for comparing number of offenders for the various offences and during the five year period.

Source of Variation	SS	Df	MS	F	P-value	F crit
Types of Offences	1008452.6	4	252113.16	255.5801	2.82E-14	3.006917 NS
Years	4423.44	4	1105.86	1.121067	0.381184	3.006917*
Error	15782.96	16	986.435			
Total	1028659	24				

NS not significant ((P≥ 0.05) * Significant (≤ 0.05)

Summary of common problems itemized by the respondents hindering the effective control of illegal felling and the performance of log control team in the state are inadequate vehicles and motor cycles for patrolling the forest, bad road network in forest areas, inadequate number of trained staff, inadequate funding, lack of information or communication equipments and non provision of incentives for the log control team members. Other problems are the weak nature of the forest laws and policies, corruption and lack of arms for forest guards. It is known that during the rainy season, some of these roads are not motorable, making assess to the forest by monitoring team to be very difficult.

The result of this study gives some suggestions that can go a long way to avert illegal felling activities in Nigeria. The suggestions provided by the respondents are (i) provision of job opportunities most especially to restless and jobless mammoth youths in the state, (ii) demanding of higher fines from offenders, (iii) regular monitoring of forest reserves, (iv) provision of patrol vehicles and motor cycles for effective patrolling of the forest and routes been use by illegal loggers, (v) increasing the number of personnel and adequate training for them and (vi) provision of necessary incentives for the patrol team member in order to discharge their duty effectively and prevent bribe collection and dishonesty.(vii) extension service and education of the populace on the grave consequences of illegal felling and forest destruction on biodiversity conservation, climate change, food security and rural livelihood and (viii) review of the old western state of Nigeria forest laws and policies to meet the need of the day. Reich et al (2001) reported on the adverse effects of logging on biodiversity conservation and forest productivity.

Estimate of revenue generated to Ekiti State government from forestry sub sector (forestry activities) over period of 5 years is shown on Table 4. About 42 million Nigerian Naira was generated as revenue from forestry sub sector in the study area in 2000, 47 million Naira in 2001, 48.5 million Naira in 2002, 47.5 million Naira in 2003, 50 million Naira in 2004 and 2005 and 56 million Naira was generated in 2006.

Table 4: Estimate of revenue generated from forestry sector in the study area.

Variables	Years				
Revenue as fine from illegal loggers	2002	2003	2004	2005	2006
	Amount generated (N'000,000)				
Ikole	2.3	2.9	3.1	2.7	3.5
Ado	1.5	1.3	2.7	1.6	2.4
Ikere	1.4	1.4	1.2	1.3	1.5
Ido/Osi	1.1	1.3	0.9	1.1	1.3
Total	6.3	6.9	7.9	6.7	8.7
Total annual revenue from forestry sub-sector					
Logging activities and payment for forest allocation	37.2	36.1	38.3	40.2	42.5
Fine	6.3	6.9	6.9	6.7	8.7
Minor forest produce	3.5	4	5.1	5.2	4.1
Others	1.5	2.6	1	1.4	2.1
Total	48.5	49.6	51.3	53.5	57.4

Conclusion and Recommendation

This study considered the implication of illegal logging activities in tropical rainforest ecosystem of southwest Nigeria using Ekiti state as a case study. There is a tremendous increase in the rate of illegal felling due to inefficient log control in the state. There is also an increase in the amount of money realized from forest offenders arrested by government officials charged with the duty of protecting the forest. Illegal and indiscriminate logging is a great challenge to sustainable forest management in developing countries of the world. Illegal logging could lead to biodiversity loss and loss of important timber species, soil compaction and loss of revenue to the government.. There is an urgent need to put illegal felling to an end. To be able to achieve this, the following recommendations should be adhere to:

i. The number of forest guards should be increased, they should be properly trained and aarmed to instill fear in illegal loggers.
ii. Vehicles and motorcycles should be provided for log control team to allow effective patrol of the forest and constant monitoring.
iii. Incentives should be provided for log control to reduce corruption and bribery
iv. The existing forest laws and policy are due for review. New laws in line with recent advance in SFM should be promulgated.
v. Stiffer punishment should be melted out to illegal loggers to serve as deterrent to others.
vi. The participation of local communities and other stakeholders in forest management should be encouraged. Agbeja et al. (2005) has reported on the effectiveness of community participation in forest management. Joint management of forestry could go a long way to reduce illegal logging and prevent its environmental, economical and ecological consequences.

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Assessment of Fish Farming Profitability and Viability in Osun State: Implication for Extension Services and Food Security at Household Level.

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Abstract

Gross Margin procedure and Benefit Cost Ratio were cross-adapted to determine the profitability and viability of rearing four types of fishes (Tilapia, Clarias, Heterotis and Heterobranchus) in the three agro-ecological zones of Osun State for appropriate extension policy formulation and implementation towards facilitating food security at household level. Multistage sampling procedures were employed to select three hundred fish farmers: (Ife/Ijesa 72; Osogbo 103, and Iwo, 125) based on the number of registered fish farmers in the LGAs in each zone. Data were collected with the aid of structured interview schedule from the farmers in 2007. The results showed that the mean age of fish farmers in Osun State was 47.7 years. About 18.0 percent of the respondents belonged to fish farmers' association and 43.0 percent had contact with agricultural extension agents. Majority (58.0%) sourced information from friends and neighbours and 71.0 percent sourced information from private companies. The mean fishpond size was 0.14ha; and the mean yields of Tilapia and Clarias fishes were 1.50 tons/ha and 4.97 tons/ha respectively while the mean yields of Heterotis and Heterobranchus were 0.20 ton/ha and 1.26 tons/ha, respectively. The mean income of fish farmers was ₦166, 399.70 per annum. The profitability of fish farming in form of gross margin for Tilapia fish in Osogbo zone was the highest (₦232,198.88/ha) while it has the least value in Ife/Ijesa zone (₦220,024.35/ha). The Gross margin in Iwo zone was ₦226, 632.40/ha. The Benefit Cost Ratio for Ife/Ijesa, Osogbo and Iwo zones were 1.01, 1.02 and 1.02 respectively. However, the profitability (Gross margin) of Clarias fish was also highest in Osogbo zone with ₦3,462,610.65/ha; Ife/Ijesa zone had ₦1,509,931.20/ha while Iwo zone had ₦1,852,394.88/ha. The Benefit Cost Ratio (BCR) for the three zones Ife/Ijesa, Osogbo and Iwo were: 2.15, 2.87, and 2.97 respectively. Clarias fish was found viable in all the agro-ecological zones of the State. Also the profitability (Gross margin) of the other two types of fishes (Heterotis and Heterobranchus) investigated showed that Heterotis is reared in both Ife/Ijesa and Iwo zone but none of the respondents reared Heterotis in Osogbo zone. The Gross margin of this fish in Ife/Ijesa was ₦255,807/ha while the Gross margin was ₦643,372.92/ha in Iwo zone. The Benefit Cost Ratio was 1.09 in Ife/Ijesa and 2.04 in Iwo zone. Only respondents in Iwo zone r reared Heterobranchus fish. However, the Gross margin for Heterobranchus in Iwo zone was ₦832,982.60/ha. The Benefit Cost Ratio of Heterobranchus fish in the only zone producing it was 2.75.

It is concluded that Iwo zone is suitable in topography, climate, soil type and vegetation for rearing the four types of fishes investigated; also extension efforts in facilitating and enhancing increased fish farming production in Osun State should be based on the ecological factors and types of fishes identified suitable for each zone.

Key words: Assessment, fish farming, profitability, viability, fish farmers.

Introduction

Despite the wide acceptance of fish farming as an income generating activity in Nigeria, its contribution to total domestic fish production has not been very encouraging though with gradual increment. Fish contributed 128.29 billion Naira to the nations G.D.P in 2004 more than 43.97 billion Naira in 1998 (CBN, 2004). Fish demand in Nigeria was estimated at 1.06 metric tonnes, while the supply stands at 0.81 metric tonnes leaving a deficit of 0.25 metric tonnes (FAO, 2000). This is not unconnected with observation of the Federal and State Government coupled with historical experiences of government on fish production in controlled water in 2003 when broad based policy was formulated. The design and formulation of the fish farming policy was based on the realization that fish farming (aquaculture) remains the only viable alternative for increasing fish production in order to meet the protein need of the Nigerian people. Nigeria is blessed with suitable land where freshwater, marine and brackish fish

species can be cultured. However, out of about 1.8 million hectares of suitable land for aquaculture less than 20% are under cultivation (Tobor, 1990) and the situation remain unchanged.

Historically, the first fish farm was established in Nigeria at Panyam in 1951 while Agodi fish farm was established in the Western region in1953. The Federal government started additional pilot fish farm in 1967 in Ikeja, Lagos State. Another was sited in the East which was short –lived due to civil war. Fish seed multiplication centres were sited at Oyo (South West), Umuna Okigwe (South East), Kaduna (North West) and Panyam (North East) (Omitoyin, 2007). According to the Federal Ministry of Agriculture and Natural Resources (2003), the objectives of the Federal Government on aquaculture development include:

* the achievement of self-sufficiency in fish production on a sustainable basis in the next ten years;

* researching, developing and modernizing aquaculture production systems;

* improving the socio-economic life of fish farmers in rural communities;

* conducting on-farm research on fingerlings, feed and table fish production;

* providing and improving employment opportunities in the rural areas;

* arresting rural - urban drift;

*enhancing foreign exchange earnings through promotion of export of cultured fish/ornamental/shrimp;

* optimizing the appropriate use of water bodies for culture based fisheries;

* supporting and strengthening the fisheries related associations;

* enhancing women contribution in aquaculture development; and

* promoting fuller utilization of all agro-chemical by-products of crops and animal residue, which are found to be suitable.

The effective implementation of the policy statements above due to the commitment of both federal, state, private companies and groups of farmers was informed by the need to reduce poverty among rural households, improve the socioeconomic conditions of rural dwellers and generate more income and foreign exchange through economic empowerment and diversification in Agriculture. The manifestation of this is seen in the upsurge in the increasing fish farming activities in Nigeria and increasing contribution to GDP. According to CBN report (2004), fish production increased by 4.5 per cent compared with 2.0 percent in 2003. Likewise, the output of fish from fish farming has increased from 42,000 tonnes in 1998 to 43,900 tonnes in 2004 and 56,300 tonnes in 2005. The increase was attributed to many government initiatives during the year, including the Federal Government's collaboration with host states and the private sector to rehabilitate selected fish farms and hatcheries for the production of fish fingerlings and, the training of fish farmers as part of the National Special Programme for Food Security (NSPSF) in Nigeria.

Statement of research problem

Fish farming as a community based activities is an established enterprise in Osun state but not many people are venturing into investing in fish farming enterprise as reflected in the production statistics of fish farming in Osun state on local government basis (MANR, 2005). The fact still remain that not many people have deep knowledge of both technical and economic values of fishes reared or could be reared on ecological bases in Osun state. Secondly, out of many studies on profitability of agricultural

enterprises i.e. change from inorganic fertilizer to organic (Alimi, 2007); cowpea production (Akande, 2006); cassava production (Adelaja, 2005); cowpea production (Oladebo and Sanusi, 2005); plantain production (Baruwa, 2004); goat production (Oguniyi and Olaniyi, 2004); and fish farming in Ondo state (Fapohunda, 2004); none focus on the profitability of fishes reared on ecological basis in Osun state. Therefore, there is need to determine the profitability and viability of fish farming enterprises in Osun state such that farmer would know type of fish to rear in their respective ecological zones. The study was designed therefore to provide answers to the following research questions:

(i) what are the fish farmers and fish farming characteristics in Osun state?;
(ii) what are the types of fishes reared in Osun state?;
(iii) how profitable and viable are the fishes reared in each ecological zone ?; and
(iv) what are the implications for extension service delivery and food security at household level?.

Objectives of the study

The major objective of the study is to find out whether fish farming is a profitable and viable enterprise to draw implication for extension service delivery and food security at household level in Osun state. The specific objectives are to
(i) examine the characteristics of the fish farmers and fish farming in Osun state;
(ii) identify type of fishes reared and determine their profitability and viability on ecological basis; and
(iii) draw implications for extension service delivery and food security at household level in the study area.

Methodology

Area of study:

The area of study is Osun State, which was created on the 27th August 1991 with its Headquarters in Osogbo. The state lies in the South West of the Niger Valley in the savannah and rainforest zones of the country. It lies within latitude 5^0 56^1North of the equator and 8^0 07^1 east of the Greenwich Meridian to the south. It is marked by Longitude 4^0 to the west and Longitude 5^0 5^1 to the East (Osun State Directory, 2004). This state is bounded in the south by Ogun State, in the North by Kwara State, in the East by Ondo State and Ekiti State and Oyo State in the West. Osun State is homogeneous comprising of Major Yoruba ethnic group sandwich with few other minor tribes like Hausas, Igbo, Ebiras, Tiv and Nupes. The total land area under cultivation is 235,308 hectares amounting to 26.5 percent of total land area (Osun State Agricultural Development Programme 1993).

The population of the State according to 2006 population census is 3,423,535. There are distinct vegetation types in the State, the rainforest in the southern part, derived Savannah and Savannah vegetations in the north and western parts, respectively. The soil in the rainforest is generally red and yellow earths (Ferrasols). On the other hand, ferruginous soils developed from acid crystalline rocks are common in the Savannah sectors (OSSADEP, 2000). The tropical climate in the State favours the cultivation of varieties of arable crops, which include yam, cassava, maize, rice, cowpea, soybeans and many species of leafy and fruit vegetables. The policy of the state government on agriculture is not only aimed at increasing food, animal and fish production, but also to ensure employment generation through Osun State Agricultural Youth Empowerment (OSSAYEP, 2004).

Osun State is divided into six administrative zones which are: Osogbo, Ikirun, Iwo, Ife, Ilesa and Ede for ease of governance. Also the State is divided into three agro - ecological zones by Osun State Agricultural Development Programme (OSSADEP), the zones are: Iwo, Osogbo and Ife/Ijesa that were covered in this study. Each zone has the capability and the resources for fish farming in the state (OSSADEP, 1993).

Sampling technique

Multi-stage and proportionate sampling procedures were used to select 12 out of the 30 Local Government Areas (LGAs) in the state ,and a total of 300 fish farmers were selected on zonal basis. The number of respondents (fish farmers) interviewed in each of the LGA selected are: Irewole 6 registered and 6 unregistered, Ejigbo 52 registered and 51 unregistered and Iwo 5 registered and 5 unregistered (Iwo zone); Osogbo 15 registered and 16 unregistered, Olorunda 15 registered and 15 unregistered, Odo-Otin 8 registered and 8 unregistered, Irepodun 7 registered and 7 unregistered and Egbedore 6 registered and 6 unregistered (Osogbo zone); Ife East 5 registered and 5 unregistered, Ife North 7 registered and 7 unregistered, Ilesa West 14 registered and 14 unregistered, Oriade 10 registered and 10 unregistered in Ife/Ijesa zone. The ratio of registered fish farmers is 1:1.43:1.74 on ecological basis, Ife/ijesa, Osogbo and Iwo respectively was used to select three hundred fish farmers in the zones as follows: 72 from Ife/ijesa zone, 103 from Osogbo zone while 125 were selected from Iwo zone. Both registered fish farmers selected through simple random sampling technique and unregistered fish farmers selected through snowballing technique were considered in the study because both of them have assess to fish information either through extension contact, electronic or print media, friends and neighbours or through fish farming associations.

Measurement, validity and reliability of variables

Profitability of fish farming is measured as the Profit Gross Margin using Budgetary Technique while Viability is the efficiency ratio computed by Benefit Cost Ratio (BCR). Revenue of the farm was computed as monetary value of the total farm output consumed by the farmers' household, sold, given out as gift or reserved for other purposes. The revenue is equal to the output of fish multiplied by the price per kg of the fish. Cost of inputs associated with the output was taken as absolute value given for hired labours, rent on land, consumable inputs like fertilizers, feeds, lime and herbicides. Cost of implements, cropping, handlings, labour, consumables and transportation were taken as variable cost (VC). Profit was computed as the difference between revenue and variable cost of production (Alimi and Manyong, 2000). Characteristics of fish farming were measured in absolute value given by fish farmers as follows: size of the pond in sq metres, location is in Km from source of water, age of pond in number of years, number of croppings is number of harvesting time, yield of fish in tonnes is the total output of fish cropped- eaten, sold, and gave out as gift and type of stock in number fishes reared. The interview schedule was subjected to both content validity and test-retest reliability, which was adjudged reliable with reliability coefficient of 0.76.

Data collection and data analysis

Data were collected with the aid of interview schedule on fish farmer and fish farming characteristics, types of fish reared, cost of farm input and yield of fish from fish farmers in 2006. Descriptive statistics such as frequency counts, percentages, mean and standard deviation were used to summarise the data. Budgetary technique was employed to determine the profitability of fish farming enterprises in Osun State. Total Revenue (product of output and price per unit) minus Total Variable Cost of production gives the Profit in Gross Margin. Efficiency ratio of production as computed by Adeyeye and Dittoh (1985) and Anandarup (1984) was also employed to determine the viability of the enterprise. Benefit Cost Ratio (BCR) can be simply expressed as:

$$B.C.R. = \frac{\text{Present value of Benefit(TR)}}{\text{Present value of cost (TC)}}$$

A project or investment is viable, if the Benefit Cost Ratio is equal to 1 at the particular discount ratio. The higher the BCR**,** the more viable is the investment / Project. Only the cost of construction of fishpond was used as the fixed cost and was used to calculate the BCR and not the profitability.

Results and Discussion

Farmer selected characteristics

The mean age of fish farmers in Osun State was about 48 years; they were male and well educated; belonged to one type of organization or the other but few were members of the fish farming association while majority of fish farmers had no extension contact for trainings in fish farming technologies. Majority of fish farmers in the State sourced fish farming information from friends and neighbours and during electronic media agricultural programme. However, cooperative and thrift society remained the major source of loan/credit to fish farmers while private companies and individuals remain the major sources of fishery inputs in Osun State.

Fish farming Characteristics

Detailed analysis showed that the mean size of pond in the state was 1455.9m^2 (.145Ha) and standard deviation of 459ha. Majority (66.0%) of the respondents had medium size ponds and only about 34.0 percent had large ponds. None of the respondents had small size ponds. Majority (73.3%) of the total respondents located or sited their fish farms near a flowing river/stream. This finding supports that of Raji (2003) that majority of fish farmers had between 0.01 and 0.1 ha of fish farms and 77.8 percent of fish farmers used perennial streams as their source of water in Osun State. Fapounda (2004) reported that about 72.0 percent of fish farmers in Ondo State had between 100m^2 and 999m^2 fishpond and that about 57.0 percent of fish farmers made use of well/spring water as source of water for their fish farm in Ondo State. Four types of fishes stocked were Tilapia, Clarias, Heterotis and Heterobranchus that were identified by the majority of the respondents. However, all (100.0%) of the respondents reared Clarias fish specie in their fish farms.

The mean yield of Tilapia fish was 1.50 ton/ha in Osun State. The yield of Tilapia fish was best in Iwo zone with mean yield of 3.34 tons/ha. The mean yield of Clarias fish was 4.97ton/ha in Osun State. The yield of Clarias fish was best in Ife/jesa zone with the mean yield of 5.84 ton/ha followed by Iwo zone with 5.27 tons/ha. The mean yield of Heterotis was better in Iwo zone with 0.24 tons/ha than the 0.20 tons/ha in Ife/jesa zone. The mean yield of Heterobranchus fish was 1.26 ton/ha in Osun State. The fish was only found in Iwo zone. Income was money realised from the sales of fishes harvested from the various fishponds. Price of Tilapia fish ranges between ₦80 and ₦100 per kg while Clarias ranges between ₦250 and ₦400 per kg. Price of Heterotis and Heterobranchus ranged between ₦250 and ₦300 per kg during the period, year 2005. The mean income from fish cropped per annum was ₦ 166.399.70.

Profitability and viability of fish farming

Table 1 showed the profitability of fish farming in form of gross margin and viability in terms of Benefit Cost Ratio (BCR) of the four types of fishes investigated in the three agro-ecological zones of Osun State. Gross margin for Tilapia fish in Osogbo zone was the highest (₦232,198.88/ha) while it was least in Ife/Ijesa zone (₦220,024.35/ha). The Gross margin in Iwo zone was ₦226,632.40/ha. The Benefit Cost Ratio for Ife/Ijesa, Osogbo and Iwo zones were 1.01, 1.02 and 1.02, respectively.

The implication of this finding was that Tilapia fish was likely to be less profitable in Ife/Ijesa zone than the other two zones, but viable in all the three agro-ecological zones of the State. However, the profitability (Gross margin) of Clarias fish was highest in Osogbo zone with ₦3,462,610.65/ha, followed by Iwo zone (₦1,852,394.88/ha) while Ife/Ijesa zone had ₦1,509,931.20/ha. . The Benefit Cost Ratio (BCR) for the three zones Ife/Ijesa, Osogbo and Iwo were: 2.15, 2.87, and 2.97, respectively. This implies that it would be more beneficial to rear Clarias fish in Iwo zone (BCR 2.97) than Osogbo zone (BCR 2.87) and Ife/Ijesa zone (BCR 2.15*).*

Table 1: Average Cost and Return to Tilapia and Clarias from fish farming per zone in Osun State

Tilapia fish	**Ife/Ijesa**	**Osogbo**	**Iwo zone**
Farm size	1.0ha	1.0ha	1.0ha
Total Revenue (TR)	699480	820860	524816
Cost of fertilizer	9230.65	6592.12	5220.16
Cost of lime	8946.00	4601.40	3919.98
Cost of feed	163020.00	288,960.0	140599.50
Cost of labour	220659	125,307.70	130271.77
Cost of Tilapia fish	77,600	163200.20	18172.19
Total Variable Cost (TVC)	479455.65	588661.12	298183.60
Fixed cost	216105	220101	216105
Total cost	695560.65	808762.12	514288.60
GM = TR – TVC	220024.35	232198.88	226632.4
Benefit Cost Ratio (BCR)	1.01	1.02	1.02
Clarias fish			
Farm size	1.0ha	1.0ha	1.0ha
Total Revenue (TR)	2422500	4974900	2464600
Cost of fertilizer	9230.65	19912.75	10390.08
Cost of lime	9009.00	13899.60	7802.24
Cost of feed	326040.00	872872.00	279846.40
Cost of labour	442013.00	378521.00	259289.60
Cost of Clarias fish	126276.15	227084.00	54876.80
Total Variable Cost (TVC)	912568.80	1512289.35	612205.12
Fixed cost	216105	220101	216105
Total cost	1128673	1732390.35	828310.12
G.M = TR – TVC	1509931.2	3462610.65	1852394.88
Benefit Cost Ratio (BCR)	2.15	2.89	2.97

Source: Survey data, 2006

Data in Table 2 also show the profitability (Gross margin) of another two types of fishes (Heterotis and Heterobranchus) investigated in the three agro-ecological zones of the state. Respondents reared Heterotis in both Ife/Ijesa and Iwo zone but none of the respondents reared Heterotis in Osogbo zone. The Gross margin of this fish in Ife/Ijesa was ₦255,807 per hectare while the Gross margin was₦643,372.92/ha in Iwo zone. The Benefit Cost Ratio was 1.09 in Ife/Ijesa and 2.04 in Iwo zone. This indicates that farming of Heterotis fish would be more beneficial in Iwo zone than Ife/Ijesa zone.

Only respondents in Iwo zone reared Heterobranchus fish. However, the Gross margin for Heterobranchus in Iwo zone was ₦832,982.60/ha. The Benefit Cost Ratio of Heterobranchus fish in the only zone producing it was 2.75. This indicates that this fish is highly profitable. It then mean that Iwo zone is suitable in both topography, climate, soil type and vegetation for rearing of the four types of fishes investigated in Osun State.

Table 2

Average cost and return to Heterotis and Heterobranchus from fish farming per zone in Osun State

Heterotis sp	**Ife/Ijesa**	**Osogbo**	**Iwo zone**
Farm size	1.0ha	1.0ha	1.0ha
Total Revenue (TR)	460526	-	837500
Cost of fertilizer	8,520.60	-	20,271.30
Cost of lime	8,316.00	-	48,764.00
Cost of feed	30,096.00	-	55,969.28
Cost of labour	40,801.00	-	50,642.50
Cost of Heterotis	40,300	-	18,480.00
Total Variable Cost (TVC)	204,719	-	194,127.08
Fixed cost	216105	-	216105
Total cost	420824	-	410232.08
GM = TR – TVC	255807	-	643372..92
Benefit Cost Ratio (BCR)	1.09	-	2.04
Heterobranchus			
Farm size	**1.0ha**	**-**	**1.0ha**
Total Revenue	-	-	968,500.00
Cost of fertilizer	-	-	6,493.80
Cost of lime	-	-	4,876.40
Cost of feed	-	-	55,969.28
Cost of labour	-	-	51,857.92
Cost of Heterobranchus	-	-	16,320.00
Total Variable Cost (TVC)	-	-	13, 5517.40
Fixed cost			216105
Total cost			351622.40
GM = TR – TVC	-	-	832,982.60
Benefit Cost Ratio (BCR)	-	-	2.75

Source: Field Survey, 2006.

Implications for extension service delivery and food security at household level in Osun state:

The issues revealed on fish farming from the results of profitability and viability investigations would help in no small measure to draw appropriate implications for extension service delivery and food security at household level in Osun state as follows

1. The four types of fishes reared and investigated are viable and profitable enterprises in Osun state however, Clarias and Tilapia fishes have been found suitable in all the three ecological zones in Osun state for rearing with Clarias fish being of highest mean yield and income. Extension programme contents on fish farming should focus on teaching farmers in Osun state improve fish farming technologies with bias in introducing Clarias fish fingerlings to farmers since feeding, pond construction and maintenance, stocking rate, harvesting and marketing are similar for all the fishes. It is also cheaper, effective and productive if all extension resources at the state and private levels are directed at promoting Clarias fish production in the state than focusing on promotion of all the four types of fishes at the same time i.e. adopting the principle of relative advantage on fish production in Osun state.

2. Extension work delivery seems more costly and less effective when programme or project is targeting farmers on individual basis rather than group approach. The strategy of group and or cooperative approach could be adopted to sensitize, mobilize and train farmers improved management practices and technologies in Clarias fish production in Osun state. This then mean that rural people should be organized into functional groups for training, capital generation, credit mobilization, input sourcing and procurement, processing of fishes, packaging and marketing. Other values of group or cooperative approach to be considered are information generation; programme planning, programme execution, monitoring and evaluation.
3. The adoption of relative advantage to fish production in Osun state would bring about macro economic values in terms of more people becoming fish farmers, increase yield, more income to farmers and creation of agro-industrial base. Agro-industrial base from fish farming enterprises across the state through establishment of processing centres and markets would generate more employment for people. The end results of all these chains of development are more food for people to eat both in quality and quantity since their economic power would improve. More income at household level is also a function of improved level and standard of living, enhanced social prestige and active participation in community development.
4. Appropriate policy design, formulation, implementation and even evaluation are essential ingredients and tools for the state government to come up with a comprehensive policy on promoting fish farming enterprises/fish production in Osun state as a viable and profitable way of generating more income to farmers, creation of more jobs for the youth, retired civil servants, retrenched and even challenged people in the state; stating the role of the Osun State Agricultural Development Programme (OSSADEP) as the only public/government extension agency; stating the role of private organizations and role of farmers' groups in fisheries research, extension work, input service delivery and fish production, processing, packaging and marketing.
5. Separate state policy on fish production in Osun state and adequate provision of logistics for it implementation at all levels would definitely enhance food security at household level in Osun state.

Conclusions

1. The mean age of fish farmers in Osun State was about 48 years; they were male and well educated; belonged to social organization but few were members of the fish farming association while majority of fish farmers had no extension contact for trainings in fish farming technologies.

2. The mean years of fish farming experience was about 8 years with standard deviation of 3.22; all fish farmers in Osun state rear Clarias fish with less than half rearing Tilapia fish while few fish farmers were involved in the rearing of Heterotis and Heterobranchus fishes.

3. The mean yield of Tilapia was 1.50ton/ha while the mean yield of Clarias fish was 4.97 ton/ha; the mean yield of Heterotis fish was 0.2 ton/ha with standard deviation of 43 while that of Heterobranchus fish was 1.2 ton/ha. The mean income of fish farmer per annum was ₦166,399.7 with ₦161,208.4 standard deviation. The mean pond size was 1455.9m^2 with 957.5 standard deviation.

4. Fish farming in Osun State is a developing enterprise, which has been found viable and profitable.

Recommendations

Based on the major findings and conclusions of the study, the following recommendations were made:

1. Principle of relative advantage should be adopted on the fish production by focusing and directing all extension resources on sensitization, mobilization, and training of farm families and other rural households in improved production recommendations of Clarias fish in the state.

2. Group or cooperative approach should be adopted in reaching the target audience for sensitization, training in improved fish production recommendations and mobilization for input such as credit, lime, land, and agro-industrial base development.

3. The establishment of the agro-industrial base should be private initiative regulated by the state government through fisheries policy implementation. It then mean that State government should as a matter or urgency and seriousness formulate a comprehensive policy for fish production in the state detailing stakeholders and their respective roles in fisheries research, fisheries extension and fisheries services from production, processing to marketing in the state.

4. There is need for establishment of ecological base hatcheries and processing centres that would embark on research in fingerlings development and production in other fishes such as tilapia, heterotis, and heterobranchus that are not common in the state for rearing. The hatcheries could also serve the need of the target audience in terms of adequate and timely supply of Clarias fish seeds from guaranteed sources. The processing centres can serve as buying centres to farmers who want to sell his/her harvest immediately and processing centres where values are added to fisheries products for farmers with large farms. The strength of this strategy lies in it ability to stabilizes fish price per measure and control of fish market regular supply of fish for households' consumption.

5. Both, OSSADEP, Private companies and farmers' groups should employ and train more extension agent in fisheries extension, fisheries production, processing and marketing such that fish farmers can have access to up to date information on fish farming in the state.

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Training Challenges of Extension Agents in Promoting Sustainable Rural Environment: Experience from Rural Food Processing Cottage Industries in Oyo State, Nigeria

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Abstract
Rural environment is generally assumed to be less disturbed and cleaner than the urban environment. Extension as conventionally described is concerned with communication of improved practices in agriculture and food production. This function had been broadened to include rural resource management which in this context encompasses water, land, biological processes and biophysical inputs. This study was designed to establish the emergence of a new challenge to the extension agents' advisory and training functions in promoting sustainable rural environment. Specifically, the food processing cottage industries in the rural areas were studied with emphasis on their wastes generation, treatments and disposal. Data were collected from twelve rural communities in Oyo State, Nigeria. Snowball sampling technique was used to identify the food processing cottage industries selected in the study. A checklist developed and standardized in the course of reconnaissance survey was used to collect relevant information from the operators of the cottage industries. Data were collected from one thousand, one hundred and fifty three cottage industries. The data were summarized in frequency tables. The categories of food processing cottage industries identified include cereal and grain processing, tuber crop processing, vegetable oil processing, locust bean condiment processing, meat and dairy product processing, milling and grinding, cowpea processing, fish smoking, beverage processing, and soybean processing. The raw materials were mostly locally sourced. Result of the study showed that the wastes being generated were in solid, liquid and gaseous forms. These wastes were in most cases disposed indiscriminately within the communities. The activities of the food processing cottage industries in waste generation and managements therefore impacts on the environment. The extension agents in the rural areas were not really giving the required advice on food processing industries' waste management because they could not see it as a serious problem. It is recommended that the training needs of extension agents in the area of waste management and the essentials of sustainable environment be identified and met with implementation. This would increase their knowledge, skill and propel a change in attitude which is required for them to promptly train operators of the food processing cottage industries to manage their wastes for sustainable environment since there is danger in waiting till the problem is out of scope. In addition, the efforts of government directed at urban waste management should begin to incorporate rural areas so as to prevent the possible problem of degraded environment due to ineffective and inefficient management of wastes generated by the rural cottage industries.

Keywords: Extension, Environment, Waste, Cottage Industry, Food.

Introduction

It is generally implicit that rural environment is less disturbed with low population density. The environment is always described as conducive, healthy with fewer occurrences of land, air and water pollutions. Hence rural environment is mostly preferred to that of urban centers. However, a closer study would show that the situation in the rural area has changed over time with the density and distribution of cottage industries which are located in the rural areas. The industries no doubt generate wastes and utilize resources from the environment with some attendant problems of pollution and environmental degradations.

Agricultural extension which focused on rural dwellers and farmers has various dimensions, and employed many approaches. Though the objective of extension remains the communication of useful information and helping the beneficiaries to learn how best to use the information provided so as to enhance a better living condition for themselves, their families, communities and the environment. Basically, extension involves the conscious use of communication of information to help people form sound opinions and make good decisions (Van den Ban and Hawkins, 1996). In a bid to describe the areas covered by

extension activities Oakley and Garforth (1985) categorized the activities into agriculture and non-agricultural extension. In addition, Obibuaku (1983) opined that extension is concerned not only with agricultural development, but also with rural transformation generally. From the foregoing, it is obvious that extension is interested in farm households and their activities through promotion of high quality of life in the rural areas where they are mostly found within the developing countries.

Agriculture, which is the mainstay of rural dwellers and an interest of extension continually, exploits the environment. Exploitation in this sense could be in term of nutrients from soil and space though in a cycle. Since the rural environment where farming takes place is consistently subjected to environmental degradation, there is a need to goad in the extension agents and agencies a guided interest in environmental management as it relates to food processing activities of cottage industries in the rural areas.

In most of the rural areas where farming takes place, various food and livestock products are being processed for consumption within the locality or for onward transmissions to some other parts of the country or even exportation to other parts of the world. These processing activities take place in cottage industries, which are located within the dwelling units and are known to generate wastes and invariably impact on the environment. Advocates of sustainable environment stressed that the interest of future generation be catered for in the contemporary efforts directed at resource utilization (Brindley, 1991). To this end, it is essential to follow the path of environmentally sustainable development by promoting good management practices relating to waste management in the affected areas.

The fact that every aspect of rural life ranging from economic to environment is of interest to extension agents in recent times as established by Adams (1992), Jones and Garforth (1997) and Bolliger *et al* (1998) prompted the need to get the agents involved in the promotion of sustainable rural environment. Exploitation of natural resources is natural to agriculture and could not be stopped in the process; however, it would be necessary to ensure sustainability by promoting environmental friendly practices through a well planned extension programme. This is justified through the picture of extension given by Uphoff (2000) and Leeuwis (2004) in which extension is described as not just concerned with agricultural or relating to land-use only; but that it is concerned more broadly with rural resource management. Resources in this context include not only water, land, biological processes and biophysical inputs, but also human relations, forms of organization, economic and legal institutions, knowledge or skills. Hence, the rural environment which is given some deal of attention in this study through a conscientious look at wastes generated by food processing cottage industries is also of great concern to extension.

Generally, the industrial sector constitutes a major component of the economy in most countries. Industries also play a major role in economic development of the respective countries and also in the economic welfare of their citizens. It provides employment for a large proportion of the population and supplies the material goods they consume (UNEP 1987). Activities of the sector include extraction and processing, as well as synthesis of various materials and their uses in the manufacture of other products. Consequently, there is also a wide range of possible environmental impacts created by this sector because various industrial process generate different airborne emissions, waste water or effluents, dusts or particles and solid wastes that can affect human health and environment in many ways (UNEP, 1987). Obviously, developing countries as typified in the case of Nigeria face special problems in implementing waste management programmes despite its importance. According to UNEP (1992) the problems include generally poor control of pollution, a lack of financial resources, shortages of people with technical and managerial skills and a low level of public awareness. It is therefore becoming increasingly obvious that current practices of waste generation and disposal cannot be considered in isolation from overall objectives of controlling pollution and managing natural

resources (Suess, 1985). According to Ekong (2003), Nigeria is an integral part of the global ecosystem and so contributes to and is affected by global environmental problems like erosion, deforestation, desertification and indiscriminate waste disposal among others. However, it is established that some wastes would continually be generated and disposed, the need to emphasize waste minimization through reclamation and recycling emerged as the best option.

Studies on industrial wastes listed the general headings as general factory nebbish, packaging materials, organic wastes from food processing, acids, alkalis, metaliferous sludge and tarry residues. Accordingly, Batstone *et al*. (1989); Holmes (1983) and Kharbanda and Stallworthy (1990) opined that the most important feature of industrial wastes is that a significant proportion is regarded as hazardous or potentially toxic thus requiring special handling, treatment and disposal.

Various studies as revealed in literatures stressed the fact that industrial activities and wastes impacts on the environment however, most of such studies did not give any serious attention to cottage industries located within rural areas. Traditionally, cottage industries refer to manufacturing or processing activities that are carried on in cottage especially in the rural districts. These industries as in the case of developing countries employed the next largest workers after agricultural sector. Evidence abounds that cottage industries also contribute to the environmental problems as they are associated with certain wastes which they generate in form of gas, effluents and solid which has the potential to pollute the environment. These did not attract the interest of researchers, as was the case with small, medium and large industries in the urban and peri-urban centers. This study is therefore designed to fill this identified gap in knowledge as it relates to sustainable rural environment and to establish the training challenges posed to extension agents. The objectives of the study are:

The work was designed to highlight the emerging training challenges of extension agents in promoting sustainable rural environment by drawing lessons from rural food processing cottage industries' wastes and their treatments. The specific objectives are therefore to:

(i) identify and categorize the food processing cottage industries in the study area;
(ii) examine the type of wastes and effluents being generated by the rural based food processing cottage industries;
(iii) investigate the wastes treatment and methods of disposal;
(iv) highlight the immediate and long-term possible effects of such wastes on the environment; and
(v) identify the emerging training challenges of extension agents in promoting sustainable rural environment.

Methodology

The study area was Oyo State, Nigeria. The state is made of thirty-three Local Government Areas (LGAs). The thirty-three LGAs were stratified into predominantly urban and predominantly rural LGAs as did Awujoola (2000). Twelve LGAs representing approximately 50 percent of all the predominantly rural LGAs were randomly selected and one community from each of these LGAs were selected randomly to make a total of twelve rural communities. A semi-structured interview schedule was developed and standardized during a reconnaissance survey. The instrument was used to collect information on the raw materials used by selected typical food processing cottage industry, their products, wastes, effluents and methods of wastes disposals. The industries were identified with snowball method of sampling. In addition, an observation checklist was used to take an inventory of notable food processing cottage industries in the selected communities. Results of the survey was analyzed and presented using descriptive statistics specifically frequency counts and percentages.

Results and Discussions

Inventory of food processing cottage industries in the study area: In this study, food-processing cottage industries are those industries in which food – processing activities are being carried out on a small – scale, usually home based, employing a few individuals using simple technology mostly inherited skills and depending on local raw materials. A list of food processing industries conforming to the above was compiled. A total of one thousand one hundred complied. A total of one thousand one hundred and fifty three (1,153) of such industries were listed in the process as identified in the study area. The industries were classified based on their raw materials and products. Ten categories were identified and presented in Table 1. The most frequent category was the tuber processing cottage industries. These industries process cassava and or yam tubers into flour or pastes.

Table 1:Frequency distribution of food processing cottage industries in the study area

Category/Type of industries	Frequency	Percentage	Cumulative
Cereal/grain processing	129	11.19	11.19
Tuber processing	247	21.42	32.61
Vegetable oil processing	130	11.27	43.88
Locust-bean processing	77	6.68	50.56
Meat and Dairy processing	73	6.33	56.89
Milling and grinding	163	14.14	71.03
Cowpea processing	120	10.41	81.44
Fish smoking	74	6.42	87.86
Beverage processing	73	6.33	94.19
Soybean processing	67	5.81	100.00
Total	**1153**	**100.00**	

The least category was the soybean processing cottage industry. This shows that cassava and yam production is the most popularly processed farm produce in the study area. This might be due to the fact that they are highly perishable may require one form of processing or the other to ensure high durability and consequent monetary values.

Cereal Grain Processing Industries: These industries use maize as their raw material, processing "*ogi"* (a kind of fermented maize pap) which is either sold as produced or further processed by cooking and wrapping same in leaves to a semi-solid state for consumption. They constituted 11.19 percent of the total food processing industries in the area. The wastes generated by this industry are shown in table 2.

The fermentation process is annunciated with certain odor, which may be detestable when discarded into the environment in an unguided form. Discarded stagnant wastewater serves as breeding places for mosquitoes and other insects. However, it was observed that several households also did process **"*ogi"*** regularly, not for commercial purposes but for household consumption, which means that there are many more sources of pollution besides the identified cottage industries.

Table 2:Wastes from cereal grain processing industries

Wastes		**Form**		**Approximate**	**Disposal methods**
				quantity/kg	
Waste water		Liquid		15 litres/kg	Discarded
Maize Residue		Solid		20g/kg	Livestock feed
Odour		Gaseous		NM*	None

Not measured

Tuber processing Cottage Industries: These cottage industries accounted for 21.42 percent of all the listed industries. A breakdown of the type and frequency distribution is presented in table 3. Cassava tuber based processing cottage industries constituted 78.14 percent of the tuber processing industry. It is being processed into *"garri"* (a grated fermented fried granulated product), *"lafun"* (cassava flour) and "*fufu*" (meal of retted cassava). Yam is processed into "*elubo*" (yam flour).

Table 3: Types and frequency distribution of tuber processing industries

Industries	**Raw material**	**Frequency**	**Percentage**	**Cumulative**
Gari	Cassava	65	26.32	26.32
Lafun (flour)	Cassava	88	35.63	61.96
Fufu	Cassava	40	16.19	78.14
Elubo (flour)	Yam	54	21.86	100.00
Total		**247**	**100.00**	

The types and approximate quantity of the wastes as well as methods of wastes disposal are prevented in table 4. The data in the table showed that most of the cassava peels are being used to feed livestock while excess are dumped and burnt. This act of burning the wastes to a large extent constituted a great deal of environmental pollution from the smokes mostly emitted from the burning wastes. In addition, wastewater is being discarded indiscriminately and at times into existing body of water. Such waste water may flow into the existing flowing stream or pond which could eventually pollute the respective water bodies. This is also a source of environmental pollution, which must be addressed for a sustainable environment.

Industry	Wastes	Form	Approximate quantity	Treatment Disposal
Gari	Cassava peel	Solid	250-500g/kg	Livestock feed/dumped and burnt
	Waste water	Liquid	20-30 litres/I	Discarded indiscriminately
	Grating residue	Solid	100g/ 1kg	Livestock feed/Consumed by man
	Effluents from pressing	Liquid	4 litres/50kg	Discarded indiscriminately
	Fried residue	Solid	1kg/50kg	Consumed by man/livestock
	Heat/thermal emission	Heat/Smoke	*NM	Just to the surrounding
	Ash from fuel wood	Powdery	1kg/50kg fuel wood	Discarded or used for local soap
	Odour	Gaseous	*NM	Discarded None
Lafun	Cassava peel	Solid	250-500g/kg	Livestock feed/dumped and burnt
	Waste water	Liquid	1000 litres/ton	Discarded indiscriminately
	Residue from sifting	Solid	<1kg/50kg	Discarded/re-used Livestock feed
	Odour	Gaseous	*NM	None
Fufu	Cassava peel	Solid	250-500g/kg	Livestock feed/dumped and burnt
	Waste water	Liquid	900 litres/ton	Discarded/re-used
	Residue	Solid	1kg/50kg	Livestock feed
	Ash from fuel wood	Powdery	1kg/50kg fuel wood	Discarded or used for local soap
	Odour	Gaseous	*NM	None
Elubo	Yam peel	Solid	250-500g/kg	Livestock feed/dumped and burnt
	Waste water	Liquid	200 litres/ton	Discarded/re-used
	Residue from sifting	Solid	1kg/50kg	Livestock feed
	Heat/thermal emission	Heat/Smoke	*NM	Just to the surrounding
	Ash from fuel wood	Powdery	1kg/50kg fuel wood	Discarded or used for local soap
	Odour	Gaseous	*NM	None

Table 4: Description of Waste Products Being Generated from Tuber Processing Industries

NM = Not Measured

Vegetable Oil Processing Industries: Two types of oil-bearing seeds are commonly processed in the study area. They are oil palm fruits and shea butter. Palm oil and palm kernel oils are products of oil palm fruits while shea butter tree *Vittellaria paradoxa* ("*emi*") is a valuable source of fat ("*ori*") for cooking in rural areas which is also medicinal. It is a product from nuts of a tree. Data in table 1 shows that the class of this industry constitutes 11.27percent of the total number of the industry in the inventory. Production process in the industries also generates wastes of various types in solid, liquid (oil-lateen wastewater) and gaseous forms as presented in table 5. In addition, hot water and heat energy being used also produce thermal emission.

Table 5: Description of Wastes being generated from vegetable oil processing industries

Industry	Waste	Form	Approximate quantity	Disposal /Treatment
Palm oil	Waste water	Liquid	3-5 litres/kg	Discarded/re-used
	Residue (shaft)	Solid	1kg/5litres of oil	Used as fuel
	Heat/thermal emission	Heat/Smoke	*NM	Just to the surrounding
	Ash from fuel wood	powdery	1kg/50kg fuel wood	Discarded or used for local soap
Palm kernel oil	Kernel shell	Solid	2kg/kg kernel	Used as fuel
	Residue (PKC)	Solid	3kgPKC/kg oil	Livestock feed
	Heat/thermal emission	Solid	*NM	Just to the surrounding
	Ash from fuel wood	Heat/Smoke	1kg/50kg fuel wood	Discarded or used for local soap
Shea Butter	Nut shell	Solid	1kg/10kg nut	Fuel/Discarded
	Waste water	Liquid	2 litres/10kg	Livestock feed
	Residue (slurry)	Solid	100kg/2kg fate	Discarded
	Heat/thermal emission	Heat/Smoke	*NM	Just to the surrounding
	Ash from fuel wood	Powdery	1kg/50kg fuel wood	Discarded or used for local soap

NM = Not Measured PKC = Palm Kernel Cake

Locust Bean Processing Industries: The only condiment processing industry identified within the study area was locust bean *Parkia biglobosa* seed ("*igba"*) processing industry. The condiment ("*iru")* is the fermented product of locust bean. It is used as a condiment widely consumed by people in the rural and urban area. They constituted 6.68 percent of the industries listed. The waste products of this category of industry are presented in table 6. Most of the wastes are discarded into any open space.

Table 6: Description of Wastes being generated from locust bean processing industries

Wastes	Form	Approximate Quantity/kg	Disposal/Methods
Waste water	Liquid	25litres/2kg products	Discarded to the open
Residue (shell)	Solid	1kg/5kg	Discarded on the dump
Locus bean slurry	Solid	1kg/3kg	Discarded to the open
Heat/ thermal emission	Heat/Smoke	*NM	Just to the surrounding
Ash from fuel wood	Powdery	1kg/50kg fuel wood	Discarded or used for local soap
Odour	Gaseous	*NM	None

NM = Not measured

Meat and Dairy Processing Industries*:* Meat and dairy processing industries constituted 6.63% of the total industries. The constituent industries include 11 abattoirs, 34 cow skin ("ponmo" for human consumption) processing and 28 local cheese industries. The wastes generated in abattoirs and cow skin processing are cow dung, blood, bones, burnt hair residues, horns, hooves and wastewater. The commonly used method of disposal of these wastes includes open dumping on garbage heaps and discharge of effluents into nearby streams. Local cheese processing generates wastewater, which is also discharged into the surroundings. Thermal emissions and smokes were also common waste output of these industries.

Milling and Grinding Industries*:* A variety of milling and grinding activities were identified. These industries engage in wet and dry milling processes on a variety of food materials. The wastes generated by the industries include food waste, dust, waste water, engine oil and grease. The machines also generate a lot of noise, vibration, smokes and heat. Although the noise level was not determined as well as vibration, it was observed that they interfere with conversation in the area. The decaying food wastes and wastewater being discharged from the milling activities emit unpleasant odour, and also breed flies, maggots and mosquitoes.

***Fish smoking cottage industries*:** Within the study area fish smoking cottage industries constituted about 6 percent of the total. The wastes generated in this group of industries are smoke, wastewater, heat and odour. In addition, the fuel wood also generates ashes, which are used for non-food purposes such as the manufacturing of local soap.

Cowpea processing cottage industries also generates wastes. The main products of the industries in this category are fried cowpea balls and steamed cowpea pudding (*moin-moin*). The wastes being generated in the cottage industry are presented in the table 7.

Table 7:Wastes from Cowpea processing

Wastes	Form	Approximate Quantity/kg	Disposal/Methods
Bean coat	**Solid**	**100g/kg**	**Open dumpling/ livestock feed**
Wastewater	**Liquid**	**8 litres/kg**	**Discarded indiscriminately**
Heat/ thermal emission	Heat/Smoke	*NM	Just to the surrounding
Ash from fuel wood	Powdery	1kg/50kg fuel wood	Discarded/ used for local soap
Odour	Gaseous	*NM	None

**NM = Not measured*

Beverage Processing Industries: A traditional alcoholic drink known as Otika was also being produced in the study area. The raw material is guinea corn which is locally sourced. There were 73 of such cottage breweries. The waste commonly generated by the industry is mostly water put at about 5 litres per kilogram of grain which is indiscriminately discharged into the surroundings. In addition, brewery wastes are generated but are largely used to feed livestock. Other bye-products are heat, smoke, and ash from fuel wood. All of these bye-products are being discharged into the environment.

***Soya bean Processing**:* Soya bean is being adopted and gradually integrated into the diet of the people in the study area. Commonly produced from soybean are *soymilk* and *soya wara*, a type of local cheese. Both solid and liquid wastes are being generated in the industry. The wastewater is being discarded into the surrounding while soybean coat and meal residue are fed to livestock as protein source in their feed. Ash is also generated from fuel wood and the waste is usually discarded or used for local soap.

On a general note, most of the wastes being generated were discarded into the surrounding environment without any form of care. The environmental and public health implications of such acts are numerous. Land pollution for example can result and pollutants can be leached into the ground water resulting in water pollution. In addition, untreated solid and liquid wastes dumped near water source remain a potential source of microbial and chemical contaminants. Subsequently fresh water would become progressively scarce and the ecology could be disturbed to a dangerous level. This would impact on flora and fauna adversely and treat the further existence of some beneficial organisms.

Decaying waste matter as well as stagnant wastewater do not only give off offensive and obnoxious odours, but also serve as breeding space for maggots, flies and mosquitoes all of which can pose some dangers to the rural dwellers health.

The health implications of dust, smoke and other suspended particulates include eye, nose and throat irritation and acute respiratory infections in children and chronic respiratory diseases in adults. Noise and vibration condition could affect health adversely by producing noise induced hearing loss in people exposed to above normal levels of noise for a long period of time (WHO, 1995). Emissions from heat could result in serious health problems such as heat stroke, heat cramp and headache.

From the above, it became obvious that significant environmental impacts arise from rural based-food-processing cottage industries as demonstrated in this study. Although cottage industries play an important role in the economy of the rural populace, they could as well pose problems when inadequate environmental safety, protection and sustaining awareness are lacking in the operators and rural dwellers in general. While their products are used for the benefit of the present population, the long-term damaging effects on the environment being caused are left for the future generations to contend with. The situation would be appreciated better if the numbers of such industries in the sampled communities are considered in addition to non-existence of proper and environmentally sustainable waste treatment and disposal methods. This situation calls for adequate attention of stakeholders.

The Training Challenges posed to Extension Agents*:* Empirical evidences presented in the above study revealed some training challenges to extension in the study area. Training challenges posed to extension as visualized could be categorized into two. The first category is the ones expected to be directed at extension agents while the second is those to be directed at the rural dwellers especially operators of the respective cottage food processing industry. Training challenge to extension agents includes identification of relevant training needs for sustainable environment with emphasis on waste management. Such training needs may result in the call for revision of the pre service training curriculum of the various institutes involved in the training of extension agents. In addition, the training needs identified could also be addressed during the various in service training for knowledge, skill and attitude changes of extension agents. All of these are relevant to ensure sustainable environment in the rural areas. In addition, the need to train extension agents in the specialized area of preparing communication aids relating to sustainable environment also emerged as a training need.

Another training challenge emerging from the study is the need to learn the required skill in assessing the environment related problems and addressing relevant problems that might ensue in the process of promoting sustainable environment.

The other related challenge to extension is the education and guidance of rural dwellers to embark on the effective and efficient management of environment especially cottage industry's wastes to promote a sustainable and healthy environment.

Conclusions and Recommendations

Extension is basically meant for the education of the public on the ways to ensure high quality of life and promote their good well-being. In the case of food processing cottage industries, extension has training challenges relating to understanding the environmental problems associated with rural based cottage industries. Also extension should ensure a link with subject matter specialists who are scientists and researchers to find solutions to the possible problems of environment identified in this study as related to rural cottage industries.

In addition, data on the food-processing industries, their emergence, coverage, locations and wastes should be collected analyzed and carefully stored such that they could be retrieved and used in problem identification and subsequent programme planning on sustainable rural environment.

Operators of the rural-based food processing cottage industries and the rural public should be targeted for awareness and training programmes on environment. Such operators should include women and children who dominate the food processing in terms of education and enlightenment. The link between women, children and environmental management has been recognized as a crucial aspect of sustainable environmental development (Racelis and Aguirre, 2002).

Extension should appropriate their stake in ensuring sustainable rural environment through the promotion of participatory approach to problem identification and solution by ensuring that rural dwellers also plays their expected roles in ensuring sustainable environment.

Local leaders and the various government and non governmental agencies should be informed of the need for a better environment by putting in place a practical and functional environmental protection and waste management strategy and or programmes not only in urban areas but also in rural areas.

Extension and related agencies should work closely with media houses in creating awareness through radio and television programmes on the importance and essentials of sustainable environment. Also, preparation and use of printed materials such as handbills, posters and pamphlets should be scientifically designed to teach the essentials of sustainable environment to the literate rural dwellers and operators of cottage industries.

There is a danger in waiting until the problem is out of scope before taking action. Environmental friendly practices such as conversion of biodegradable wastes to manure should be encouraged for the sustenance of the environment. An example is the use of cassava peels to prepare organic manure in the work of IAR&T (2007) instead of burning excess as is the case now should be encouraged. Use of wastes as livestock feed component within and outside the areas where they are being generated should be well researched, promoted and commercialized. The wastes that have to be disposed should be well managed, treated and adequately disposed. These would ensure a cleaner, healthy, sustainable environment and good economic gains for which extension is known. All of these are relevant to the achievement of any proposed healthy and sustainable rural environment through meeting the various challenges which wastes of rural food processing cottage industries posed to extension training.

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Quality of Herbal Medicinal Products in the Nigerian Market – The Challenges

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Abstract

Herbal medicine, a form of complimentary and alternative medicine, is becoming increasingly popular in both developing and developed countries. A World Health Organization (WHO) survey has indicated that about 70-80% of the world population particularly in the developing countries rely on non-conventional medicines mainly of herbal sources in their primary healthcare. In Nigeria, there appears to be an overwhelming increase in the public awareness and usage of herbal medicinal products in the treatment and/or prevention of diseases. This may not be unconnected to the active mass media advertisement embarked upon by the producers and marketers of the herbal medicinal products (HMPs) who have taken the advantage of the relatively high cost of the conventional pharmaceutical dosage forms, inaccessibility of the orthodox medical services to a vast majority of people particularly in the rural areas and the reservations by the public due to the prevalence of fake, substandard or counterfeit drugs in the market. These have placed the HMPs as a ready alternative to conventional dosage forms in the treatment of diseases. With this increased usage, the safety, efficacy and quality of these medicines have been an important concern for health authorities and health professionals. Although herbal remedies are often perceived as being natural and therefore safe, they are not free from adverse effects which may be due to factors such as adulteration, substitution, contamination, misidentification, lack of standardization, incorrect preparation and/or dosage, inappropriate labeling and/or advertisement. In an attempt to enhance the acceptability of the HMPs by consumers, many of the products have been formulated into conventional modern dosage forms such as tablets, capsules, suspensions, solutions and powders. There is need for constant monitoring and control of the standards of herbal medicines available in the Nigerian market.

Keywords: Herbal medicinal products, pharmaceutical, dosage form, toxicity, contamination

Introduction

Herbal medicines, herbal remedies, phytopharmaceuticals are forms of complimentary and alternative medicine which are becoming increasingly popular over the past decade in both developing and developed countries where they are widely used for the treatment and prevention of various diseases (Eisenberg *et al*., 1998). Herbal medicine business is estimated at 70 billion dollars yearly. Africa has 70% of the world reserve in medicinal plants growing in their soil. These medicinal plants have been said to be used for the treatment of a variety of diseases ranging from malaria to HIV/AIDS and hepatits B. Herbal medicines are used throughout the world and in the past herbs often represented the original sources of most drugs (Cooper, 2004, 2005; Tsao and Zeltzer, 2005). These medicinal plants were first used in their crude forms as herbal teas, syrups, infusions, ointments, liniments and powders. With the development of chemistry and Western medicine, the active substances of many species have been isolated and in some cases duplicated in the form of synthetic drugs (Farnsworth and Morris, 1976). Herbal-derived substances remain the basis for a large proportion of the commercial medications used today for the treatment of heart disease, high blood pressure, pain, asthma and other illnesses. No less than 400 compounds derived from plants are currently used in the preparation of orthodox drugs. An example is vincristine and vinblastine used in the treatment of cancer and ephedrine used in the treatment of asthma and other respiratory problems. About 25% of all prescription drugs contain one or more active ingredients from plants (Saad *et al*., 2005).

The rapid increase in consumption of herbal remedies worldwide has been stimulated by several factors, including the notion that all herbal products are safe and effective. A World Health Organization (WHO) survey indicates that about 70-80% of

the world population particularly in the developing countries rely on non-conventional medicine mainly of herbal sources in their primary healthcare (WHO; 1998). The WHO has described traditional medicine as one of the surest means to achieve total health care coverage of the world's population. In pursuance of its goal of providing accessible and culturally acceptable health care for the global population, the WHO has encouraged the rational use of traditional plant based medicines by member states and has developed technical guidelines for the assessment of Herbal medicine (Akerele, 1993; WHO, 1998).

In spite of their efficacy, herbal medicinal products have been widely criticized due to lack of standardization and poor presentation. In traditional medicine, plant parts are usually soaked in water and unspecified quantities of the decoction consumed without regard to toxicological and other adverse effects. In an attempt to enhance the acceptability of HMPs by consumers, many of the products have been formulated into conventional dosage forms such as tablets, capsules, suspensions, solutions and powders. This has conferred on them many of the good properties of conventional dosage forms which include elegance, ease of administration, patient acceptance due to better presentation, prolonged shelf life especially for those formulated as tablets, quality assurance in dispensing and reduction in transportation cost arising from formulation transportation of bulky plant parts (Gunsel and Kanig, 1986).

In Nigeria, there appears to be an overwhelming increase in public awareness and usage of herbal medicinal products in the treatment and/or prevention of diseases. This increased use of herbal medicines may not be unconnected to the active mass media advertisement which range from radio, television to motorcade announcement, embarked upon by the producers and marketers of the herbal medicinal products (HMPs) who have taken the advantage of the relatively high cost of the conventional pharmaceutical dosage forms, inaccessibility of the orthodox medical services to a vast majority of people particularly in the rural areas and the reservations by the public due to the prevalence of fake, substandard or counterfeit drugs in the market (Okunlola *et al*., 2007). These have placed the HMPs as ready alternative to conventional dosage forms in the treatment of diseases. In Nigeria, Ghana, Mali and Zambia, the first line of treatment for 60% of children with high fever resulting from malaria, is the use of herbal medicines at home (WHO, 2003). Eighty-five per cent (85%) of Nigerians have been said to use and consult traditional medical practitioners for their healthcare, social and psychological needs. With this increased usage, the safety, efficacy and quality of these medicines have been an important concern for health authorities and health professionals.

Herbal medicines, both native and imported, are now sold in Nigeria alongside orthodox medicines in Pharmacies and several companies have expanded in the past few years and are starting to acquire National Food and Drug Administration and Control (NAFDAC) licensing for their products. Many of the products are now manufactured by companies specifically presenting these herbal medicines in conventional dosage forms.

Differences between Conventional Drugs and Medicinal Herbs

Conventional drugs are single target-based substances which elicit specific metabolic reactions in the body and their associated side effects are usually traded as a risk against the benefit of the primary effect. In contrast, herbal medicines act multi-systemically, they tend to have broad and non-specific actions on a number of physiological systems simultaneously. These reactions are sometimes in the same therapeutic action, and are complementary or synergistic with mild to adverse side effects.

Pharmaceutical drug discovery begins with the understanding of the disease mechanism, followed by compound and target identification, validation and optimization. Scientists develop new drugs based on their research and understanding of the human body and disease mechanisms, and a large collection of molecules are screened for compounds that may show potential

efficacy with low toxicity. Herbal medicine on the other hand, is a holistic therapy which integrates plant remedies with the mental, emotional and spiritual aspects of health into the understanding of the body's functions. It acts gently by supporting systems and processes that have become deficient and helps to remove excesses in the body (Saad *et al*, 2005). The vast majority of herbal medicines contain a complex mixture of compounds such as terpenes, alkaloids, polysaccharides or other chemicals that buffer, modulate and modify the effects of any active ingredient in the herb. Therefore, administration of isolated compounds of a plant cannot easily mimic the effects of extracts from the whole plant. Furthermore, the constituents responsible for the claimed therapeutic effects are often unknown or only partly explained and thus precludes the level of control which could be routinely achieved with synthetic drug substances in conventional pharmaceuticals (WHO, 2000).

Problems associated with the use of herbal medicinal products:

1. Lack of adequate knowledge among health professionals

The lack of adequate knowledge among health professionals on the effectiveness and safety of HMPs has contributed greatly to the misuse of these products. There is a deficiency in the knowledge base of physicians, pharmacists and other health care givers both in the developing and industrialized countries on the pharmacology, potential interaction and toxic effects of herbal medicines (Molassiotis *et al*., 2005; Suchard *et al*., 2004; Aziz, 2004; Fakeye and Onyemadu, 2008). Health professionals are generally faced with the problem of assessing the effectiveness and safety of natural HMPs since information regarding the products is not readily available in official references. Moreover, these products have not been extensively studied as orthodox drugs and are sold without much knowledge of their mechanism (s) of action or side effects (WHO, 2000). The chemical entity and behavior of the HMPs are not well documented (The European Agency for the Evaluation of Medicinal Products, EMEA, 2003). A study carried out by Adisa and Fakeye (2006) to assess the knowledge of community pharmacists who sell herbal/phytopharmaceutical formulations in retail pharmacy outlets in South Western Nigeria has revealed that pharmacists, who are supposed to be custodian of drugs, have grossly inadequate knowledge of the phytopharmaceuticals sold in their pharmacies. Majority (74%) of the community pharmacists did not possess adequate knowledge of the potential interaction and side effects of Herbal remedies sold in their pharmacies and therefore cannot provide advice or counsel patients on the use of these products.

2. Misidentification of the plant and/adulteration and substitution

In contrast to synthetic substances, the composition of an herbal drug preparation is determined by the practitioner who should be able to identify the correct plant species. Thus, misidentification of the plant is possible and the plants may contain potentially toxic constituents. As a result, there is no guarantee of the authenticity and quantity of plant material used in the preparations and the quality of traditional medicines so produced varies widely and may not even be effective (WHO, 2000). Thus, HMPs are not free from adverse effects which may be due to factors such as adulteration, substitution, contamination, misidentification, lack of standardization, incorrect preparation and/or dosage (Lau *et al*., 2003). In addition, batch-to-batch variation due to weather conditions, maturity of the plant and soil composition significantly affect the pharmaceutical properties of herbs and therefore the actual dose of active ingredients in the herb is variable, unpredictable or even unknown.

The problems of adulterants and contaminants in HMPs, as well as the rapid appearance of a significant number of counterfeit products, have been exacerbated in recent years by the emergence of increased entrepreneurial activity. A few products contain poisonous herbs and should not be consumed under any circumstances. A study has revealed that in almost all known

cases of poisoning from Chinese herbs, the toxic components came from preparations containing aconitine, podophyllin or anticholinergics (Chan and Critchley, 1996). In another report, six cases of herbal poisoning involving six patients in Hong Kong, Taipei and Kuala Lumpur are reported (Butt, 1994). The sources of poisoning were identified as adulterants (Podophyllum emodi) or erroneous substitutes (Datura metel).

A number of products have also been found to have been adulterated with pharmaceutical drugs. The presence of established antimicrobial agents, immune modulating agents, antioxidants, other vitamins and minerals, volatile oils and emollients, and anti-inflammatory agents have been reported (Ajose, 2007). These drugs are usually added to enhance the effects of the herbs presented in the formulation (Benzi and Ceci, 1997). According to a study by the Taiwanese FDA, these products may include analgesics such as acetaminophen, caffeine, salicylamide; anti-inflammatory such as diclofenac, piroxicam, indomethacin, ibuprofen, aminopyrine, mefenamic acid, phenylbutazone, ketoprofen; sedatives such as diazepam; diuretics such as hydrochlorothiazide; steroids such as prednisolone; muscle relaxants such as chlormezanone; vasodialators such as papaverine. About 25-30% of herbal formulae sold in East Asian herbal stores and Chinese medicine clinics for the treatment of asthma, pain and arthritis were found to contain one or more of these drugs (Huang *et al*., 1997).

3. Inappropriate labeling and or advertisement

Although herbal remedies are often perceived as being natural and therefore safe, inappropriate labeling and/or advertisement have become a major problem (Lau *et al*., 2003). Of great concern is the "cure all" claims often indicated in the therapeutic claims and advertisements by the various manufacturers of HMPs in Africa. The same herbal medicines are said to cure from headache to cancer to HIV/AIDS. This has led to toxicity problems and several cases of death resulting from non treatment of these diseases have occurred.

There is a great deficiency in the information given on the label or leaflet inserts of most herbal medicines. In a study carried out to investigate the adequacy of safety warnings and first aid instructions on the labels of 122 made in Nigeria herbal remedies, only 6.6% of the herbal preparations had correct and appropriate information on their labels while another 6.6% carried legible print size. Only 9, 1.6, 3.3, 1.6% showed dosage, composition, expiration date and indication to consult expert if symptoms persist respectively (Obi et al., 2006). The paper further revealed that none of the herbal remedies described signs and symptoms of poisoning or recommended consultation of a poison control center in the event of poisoning. There is an haphazard pattern of naming the HMPs, as most names are derived from purported claims or after the traditional practitioner or locality where it is produced while some are given names of some microorganisms.

In another study carried out on some HMPs sold retail pharmacies in South Western Nigerian, 43% of the products evaluated did not have their manufacturing and expiry dates and 48% did not have their contents stated even though their therapeutic claims were indicated either on the container or in the leaflet inserts (Okunlola *et al*., 2007). This is contrary to the recommendation by EMEA and WHO which stated that the quantity of the herbal drug or the quantity of the native herbal drug preparation, dosage form, therapeutic indications and expiry dates should be stated if constituents responsible for the therapeutic activity are unknown (WHO, 2000; EMEA, 2003).

4. Toxicity problems

Many people mistakenly think that all medicinal herbs, being natural, are generally safe and free from undesirable side effects while acting as an effective agent. The reported adverse effects of herbal remedies include allergic reactions, toxic reactions, adverse effects related to a herb's desired pharmacological actions, possible mutagenic effects, drug interactions, drug contamination (Chan and Critchley, 1996). Adverse events arising from consumption of herbal medicines may be due to any one of a number of factors. These include the use of the wrong species of plant by mistake, adulteration of herbal products with other undeclared medicines, contamination with toxic or hazardous substances, overdosage, misuse of herbal medicines by either health care providers or consumers and use of herbal medicines concomitantly with other medicines. Therefore, analysis of adverse events related to the use of herbal medicines is more complicated than in the case of conventional pharmaceuticals.

Toxicological studies have reported that toxic effects due to the use of herbal medicine are associated with hepatotoxicity, mutagenicity and carcinogenicity (Chan and Critchley, 1996). Other toxic effects on the kidneys, nervous system, blood, and cardiovascular system have also been reported. Traditionally, herbal medicines are divided into three categories: those with heavy toxicity, minor toxicity and no toxicity. According to Chinese medicinal pharmacology, serious toxic effects are coma, nausea, numbness in the mouth and in the limbs, which can be easily induced by drugs such as unprocessed croton fruits and monkshood. Medicines with minor toxicity like apricot seeds and ginkgo nuts, if used in high dosages, can cause mild breathing difficulties, abnormal heartbeat and dizziness. Drugs without toxicity are mild in nature and are less likely to have side effects and are commonly used ingredients (Butt, 1994). Some plants must be used with caution because they may be toxic for liver e. g. pyrrolizidine alkaloids, apiole, safrole, lignans, kidney e. g. terpenes, saponins; skin e. g. sesquiterpene lactones, furanocumarins, etc..and other tissues.

The over dosage of the herb “Ma Huang” (Ephedra), used traditionally in China for the treatment of respiratory congestion which was marketed as a dietary aid in the United States has led to at least a dozen deaths, heart attacks and strokes. In Belgium, at least 70 people required renal transplant or dialysis for interstitial fibrosis of the kidney after taking an herbal preparation made from the wrong species of plant as slimming treatment (WHO, 2003). Toxic effects resulting from the use of herbal medicines meant for topical application have also been reported. Severe cardiomyopathy has been reported following a two week course of Chinese herbal medicines for the treatment of chronic skin disease (Ferguson *et al*., 1997).

5. Drug-Herbs interaction

The concurrent administration of orthodox medicine with herbal medicines is another major source of concern. It is common to find patients in both developing and industrialized countries using herbs concurrently with prescribed drugs without informing their health practitioner (Kuhn, 2002; Eisenberg 1998; Fakeye et al. 2007a). Reports of patients combining orthodox medicines with HMPs usually without the knowledge or awareness of the doctors or other healthcare providers have been on the increase (Molassiotis *et al*., 2005; Howell *et al*., 2005; Fakeye *et al*., 2007). This practice may endanger the patient as a result of unexpected interactions or adverse drug reactions. In most cases, patients only attend clinics to consult a medical practitioner only after the herbal medicines have provided no relief for their conditions and sometimes continue to use them even though an orthodox drug has been prescribed. A study carried out on patients attending a dermatological clinic in a tertiary health care facility in Nigeria has revealed that sixty-five percent (65%) of patients had applied some form of herbal remedy before attending

our clinic. The reasons for consultation of a doctor included relapses, unsustained relief, incomplete resolution, and post inflammatory hyperpigmentation (Ajose, 2007).

The problem of drug-herb interaction has become clinically significant when the drug level or its pharmacokinetics or pharmacodynamics is significantly affected. This may also lead to therapeutic failure as the concentration of drug in the body may be decreased or increase which usually results in toxicity. The widely used herbal remedy for depression, St John's Wort (Hypericum perforatum), can interact with HIV protease inhibitors, oral contraceptives and warfarin, resulting in a loss or reduction in the intended therapeutic effect of these prescribed medicines. The co-administration of the leaf extract of *Carica papaya* often used for the treatment of diabetes has been shown to delay the onset of the hypoglyceamic activity of glimeprimide and increase the hypoglyceamic effect of metformin in animal model (Fakeye *et al*., 2007c).

Some herbs, vegetables and fruit drinks have been shown to interact significantly with a wide range of drugs including chloroquine, omeprazole, cyclosporine A and acetaminophen, by affecting their metabolism and consequent pharmacokinetics (Mahmoud *et al*., 1994; Chen *et al*., 1996; Ho *et al*., 2000; Tassaneeyakul *et al*., 2000; Fakeye *et al*., 2007b). Often times patients swallow oral medications with freshly prepared or canned fruit juice or herbal beverages such as orange juice, pineapple, and water extract of *Hibiscus sabdariffa* otherwise known as 'roselle juice' or zobo'. This practice has been shown to significantly affect the bioavailability of some drugs. For instance, water extract of *Hibiscus sabdariffa* has been shown to lead to significant reduction in the bioavailability of chloroquine (Mahmoud *et al*., 1994) and in the amount of diclofenac excreted in healthy volunteers (Fakeye *et al*., 2007b).

6. Contamination

i. Microbial contamination

Herbal medicinal products because of their natural origin usually contain bacteria and molds from soil and atmosphere. The limits of microbial contamination for oral dosage forms are: total aerobic bacteria 10^5cfu/g, yeasts and molds 10^3 cfu/g, *Enterobacteria* and other Gram negative organisms 10^3cfu/g and *E. coli* and *Salmonella* should be absent (European Pharmacopoiea, 2007). A recent study carried out to assess the pharmaceutical and microbial quality of some herbal medicines sold in South Western Nigeria has shown that the microbial load of the HMPs were considerably high (Okunlola *et al*., 2007). The HMPs were contaminated to varying degrees with bacteria and Fungi. Of concern is the level of contamination of the products by Gram negative organisms which are considered pathogenic. Forty eight percent (48%) of the products were contaminated by *E. coli*, which is an intestinal bacteria and is an indicator for contamination by feaces, 33% were contaminated with *Salmonella*, 71% were contaminated by *Staphylococcus aureus* and 57% were contaminated by fungi. Among the products which did not show acceptable pharmaceutical and microbial qualities were expensive, popular, widely advertised and used in Nigeria for the treatment of various conditions. Another study carried out to assess the microbial load of two herbal remedies widely advertised and used as antibacterial agents has revealed that the products were contaminated with Bacillus species and four fungi. Furthermore, the herbal remedies which were claimed to have 99.9% efficacy against bacteria and fungi were found to be bacteriostatic and bactericidal (Oyetayo, 2008).

Soil, harvesting, drying, storage conditions and improper handling influence the microbiological quality of herbal drugs. The presence of microbial contaminant in non sterile pharmaceutical products can reduce or even inactivate the therapeutic activity of the products and has the potential to adversely affect the patients (Chan, 2003) and some infectious outbreaks have been

associated with the use of heavily contaminated raw materials of natural origin (Kalling *et al*., 1966). The microbial quality of pharmaceuticals is influenced by the environment and quality of the raw materials used during formulation. Furthermore, the excipients used in the formulations could also act as nutrients for contaminating organisms which could lead to an increase in the microbial load of the products during storage. Some of the plants may be contaminated by mycotoxins because of poor storage. Thus, manufacturers should ensure as low level of microbial contaminant as possible in the raw materials, finished dosage forms and the appropriate packaging components to maintain appropriate quality, safety and efficacy of the products.

ii. Heavy metal contamination

Herbal medicines, particularly those grown as cultivated crops have been shown to be contaminated by pesticides, fumigants, toxic metals and endotoxins while some have been contaminated by mycotoxins because of poor storage (Chan, 2003). A study carried out on HMPs produced in South Asia and available in Boston, US, South Asian grocery stores showed that one of every 5 Ayurvedic HMPs contains potentially harmful levels of lead, mercury, and/or arsenic (Saper *et al*., 2004). The researchers tested 70 HMPs at the New England Regional Environmental Protection Agency Laboratory and found 14 (20 percent) contained lead, mercury, and/or arsenic. Each of the 14, if taken as recommended by the manufacturers, could result in heavy metal intakes above regulatory standards. Several of the HMPs, could result in lead and arsenic intakes of 1,000 - 10,000 times greater than the regulatory standards. Half of the HMPs containing potentially toxic heavy metals were recommended by the manufacturers for use in infants and children. Eleven different manufacturers produced one or more HMPs containing heavy metals. Eighty percent (80%) of the 30 stores sold at least one HMP which contained significant amounts of heavy metals. Because Ayurvedic HMPs are marketed as dietary supplements, they are regulated under the Dietary Supplement Health and Education Act (DSHEA), which does not require proof of safety or efficacy prior to marketing. The researchers believe that testing HMPs should not only be mandatory, but call for reform that would require mandatory testing of all imported dietary supplements for toxic heavy metals. This indicates that users of HMPs medicine may be at risk for heavy metal toxicity, and testing of HMPs for toxic heavy metals should be mandatory. Therefore, there is a need to select proper and appropriate technologies for the industrial production of traditional medicines such that the effectiveness of the preparation is ensured.

7. Formulation problems

One of the major problems of HMPs is the lack of standardization. In the past, herbal formulae are prescribed as teas, powders, extracts and infusions in very large amounts of active ingredients, often beginning with raw material of more than 100 grams for a daily dose of decocted herbs. In recent times, HMPs are now formulated into conventional dosage forms such as tablets, capsules, suspensions, solutions and powders. Often times, the herbal medical practitioners themselves formulate these herbs into dosage forms without an understanding of the formulation requirements which usually varies depending on the dosage form prepared. Excipients are used in conventional dosage form to improve the properties of the drug compounds for uniform dosing, improved bioavailability and stability. For instance, powders are expected to have uniform flow to ensure the uniformity of dose dispensed while for suspensions, the suspending medium should be viscous enough so that the drug particle will remain uniformly suspended for a reasonable period of time to allow dispending of uniform doses of the suspension. HMPs because of their sources often have unpleasant taste which can make them unpalatable when formulated as liquid dosage form. It is often necessary to incorporate sweeteners and flavours to mask the taste and odor. A careful selection of the right excipient is necessary

to ensure patient acceptance. Such plants may also be formulated as capsules. Coloured capsules may also be used to encapsulate ingredients that would appear unattractive in colourless capsules. In addition, capsule formulations which are stable under ordinary condition may absorb moisture under high humidity and soften, but under dry conditions, may become brittle and crack during the process of filling. Tablets with unpleasant taste could also be presented as either sugar or film coated tablet.

Most plants are extracted using either aqueous or alcoholic solvents. Lyophilization may be required to convert aqueous extracts to powders which will be suitable for compression into tablets. This technology may not be available to the herbal medical practitioners. While some extract could be tabletted on their own, some may require excipient such as binders to form suitable tablets. Studies have shown that the method of preparation, the type and concentration of excipients and binders employed in the formulation of HMPs need to be carefully chosen to enable the production of tablets with adequate bond strength to withstand the rigors of handling and at the same time release the active compound (s) for biological action (Majekodunmi *et al*. 2008).

One of the problems often encountered with tablet dosage forms is the incomplete disintegration/dissolution of the tablets which is a prerequisite for non problematic bioavailability and clinical efficacy of HMPs. A study has shown that a particular brand of HMP tablets showed a disintegration time of 120min which is significantly higher than 15min specified by the Pharmacopoeia for immediate release tablet (Okunlola *et al*., 2007). Such products may require the addition of disintegrants to facilitate disintegration of the tablets. Moreover, herbal drugs are often complex mixtures of compounds which my include lipids and essential oils which are not easily soluble and do not completely dissolve from the pharmaceutical formulation (EMEA, 2003). Such HMPs may require excipients such as disintegrants and surface active agents to aid the release of the active agent from the dosage form and enhance the pharmaceutical quality of the HMPs.

Conclusions

It has become imperative that education and good information about herbs as well as satisfactory quality control will make physicians, pharmacists and other health care providers more confident in the use of HMPs. There is an urgent need for the inclusion of the pharmacology of common herbal medicines in curriculum of the medical and pharmacy programs in Nigeria. The awareness of their toxicity, interactions and pharmacodynamics will allow for more rational use of the herbal products. Adequate information should also be provided both on the labels and leaflets of these herbal preparations even if it is in vernacular of the people. Furthermore, systematic nomenclature, good quality control and accurate identification of herbs are important in the manufacture of safe and effective HMPs. In cases of suspected herbal poisoning, it is recommended that the prescriptions, herbal residues and herb samples should be collected for pharmacognostical and chemical analysis to substantiate the cause of poisoning. There is also the need to establish poison control centers for proper education of the general populace. Quality has to be built into the whole process beginning from the selection of propagation material to the final product reaching the consumer. This responsibility falls on the National Agency for Food and Drug Administration and Control (NAFDAC), Standard Organization of Nigeria (SON) and the herbal practitioners. However, there is the need for constant monitoring and quality control of herbal medicinal products manufactured, sold, advertised and used in Nigeria.

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Production of Diacetoxyscirpenol, Fumonisins B_1, B_2, B_3 and Neosolaniol by rice culture of *Fusarium species* from Nigerian maize

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Abstract

The ability of mycotoxin production by sixteen isolates of *Fusarium* species from Nigerian maize cultured in autoclaved rice and incubated for 4 weeks at 25°C were determined by high-performance liquid chromatography with mass spectrometry (HPLC/MS). The seventeen mycotoxins include the trichothecenes: deoxynivalenol (DON), 3-Acetyldeoxynivalenol (3 AcDON), 15-Acetyldeoxynivalenol (15 AcDON), nivalenol (NIV), Fusarenone-X (FUS X), Monoacetoxyscirpenol (MAS), Diacetoxyscirpenol (DAS), Neosolaniol (NEO), HT-2 toxin (HT2), T-2 toxin (T2). Others are zearalenol (ZOL), zearalenone (ZON), Fumonisins B_1, B_2 and B_3, Enniatins B, B_1, and A_1 using Acetonitrile: Water (84:16) and Methanol: Acetic Acid (99:1). Only the cultures of *F. acuminatum* produced DAS and NEO, while those of *F. proliferatum* and *F. verticillioides* produced Fumonisins B_1, B_2 and B_3. This is the first report of the Neosolaniol-producing ability of *Fusarium* species isolated from maize meant for human consumption in Nigeria.

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Key words: *Fusarium*, maize, mycotoxins, neosolaniol, Nigeria.

Introduction

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Fusarium spp. infection is a problem in grain crops worldwide. As well as causing reduced grain quality, it also leads to grain contamination by toxic metabolites: mycotoxins such as the tricyclic sesquiterpenoid trichothecenes (Cooney *et al*., 2001), which are a very large family of chemically related toxins produced by various species of *Fusarium*, *Trichoderma*, *Trichothecium*, *Stachybotrys*, *Verticimonosporium*, *Cephalosporium*, *Myrothecium*, and *Cylindrocarpon* (Ueno, 1989; Pronk *et al*., 2002). They are markedly stable under different environmental conditions and they cause multiorgan effects including emesis and diarrhea, weight loss, nervous disorders, cardiovascular alterations, immunodepression, hemostatic derangements, skin toxicity, decreased reproductive capacity, and bone marrow damage (Wannemacher *et al*., 1991). Once the trichothecene mycotoxins enter the systemic circulation, regardless of the route of exposure, they affect rapidly proliferating tissues. The toxic effects for NIV, FusX, DAS, 3- and 15-Ac-DON and NEO fit quite well into the profile of toxic effects of trichothecenes in general. The most important observed effects are haematotoxicity (Pronk *et al*., 2002).

Fumonisins are produced by *F. verticillioides* and *F. proliferatum* and they occur world wide on corn (Shephard *et al*., 1996). These toxins have been reported to cause animal diseases like leukoencephalomalacia (LEM) in horses (Kellerman *et al*., 1990), pulmonary edema syndrome (PES), hydrothorax in pigs and liver cancer in rats (Harrison *et al*., 1990; Haschek *et al.*, 2001). Consumption of contaminated grains with fumonisins has also been linked with esophageal cancer in humans (Rheeder *et al.*, 1992) but the relationship has not been established. Twenty eight structurally related fumonisin analogues have been identified (Rheeder *et al*., 2002) only fumonisins B1 (FB1), B2 (FB2) and B3 (FB3) occur at abundant levels. FB1 was reported to be carcinogenic (Gelderblom *et al.*, 2001).

The objective of this study was to determine the toxic metabolite producing potential of the *Fusarium* species previously isolated from Nigerian maize seeds. These include seventeen mycotoxins: the trichothecenes, fumonisins and enniatins.

Materials and methods

Identification of Fusarium isolates

Fusarium species were subcultured on PDA and KCl Agar incubated at 25^0C for 7 days, and Spezieller Nahrstoffarmer Agar (SNA) incubated for 4 weeks at 22^0C under UV light. Final identifications were made using Summerell, Salleh and Leslie (2003), Leslie and Summerell, 2006. *Fusarium verticillioides* was confirmed by specific fragment of 578 bp observed by using the primers VER1 and VER2 primers described by Mule *et al*, 2004.

Single-spore isolations of *Fusarium* spp.

Methods of Lee, 1986 and Ghiasian, 2005 were used for purification of fungal isolates. Single spores of *Fusarium* species were isolated by removing the germinating spores on Potato Dextrose Agar (PDA) and placed under a dissecting microscope with a needle. A spore of each *Fusarium* was placed on PDA and incubated at 25°C for 24 h. Single-spore strains of each *Fusarium* isolate was used for testing the production of *Fusarium* mycotoxins.

Preparation of *Fusarium* extracts and Culture conditions for production of mycotoxins

Crude fungus culture extracts were prepared by a modification of a parboiled rice method reported by Lee, 1986 and Bosch *et al.,* 1989. Fifty gramme of rice and 30 ml distilled water were put in Erlenmeyer flasks (500 ml), stoppered with cotton plugs and allowed to soak for 1 hr before 30 ml of water was added and autoclaved. After cooling, spores of each of the sixteen *Fusarium* isolates were inoculated. The cultures were shaken daily for the first 1 week to permit the fungus to penetrate the rice and later incubated for another 3 weeks at 25°C. The cultures were harvested and dried on the laboratory bench at room temperature for 24 h and was finely ground and kept in the cold room (4°C) until analysis.

Detection of mycotoxins in Fusarium extracts:

Trichothecenes, zearalenol and zearalenone analysis
Methods of Royer *et al*. (2004), Klötzel *et al*. (2006) and Adejumo *et al.* (2007a) were used with modifications for analysis of deoxynivalenol (DON), 3-Acetyldeoxynivalenol (3 AcDON), 15-Acetyldeoxynivalenol (15 AcDON), nivalenol (NIV), Fusarenone-X (FUS X), Monoacetoxyscirpenol (MAS), Diacetoxyscirpenol (DAS), Neosolaniol (NEO), HT-2 toxin (HT2), T-2 toxin (T2), zearalenol (ZOL), zearalenone (ZON). Four grams of each of the eight ground fungal-rice culture were extracted with 40 ml (1:10) Acetonitrile: Water (84:16) in 50 ml Falcon tubes in a wrist action shaker at 150 rpm for 5 days. An aliquot of the supernatant was diluted with water (1:1) and extracted with hexane 1:1 (v/v). The lower phase of the preparations was filtered through (OPTI-FLOW, 13mm, 0.2 mm; PTFE; WICOM, Heppenheim, Germany) into HPLC vials. ZON and the ZOLs were separated as follows: 0–7 min 20–40% B, 7–10 min 40–70% B, followed by washing and re-equilibration steps. Quantitative determination was performed in single-reaction monitoring (SRM) and multiple-reaction monitoring (MRM) for ZON and ZOLs respectively.

Fumonisins and Enniatins analysis
Four grams each of the eight ground fungal-rice culture were extracted as above except that Methanol: Acetic Acid (99:1) was used as extractants. Methods of Monti *et al.* (2000), Royer *et al*. (2004) and Adejumo *et a.l* (2007b) were used for the determination of fumonisins B1, B2, B3 and enniatins (ENNs) B, B1 and A1. FB1 and ENNs were separated as follows: 0–1 min 20% B, 1–10 min 20–60% B, followed by washing (98% B) and equilibration steps. Since it is possible to ionize FB1 in positive and negative ESI, the FB1 samples were scanned twice. Peak integration was performed from the positive mode scan. Quantitative determination was performed in single-reaction monitoring (SRM) for FB1, FB2, FB3. Transitions used for quantification were as follows: FB1 in positive electrospray ionization (ESI): 721<157, Enniatin B- 657>445, Enniatin B1- 671.5>427, Enniatin A1- 685.5>455.

The identity confirmation took into consideration the retention time and transition (Table 1).

Table 1. HPLC–MS of trichothecene toxins, Elecrospray Ionization mode

Mycotoxins	Toxin retention) time (min)	Transition
Acetonitrile water extracts		
Deoxynivalenol	4.83	295>265
Nivalenol	2.955	311>281
Fusarenone- X	7	352>263
3-Acetyldeoxynivalenol	12.15	337>307
15-ADON	12.15	337>150
Neosolaniol	10.07	400>305
Diacetoxyscirpenol	16.03	400>305
HT-2	17.91	442>263
T-2	19.71	484>215
Zearalenol	20.65	319>275
Zearalenone	21	317>175
Methanol-Acetate extracts		
Fumonisin B_1	7.05	721<157
Enniatin B	8.91	657>445
Enniatin B_1	9.16	671.5>427
Enniatin A_1	9.45	685.5>455

Table 2. Production of mycotoxins by *Fusarium* isolates from maize

No	Isolate no	Fusarium species	Mycotoxins Present
1	10	*F. acuminatum*	Neosolaniol, Diacetoxyscirpenol
2	9	*F. proliferatum*	Fumonisin B_1, B_2, B_3
3	42	*F. proliferatum*	Fumonisin B_1, B_2, B_3
4	17	*F. verticillioides*	Fumonisin B_1, B_2, B_3
5	175	*F. verticillioides*	Fumonisin B_1, B_2, B_3
6	244	*F. verticillioides*	Fumonisin B_1, B_2, B_3
7	378	*F. verticillioides*	Fumonisin B_1, B_2, B_3
8	18	*F. equiseti*	None
9	118	*F. equiseti*	None
10	241	*F. equiseti*	None
11	62	*F. graminearum*	None
12	330	*F. graminearum*	None
13	1378	*F. graminearum*	None
14	21	*F. pallidoroseum*	None
15	3	*F. subglutinans*	None
16	3b	F. oxysporum	None

Results and Discussion

In this study the ability of 7 *Fusarium* species isolated from Nigerian maize grains intended for human consumption was tested for mycotoxin production in 16 rice cultures. Results in Table 2 show that 1 strain of *F. acuminatum* produced Diatoxyscirpenol (DAS) and Nesolaniol (NEO), while 2 strains of *F. proliferatum* and 4 strains of *F. verticillioides* produced FB_1, FB_2 and FB_3. It was observed that there was no mycotoxin present in the rice cultures with 3 strains of *F. equiseti*, 3 strains of *F. graminearum*, 1 strain of *F. pallidoroseum*, 1 strain of *F. oxysporum* and 1 strain of *F. subglutinans.*

The result on production of mycotoxins by Fusarium isolates is in accordance with reports in other countries (Fotso *et al*., 2002, Bailly *et al*., 2005, Ghiasian *et al.*, 2005), but in contrast to Tseng *et al*., 1995 who reported that all the *F. verticillioides* strains tested did not produce FB1 and/or FB2. The production of the three main fumonisin analogues by *F. proliferatum* strains is in agreement with the reports of Nelson *et a*l., 1992, Visconti et al., 1994, Musser *et al*., 1997. Although the degree of variability in the amount of DAS, NEO, FB1, FB2 and FB3 produced by *F. acuminatum*, *F. proliferatum and F. verticillioides* could not be ascertained, this work however complement the earlier reports (Adejumo *et al*., 2007a, 2007b) and that Nigerian maize are contaminated by toxigenic molds and trichothecenes (especially NEO) which is being reported to be present for the first time.

DAS (Anguidine) is a high toxicity (IARC, 1993), non estrogenic trichothecenes and naturally occurring mycotoxins in agricultural products: foods and feeds (Ueno, 1983). DAS inhibits the initial step of protein synthesis (I-type), while NEO is highly cytotoxic to cultured cells and possesses protein synthesis inhibiting activity (Pronk *et al*., 2002).

Fungal growth and mycotoxin contamination of maize and maize-based products are favored by the warm, moist climate that is prevalent in the south of West Africa (Adebajo, 1994). Therefore, proper handling and storage, monitoring of maize in all agroecological zones year to year in Nigeria are necessary in order to present a more complete picture of the incidence of these toxins in our foods. In this study, the demonstrated ability of the *Fusarium* isolates from Nigerian maize to produce DAS, NEO, FB1, FB2 and FB3 has public health implications, this is because low quality, cheap and moldy grains are consumed by animals and humans in Sub Saharan Africa. This poses great risk of human and animal mycotoxicoses.

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In vitro activities of fluoroquinolones against some respiratory and urinary tracts bacterial pathogens in Lagos

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Abstract
The use of Fluoroquinolones in human infections is an important issue in health care delivery system in recent time. In this study 113 samples from two groups of patients were evaluated. Group A comprised 79 patients defined by clinicians of having respiratory tract infections such as acute exacerbation of chronic obstructive pulmonary disease, pneumonia, sinusitis and bronchitis. Group B made up of 34 patients presented with Urinary tract infections. All the samples from patients were cultured, isolates identified and antimicrobial susceptibility testing against six fluoroquinolones (ciprofloxacin, ofloxacin. norfloxacin, levofloxacin, perfloxacin and sparfloxacin) were performed by standard procedures. Out of 79 samples screened in group A, 57 (72.2%) bacterial pathogens made up 13 *Streptococcus pneumoniae*, 14 *Staphylococcus aureus*, 17, *Klebsiella pneumoniae*, and 13 *Pseudomonas aeruginosa* were isolated from patients with respiratory tract infections. Twenty-four (70.6%) of the 34 urine samples from group B were confirmed positive for bacterial pathogens made up of 18 *Escherichia coli*, 5 *S. aureus* and one strain of *P. aeruginosa.*. The results of *in vitro* micro-dilution antimicrobial susceptibility tests for the six antibiotics against 81 bacterial strains in this study revealed a very high minimum inhibitory concentration at which 90% of strains of each bacterial pathogen were inhibited (MIC_{90}) and thus, were found to be inactive against the organisms tested at the approved MIC break-points. The MIC_{90} values obtained in this study for the six antibiotics against the pathogens varied. Norfloxacin and ofloxacin inhibited *S. pneumoniae,S. aureus, K. pneumoniae* and *P. aeruginosa* at MIC_{90} value of 16µg/ml. While for levofloxacin , sparfloxacin and ciprofloxacin, MIC_{90} value of 8 µg/ml was recorded against *S. pneumoniae* and *S. aureus.* Reduced ciprofloxacin and norfloxacin susceptibilities were observed in over 60% of the *E. coli* strains at MIC_{90} and MIC_{50} value of 2µg/ml for the two antibiotics respectively. When norfloxacin, ofloxacin, ciprofloxacin, levofloxacin, perfloxacin and sparfloxacin MICs were compared, most isolates that had non-susceptible MICs to one fluoroquinolone had non-susceptible MICs for all five drugs ($P>0.01$). The study revealed that, the continuous prescription of these fluoroquinolones in the treatment of respiratory tract infections without recourse to the result of susceptibility tests should be discouraged, as it may pose a serious threat to public health. However, ciprofloxacin and norfloxacin may still be useful against *E.coli*-associated urinary tract infections when indicated.

Key words: Fluoroquinolones, activities, bacteria, pathogens, urinary tract, respiratory tract, Minimum Inhibitory Concentration

Introduction

Fluoroquinolones formed by the addition of a fluorine molecule at position 6 of the quinolone structure are broad-spectrum antimicrobial agents ((Abelson and Hallas, 2003; Peterson, 2001). In 1978, norfloxacin was the first generation fluoroquinolone to be produced as an improvement on Nalidixic acid (quinolone). Modifications of chemical domains on the central structural core of the molecules allowed the development of additional antibiotics; ofloxacin and ciprofloxacin with improved effectiveness and are

considered second generation fluoroquinolones. These had been reported to have limited activity against some strains of S. pneumoniae and other respiratory pathogens (Weigel, *et al*., 2001; Abelson and Hallas, 2003). Newer fluoroquinolones such as sparcifloxacin, tosufloxacin, levofloxacin, gatifloxacin, pazufloxacin and grepafloxacin (third generation) and trovafloxacin, clinafloxacin and moxifloxacin (fouth generation) were introduced in 1990s with enhanced activity against both gram positive and gram negative bacterial pathogens, which have provided useful alternative therapies for pneumococcal infections and urinary tract infections (Duggirala *et al.,* 2007; Low, 2005). Chronic bronchitis, pneumonia, or complications of emphysema are often treated with fluoroquinolones, which facilitate recovery in hospitalized patients (Hunter and King, 2001). Complicated urinary tract infections (UTIs), have been reported to require prolonged antimicrobial therapy and may impact the variation in fluoroquinolone resistance in both male and female patients. Fluoroquinolones are used to treat chronic prostatitis, even though they do not all readily penetrate the prostate (Naber *et al*., 2001; Wagenlehner *et al.*, 2005). However, with increased use of fluoroquinolone therapy, resistant respiratory tract bacterial pathogens such as *S.pneumoniae, Staphylococcus aureus, Klebsiella pneumoniae,Pseudomonas aeruginosa* and urinary tract bacterial pathogens particularly *Escherichia coli* and *S. aureus* have emerged worldwide ((Duggirala *et al.,* 2007; Low, 2005; Lode and Allewelt, 2002; Weigel *et al.*, 2001 Chan *et al.*, 1999). Fluoroquinolones have variable activity against Community-acquired-methicillin-resistant *staphylococcus aureus* strain (CA-MRSA) (McGowan and Miller, 2006).

In Nigeria, few current and up to date data are available on the trend of respiratory pneumococcal infections (Agwu *et al*., 2006). Fluoroquinolone antibiotics have been used extensively in the treatment of bacterial-associated diseases (Akinyemi *et al.,* 2007). The high rate of hospitalization and prolong illnesses in patients with bacterial pneumonia and other respiratory diseases with fluoroquinolone therapy in recent times have been a great concern to public health. Besides, there is a paucity of literatures on the in-vitro activity of respiratory and urinary tracts bacterial pathogens to some commonly used second and third generation fluoroquinolone antibiotics in Nigeria. The aim of this study was to determine the status of six fluoroquinolone antibiotics commonly use as therapeutic agents for bacterial-associated respiratory and urinary tracts infections.

Materials and Methods

Patient Population and Study Centres: A total of 113 patients mainly from low and middle socio-economic class of the population were the subjects for this study. They were admitted between October, 2006 and May, 2007 into the following hospitals; Lagos University Teaching Hospital Idi-Araba, Lagos; Ikeja General Hospital Ikeja, Lagos and Infectious Diseases Hospital Mainland, Lagos. Important bio-data and time of onset of illness etc were noted.

Clinical Case Definition and Sample Collection: The subjects in this study were made of two categories. Category A comprised of 79 patients defined by clinicians of having respiratory tract infections such as acute exacerbation of chronic obstructive pulmonary disease, pneumonia, sinusitis and bronchitis with one or more of the following symptoms: chest pain, cough, fever, headache and evidence of parenchymal infiltrates on chest radiography. Early morning sputum (after mouth-flushing), sinus secretion / pus and bronchial secretion were collected from the patients (depend on the clinical presentation). Category B consisted of 34 patients presented with urinary tract infections. Early morning clean-catch mid-stream urine samples were collected from the patients. Samples were collected under the supervision of nurses in order to decrease the chances of contamination and were transported to the laboratory and processed immediately, or not later than 30 minutes after collection.

Bacteriology: Sputum samples for culture were first homogenized gently with 2 ml sterile normal saline by refluxing the sputum saline mixture. Urine sample was mixed well and 0.01 ml of un-centrifuged sample was inoculated directly on solid media. All the samples were inoculated onto solid media: Eoisine methylene blue agar, MacCkonkey agar, *Pseudomonas* selective agar, Brilliant green agar, Mannitol salt agar (Oxoid, UK), and Blood agar (Oxoid, UK), followed by sub-culturing on Triple iron sugar (Oxoid, UK). All the media were incubated aerobically at 37^0C for 18-24hours. Isolates were gram stained and identified by a combination of colonial and morphological features. Significant bacteriuria count was taken as any count equal to or in excess of 10^5 per millilitres of urine (Kass, 1959). Colonies were subjected to biochemical tests as described by Cowan and Steel (16). The commercially-available identification system API 20E (bio-Mérieux, France) was used

Antimicrobial Susceptibility Testing and Determination of Minimum Inhibitory Concentration

In vitro susceptibility testing was performed by broth microdilution according to the guidelines for the National Committee for Clinical Laboratory Standards (NCCLS, 1999). The fluoroquinolones used are: Ofloxacin (Sanvid, Microlabs Ltd, India), Norfloxacin (Surflox, Medreich Ltd, India), Ciprofloxacin (Ciprogem, Gemini Pharmaceuticals Nig. Ltd, Nigeria), Levofloxacin (Levoxin, Cipla Ltd, India), Perfloxacin (Perfloxacin, V.S. International PVT Ltd., India) and Sparfloxacin (Sparflox, V.S. International Pvt. Ltd., India). The reagent powders were dissolved in accordance with the instructions of the Manufacturers, diluted with Mueller-Hinton broth, and distributed to the wells of microdilution trays. Each tray was inoculated with approximately $5x10^5$ CFU per well to yield a final volume of 0.l mL per well for each strain of the test bacterial agents. The trays were incubated at 35 ^{0}C for 18 hr., approximately 5 x 10^5 CFU of *E. coli* ATCC 25922, *Staphylococcus aureus* ATCC 29213 and *Enterococcus faecalis* ATCC 29212 were included in each test batch as control strains. Interpretative breakpoints for all the antimicrobial agents were in accordance with NCCLS (2001) guidelines. Thereafter, MIC_{50} and MIC_{90} were evaluated accordingly (Phillip *et al*., 1991).

Results

Out of 79 samples screened in group A, 57 (72.2%) bacterial pathogens made up 13 *Streptococcus pneumoniae*, 14 *Staphylococcus aureus*, 17, *Klebsiella pneumoniae*, and 13 *Pseudomonas aeruginosa* were isolated from patients with respiratory tract infections. Twenty-four (70.6%) of the 34 urine samples from group B were confirmed positive for bacterial pathogens made up of 18 *Escherichia coli*, 5 *S. aureus* and one strain of *P. aeruginosa* (Table 1). When all the pathogens were subjected to *in vitro* micro-dilution antimicrobial susceptibility tests using six fluoroquinolones antibiotics viz: norfloxacin, ofloxacin, ciprofloxacin, perfloxacin, levofloxacin and sparfloxacin, the results showed a very high minimum inhibitory concentration at which 50 % (MIC_{50}) and 90% (MIC_{90}) of strains of each of the bacterial pathogens were inhibited. Over 95% of the organisms were resistant to all the six antibiotics with varying MIC_{50} and MIC_{90} values. Norfloxacin and ofloxacin inhibited *S. pneumoniae, and S. aureus,* at MIC_{50} and MIC_{90} value of 16µg/ml, whereas 8 µg/ml was recorded as MIC_{50} and MIC_{90} value for ciprofloxacin, levofloxacin and sparfloxacin against these gram positive pathogens (Table 2). Similarly, 16µg/ml value was obtained as MIC_{50} and MIC_{90} for norfloxacin, ofloxacin and levofloxacin against strains of *K. pneumoniae, and P. aeruginos*a tested. A lower MIC value was recorded for perfloxacin against gram negative respiratory pathogens compared with gram positive cocci in this study (Table 2). *E. coli* strains were 100% resistant to perfloxacin, levofloxacin and sparfloxacin, and less than 10% was susceptible to ofloxacin at the MIC break point of ≥8 µg/ml. Reduced ciprofloxacin and norfloxacin susceptibilities were observed in over 60% of the *E. coli* strains at MIC_{90} and MIC_{50} value of 2µg/ml for the two antibiotics respectively (Table 3). In this study all *E. coli* strains from six

of the 7 urine samples of children with UTIs exhibited reduced-ciprofloxacin susceptibility When norfloxacin, ofloxacin, ciprofloxacin, levofloxacin, perfloxacin and sparfloxacin MICs were compared, most isolates that had non-susceptible MICs to one fluoroquinolone had non-susceptible MICs for other five drugs ($P > 0.01$) (Figure).

Discussion

Fifty-seven of the 79 patients presented with one of pneumonia, sinusitis and COPD were positive for bacterial pathogens. The predominating organism was *K. pneumoniae* 17 (%), followed by *S. aureus* 14(%), *S. pneumoniae* 13(%) and *P. aeruginosa* 13(%). Strains of *S. pneumoniae* were mostly isolated from cases of pneumonia as had *K. pneumoniae* strains from bronchitis (Table 1). The isolation of these pathogens from respiratory diseases had been documented by several studies (Agwu *et al*., 2006; Mclntosh, 2002; Ikeogu, 1988). *E. coli* was the most encountered bacterial pathogen from cases of UTI, isolated from 75% of the positive samples, while 20.8% and 4.2% *S. aureus* and *P.aeruginosa* strains were isolated from the remaining samples in this study (Table 1). Previous work conducted on UTI over a decade in Lagos, Nigeria indicated 26.4% prevalence rate of *E. coli* in complicated UTI (Akinyemi *et al.*, 1997), an indication of increase in the prevalence of *E. coli* -associated UTI in our environment. The results of antimicrobial susceptibility tests revealed that, norfloxacin and ofloxacin inhibited *S. pneumoniae,* and *S. aureus*, at MIC_{50} and MIC_{90} value of 16µg/ml, at the same time; 8µg/ml was recorded as MIC_{50} and MIC_{90} value for ciprofloxacin. These values were higher than the recommended standard MIC break points for norfloxacin, ofloxacin and ciprofloxacin. Similarly, 16µg/ml value was obtained as MIC_{50} and MIC_{90} for norfloxacin, ofloxacin and 8µg/ml ciprofloxacin against strains of *K. pneumoniae, and P. aeruginos*a tested (Table 2). In other parts of the world, the earlier fluoroquinolones including norfloxacin, ciprofloxacin and ofloxacin have been reported to be ineffective for the treatment of pneumococcal and other respiratory tract infections (Chen *et al*., 1999; Low, 2005). Our result was in consonance with these studies, thus justifying the resistance in bacterial pathogens observed. Furthermore, levofloxacin and sparfloxacin inhibited *S. pneumoniae*, and *S. aureus*, at MIC_{50} and MIC_{90} value of 8µg/ml, whereas 16µg/ml value for levofloxacin against strains of *K. pneumoniae, and P. aeruginos*a tested. In literature, levofloxacin, grapofloxacin and trovafloxacin have been documented to have greater activity against *S. pneumoniae* and *K. pnuemoniae* and are recommended for the treatment of pneumococcal infections, including community acquired puenmonia, acute bacterial exacerbations chronic bronchitis and sinusitis (Chen *et al*., 1999).Our present study was in contrast to this report, though unavailability of grafloxacin and trovafloxacin for evaluation made complete comparison difficult.. Worthy of note in this study was a lower MIC value recorded for perfloxacin against gram negative respiratory pathogens compared with gram positive cocci (Table 2). Similar observation had been documented elsewhere (Duggiral *et al.*, (2007). In African countries neither second nor third generation fluoroquinolone is a problem. El khol *et al.* (2003) reported less than 20% of *S. pneumonia* and *P. aeruginosa* strains resistance to fluoroquinolones. Furthermore, *E. coli* strains were 100% resistant to perfloxacin, levofloxacin and sparfloxacin, and less than 10% was susceptible to ofloxacin at the MIC break point of ≥8 µg/ml. The results are indication of high prevalence of fluoroquinolone-resistant *E. coli*-associated UTI in our environment. When ciprofloxacin, gatifloxacin, levofloxacin, and norfloxacin MICs were compared, all the isolates that had non-susceptible MICs to one fluoroquinolone had non-susceptible MICs for all other drugs ($P>0.01$). This observation is similar to findings elsewhere in which susceptibility status of one fluoroquinolone antibiotic had been found to infer from testing one of the fluoroquinolone antibiotics as a "surrogate marker (Jones *et al*., 2001; Boyd *et al*., 2008).

Generally, the current results showed that over 95 % of the bacterial isolates were resistant to the six antibiotics at standard MIC break points. Fluoroquinolone-resistant respiratory and urinary tracts pathogens had emerged in Canada, Spain, England, Italy, Hong Kong, Eastern and Central Europe and, to a lesser extent, the United States (Chen *et al*., 1999; Low, 2005) but not as high as the percentage recorded in this study which may be due to the limited scope of our study.

Therefore, the observed high resistance of both gram positive and gram negative pathogens to second and third generation fluoroquinolones commonly use in our environment in this study is worrisome and quite revealing and the explanation for this is difficult. This is because fluoroquinolone antibiotics are relatively expensive in Nigeria. For example the cost of ciprofloxacin or ofloxacin is over $10.00 for a five-day therapy in adults. The implication of this is that the hope of therapy for pneumococcal and other complicated respiratory infections in our environment is now threatened thus resulting in the prolong illnesses in affected individuals, and may culminate to decline in workforce and productivity. However, risk factors commonly associated with resistance such as indiscriminate use of antibiotics, poor enforcement of existing legislature relating to procurement and sales of drugs on the part of Nigerian government, the issue of sub-standard and/or adulterated drugs among other factors may be attributed to the current fluoroquinolones resistance upsurge.

We observed reduced ciprofloxacin and norfloxacin susceptibilities in over 60% of the *E. coli* strains at MIC_{90} and MIC_{50} value of 2µg/ml. Reduced-susceptibility to fluoroquinolones has been attributed to slower rates of response to quinolone therapy, as a result of exposure to lower concentration of the antibiotics. This tends to increase the chance for selection of resistance spurred with poor compliance and/or poor quality products (WHO, 1998). It is not surprising in this study that all *E. coli* strains isolated from six of the 7 urine samples of children with UTIs exhibited reduced-ciprofloxacin susceptibility. This is because the use of fluoroquinolone antibiotics in pediatric patients generally is not recommended: a caution that is strictly adhered to by most physicians in Nigeria. Although the only licensed use of fluoroquinolones in children is treatment of post-inhalation anthrax exposure with ciprofloxacin, some compassionate use in children suffering from serious infections, such as multidrug resistant infections have been noticed and documented (Anons, 2006; Boyd *et al*., 2008), such observation was noticed in this study where patients were presented with complicated UTI. Worthy of note in our findings, is the different origins of fluoroquinolones formulation used; because they are not reference samples but packaged (finished) products from manufacturers which may likely make the results to be biased. However, the fact that these antibiotics were able to inhibit the reference control bacterial strains at the values lower than MIC breakpoints ruled out the possibilities of sub-standard finished products from the manufacturers, but rather, an indication of emergent-mutant strains of respiratory and urinary tracts pathogens in our environment.

In conclusion, our findings revealed that ciprofloxacin, ofloxacin and norfloxacin are no longer active against both gram positive and gram negative respiratory tract pathogens at the recommended standard MIC breakpoints. We recorded reduced susceptibility of ciprofloxacin and norfloxacin in *E. coli* strains, despite this development, ciprofloxacin and norfloxacin remain the drugs of choice against *E.coli*-associated urinary tract infections. It is thus suggested that, continuous prescription of fluoroquinolone antibiotics in the treatment of respiratory tract infections without recourse to the result of susceptibility tests should be discouraged, as it may pose a serious threat to public health. Constant antimicrobial resistance surveillance is essential, in view of the emerging fluoroquinolone resistance in bacterial isolates. There is a need for close and constant monitoring through the various regulatory agencies to evaluate the claims of the manufacturers of these antimicrobials as regards the potency and spectrum of activity of their products particularly in developing countries. More importantly, there is need for National Initiatives Group (NIG)

comprising both private and public sectors to promote the judicious use of antimicrobials in the hope of slowing or reversing the increasing trend of antimicrobial resistance in strains of bacterial pathogens currently threatening health care delivery system.

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Table 1: Bacterial pathogens isolated from patients with Respiratory and Urinary tracts Infections in Lagos, Nigeria

Clinical diagnosis	No of cases	No of positive cases	Bacterial pathogens isolated				
			P.aeruginosa	*K.pneumoniae*	*S. aureus*	*S. pneumoniae*	*E. coli*
(a) RTIs							
(i) pneumonia	43	30	6	8	7	9	0
(ii) Bronchitis	22	18	4	7	4	3	0
(iii) Sinisitis	11	7	2	1	3	1	0
(iv) others	3	2	1	1	0	0	0
(b) UTIs	*34	24	1	0	5	0	18
Total	113	81	14	17	19	13	18

* Seven of the patients were children under 12 years old.

RTI = Respiratory tract Infections

Table 2: Minimum inhibitory concentrations (MIC) of each of the six fluonoquinolones against some gram positive bacterial pathogens from clinical samples

Antimicrobial agent (break point for resistant)	*Streptococcus pneumoniae* (n-13) Micro-dilution (MIC in µg/ml)				*Staphylococcus aureus* (n=19) Micro-dilution (MIC in µg/ml)			
	Range	MIC_{50}	MIC_{90}	% R	Range	MIC_{50}	MIC_{90}	%R
Norflaxacin (≥8)	16-128	16	16	100	16-64	16	16	100
Ofloxacin (≥8)	8-64	16	16	100	8-125	16	16	100
Ciprofloxacin (>4)	8-32	8	8	100	8-64	8	8	100
Penfloxacin (≥4)	16-128	16	32	100	8-32	8	8	100
Levoflaxacin (≥2)	4-32	8	8	100	4 -16	8	8	100
Sparfloxacin (≥2)	4-16	8	8	100	4 -16	8	8	100
Antimicrobial agent (break point for resistant)	*Klebsiella pneumoniae* (n-17) Microdilution (MIC in µg/ml)				*Pseudomonas aeruginosa* n=14 Micro-dilution (MIC in µg/ml)			
	Range	MIC_{50}	MIC_{90}	% R	Range	MIC_{50}	MIC_{90}	% R
Norflaxacin (≥8)	8-64	16	16	100	8-64	16	16	100
Ofloxacin (≥8)	8-32	16	16	100	8-64	16	16	100
Ciprofloxacin (>4)	4-32	8	8	100	8-32	8	8	100
Penfloxacin (≥4)	4-16	8	8	100	4-16	8	8	100
Levoflaxacin (≥2)	4-32	16	16	100	16-64	16	32	100
Sparfloxacin (≥2	16-64	32	32	100	16-64	32	32	100

n = number of strains, R= Resistance

Table 3: In-vitro activities of six fluoroquinolones against strains of *Escherichia coli* from patients with urinary tract infections

Antimicrobial agent (break point for resistant)	*Escherichia coli* (n-18) Micro-dilution (MIC in µg/ml)			
	Range	MIC $_{50}$	MIC $_{90}$	% R
Norflaxacin (≥8)	2-16	2	4	11.1%
Ofloxacin (≥8)	4-16	8	8	88.9%
Ciprofloxacin (>4)	2-4	2	2	5.6%
Penfloxacin (≥4)	4-32	8	16	100%
Levoflaxacin (≥2)	8-32	8	16	100%
Sparfloxacin (≥2)	16-64	16	32	100%

n = number of strains, R= Resistance

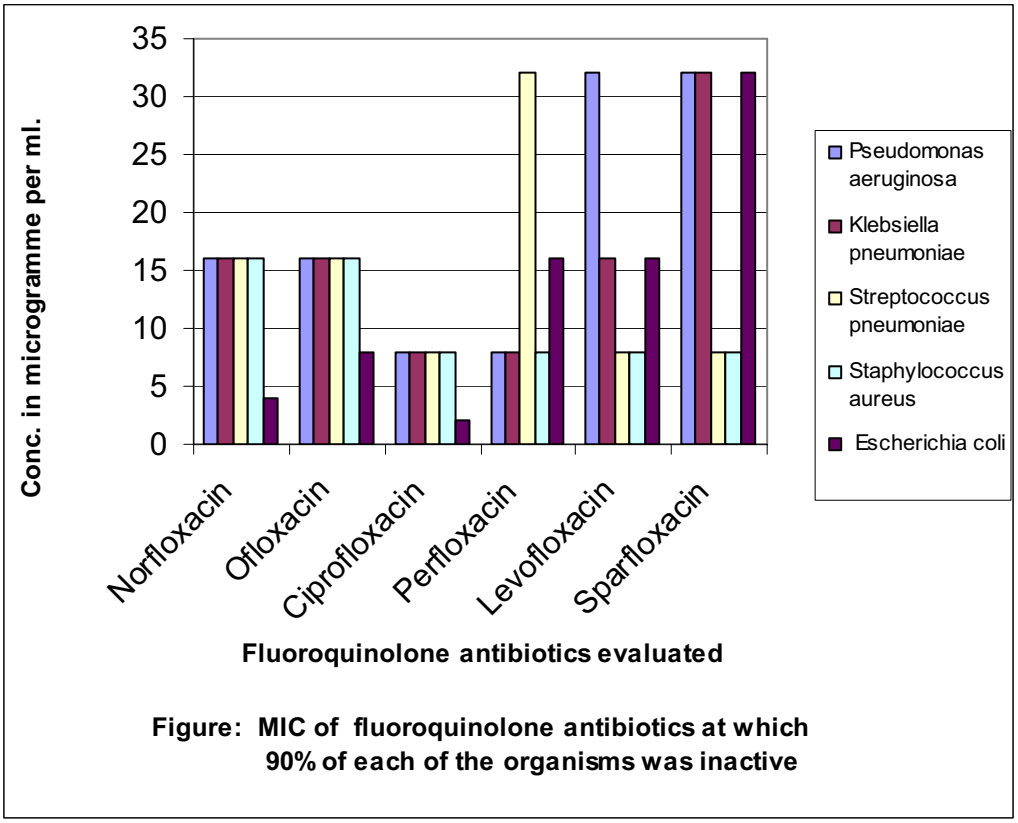

Figure: MIC of fluoroquinolone antibiotics at which 90% of each of the organisms was inactive

Maternal age at first birth, Infant and Child Care and Trends in Under-5 mortality in Nigeria (1990-2003 as a case study).

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Abstract
Impressive reductions in infant and child morbidity and mortality have been experiencing a serious set back in Nigeria despite a two-third reduction in child mortality set by Millennium Development Goals (MDGS). With the advent, introduction and mass dispensation of various vaccinations (immunizations) and other modern medical facilities around coupled with the massive campaign of exclusive breastfeeding and adequate infant and young child feeding practices in the country, one would have expected a significant improvement in infant and child health and consequently, a drastic reduction in child mortality. Though reliability of the morbidity and mortality estimates is affected by the completeness of reporting deaths and child health records; but a death of 1 in 5 children before their fifth birthday as of 1990 and 100 per 1000 live-births for the 1999-2003 period in Nigeria is significantly higher. In 2003, one-third and three-quarter of women aged 25-49 had had sexual intercourse by age 15 and 20, respectively, while their median age at first birth was less than 19years. These are ages where most of them are psychologically and physiologically unripe and ill equipped for childbirth and childcare activities and requirement. Engaging important and appropriate variables from 1990, 1999 and 2003 Nigeria Demographic and Health Survey (NDHS), the paper examined the effect of maternal age at first birth on under-5 mortality rate in Nigeria. Conclusively, it was evidently shown that under-5 mortality rate of 201 per 1,000 as discovered in 2003 report was more than 70 per 1000 internationally adopted in the 1990 World Summit for children. Significant evidences showed that maternal age at first birth per se was not the principal predictor of under-5 death but some other contributory (socio-demographic and reproductive health issues) factors, which were associated with teenage birth.

Keywords: Millennium development goal; infant, breastfeeding; mortality

Introduction:
Due to its importance in determining life expectancy at birth and generally measurement of overall developmental level of any society, study of a country's infant and under-5 mortality rate cannot be overemphasized. However, reporting and recording of vital events, (most especially death) has not been accurate in less developed countries (LDCs), but despite the underreporting of death statistic in LDCs, sub-Saharan African Countries have witnessed substantial reduction in childhood mortality. Though, the trends in the LDCs have not been so impressive when compared with the scene in the developed nations of the world. Out of more than 60 countries that have reached the goal of reducing under-5 mortality rate by one-third, none was found in the LDCs. Instead, the World Health Organization (WHO) (2008) studied and reported that 9 out of 14 countries where under-5 mortality is still increasing were found in sub-Saharan Africa (Nigeria inclusive). For instance, when compared with the minimum goal of 70 per 1000 World summit for children, Nigeria Demographic and Health Survey (NDHS), (1990) recorded a death of 87 out of every 1000 infants born in Nigeria before their first birthday while Feyisetan *et al.* (1997) reported 115 deaths of every 1000 children before reaching age five. In addition, for five years that preceded the 1999-2003 Nigeria Demographic and Health Survey, the infant mortality rate was 100 deaths per 1000 live birth, while the overall under-5 mortality rate was 201 deaths per 1000 live birth (NPC/Macro, 2003 p.xxiv).

Bringing down mortality rate among infant and under-5 children has been on the agenda of public heath and international development agencies (Mutunga, 2004). It is also one of the United Nation's Millennium Development Goals' (MDGs) objectives. With large variations in under-5 mortality rates and trends across regions and countries, millions of infants and under-5 children die each year. The State of the World's Children report indicated that nearly 13 million children die every year in developing

countries (UNICEF, 1987). Other studies have traced early childhood mortality to socioeconomic factors, which were classified under macro- and micro-level (Obungu *et al*., 1994). Parental education especially that of mother and age at first birth have been the fundamental variables in most of these investigations (Orubuloye and Caldwell, 1975; Westoff, 2003)

Many research works have revealed that most under-5 deaths in Africa countries resulted from malaria, diarrhea, acute respiratory infections, measles, neonatal tetanus, dehydration and malnutrition (Ayeni and Oduntan, 1980; Rao *et al.*, 2006; WHO, 2008). Majority of which are mainly by infectious and parasitic diseases that are easily preventable (WHO, 1996; Morley, 1973; Ogunjuyigbe, 2004; WHO, 2008). Mosley and Chen (1981) also viewed child morbidity and mortality as being influenced by some both biological and socio-economic underlaying factors which operate as proximate determinants. Eating and feeding habits and practices are other intervene variables that have great influences on the determinants of mortality in infancy and childhood. Jinadu *et al.* (1991) reported that dirty feeding bottles and cooking utensils and unhygienic storage of drinking water are all significant predictors of high incidence of infant and child morbidity and mortality. The health of the mother and her nutritional status can also influence the health and survival of the child because of the biological links between her and her infant most especially during lactation (Mosley and Chen, 1981).

Cultural belief about certain diseases may also have pronounced unfavorable influence on infant and childhood mortality rate (Odebiyi and Ekong, 1982; Ogunjuyigbe, 2004; Rao *et al*. 2006; WHO, 2008). The risks associated with early childbearing are apparent when the maternal age at first birth is been considered relative to infant and childhood morbidity and mortality. Teenage motherhood, otherwise known as early childbirth (birth by a woman before such woman's 20^{th} birthday) remains a pressing social issue and public health problem. Petra *et al.* (1999) and Alam (2000) declared in their works that teenage mothers are more likely than the older mothers to have children with behavioural and health problems. They reported that apart from high school dropout, low self-esteem, low employment opportunities and lower productivity exposed to by teenage mothers, they are equally at risk impairing their heath and that of the products of such pregnancies. Using data from 1990-2003 Nigeria Demographic and Health Survey, the aim of this paper is to examine the effect of maternal age at first birth and infant and child feeding practices on under-5 mortality in Nigeria.

Data and Methods

The Nigeria Demographic and Health Survey (NDHS) survey is a rich nationally representative database. Sequel to the aim of designing measure for the levels, patterns, and trends of demographic and health indicators, it provides up-to-date information on the population and health situation of the country. Specifically, NDHS questionnaire collected information on the maternal, child and household health, individual birth history and childhood mortality, among others.

To have a nationwide coverage, NDHS selected its respondents across all the geo-political regions of the country. NDHS 2003 selection ranges within the six geo-political zones from 12.3% in Southern south to 23.5% in the Northern west. While in the cases of the other two surveys, (1990 and 1999), the country was by then four and five regional divisions respectively. Other detailed description of the sampling methodologies and actual samples of women and households can be found in the various NDHS final reports. Statistical Package for Social Sciences (SPSS) was used to analyze the data in this paper based on both univariate and bivariate analysis. Pearson's chi-square ^{2}א was used to test the significances of the relationships between variables.

Result:

Socio-economic and demographic profile of the respondents.

There are variations in both socio-economic and demographic distributions of the respondents across the years. The median ages are 27, 24 and 26 years for 1990, 1999 and 2003 respectively; while 19.0, 18.9 and 18.6 are the mean ages at first birth for the survey respective years. Educational status of Nigerian women is improving though at a slow pace. In 1990 almost 8 out of 10 women of childbearing age did not have more than primary education, the same was reduced to about six in every 10 in 2003 (Figure 1).

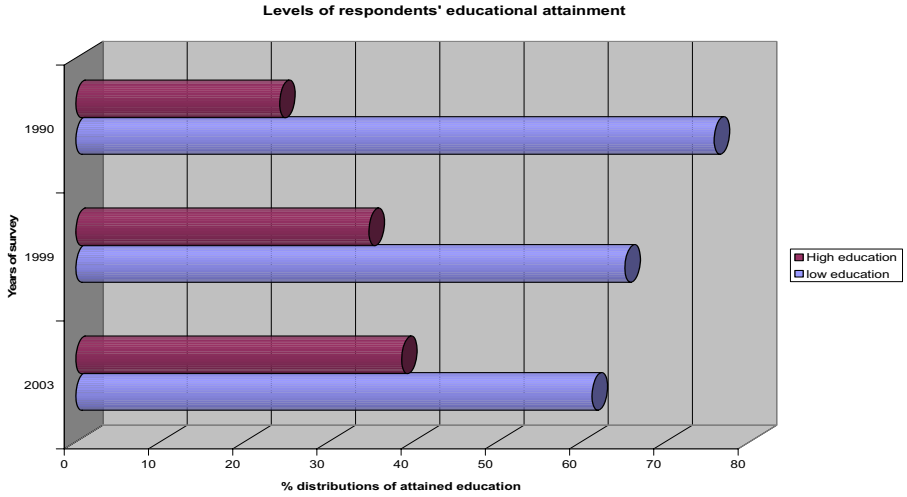
Table 1: Percent distribution of all respondents' (women) by socio-economic and demographic variables.

Variables/categories	2003	1999	1990
Respondent current age			
10 – 14	n.a	16.4	n.a
15 – 19	23.0	18.1	19.1
20 – 24	19.2	15.6	19.2
25 – 29	17.8	15.5	18.9
30 – 34	12.3	11.6	15.8
35 – 39	10.5	10.0	10.8
40 – 44	9.1	7.0	9.4
45 – 49	8.1	5.7	6.9
Type of marriage union			
Monogamy	64.1	66.8	60.3
Polygyny	35.9	33.2	39.7
Respondent current working			
No	44.4	59.0	40.6
Yes	55.6	41.0	59.4
Age of respondents at first birth	64.3	60.6	60.9
Less than 20	35.6	39.0	38.7
20 – 34	0.1	0.4	0.4
35 or older			
Type of place of residence			
Rural	40.1	32.8	40.2
Urban	59.9	67.2	59.8
Place of delivery			
Home	62.4	61.3	58.0
Govt. hospital/health	21.0	24.0	36.2
center/post	15.8	13.2	n.a
Private hospital/clinic	0.8	1.6	5.8
Others (Traditional/church etc.)			

n.a : not available

Sources: Nigeria Demographic and Health Survey, 2003, 1999 & 1990.

Figure. 1: Level of women's educational attainment by years of survey (1990, 1999 and 2003).



Sources: Nigeria Demographic and Health Survey, 2003, 1999 & 1990.

About twenty-four percent of women in 1990 had secondary school education or above (higher education) but by 2003, it had risen to 4 in every ten women. This could be the result of series of policy changes in the educational sector of the country; among which were the 1976 National Policy on Universal Primary Education, which gave every child the right to tuition-free primary education, the 1999 Universal Basic Education (UBE) and the encouragement given to female child education and series of female empowerment and enlightenment programmes in the country. Despite the reduction in the number of women with low education (no education & primary) over time, women educational trend still revealed that there are still more of women in low education category than their counterparts in higher educational group (secondary and above).

Marriage institution being a universal event in Nigeria, marriage and cohabitation are considered to be primary factors of exposure to the risk of pregnancy. It was revealed that majority of Nigerian households are in marital union of one-man one-wife. Table 1 shows with little variation that from about six in every 10 women in 1990 who were in monogamous union it increased to about 64% in 2003. The economic empowerment of women will depend on their working status, the survey revealed that more of them were engaged in a productive work in 1990 than in 2003 (59.4% vs. 55.6%). Early sexual initiation is often considered undesirable, as it increases the length of exposure to the risk of pregnancy, child bearing and STD infection due to inexperience. It is used as a proxy for the onset of a woman's exposure to risk of pregnancy (NPC/Macro, 2003 p.87). Table 1 shows the trend in age at first birth of Nigeria women. An increasing trend of early childbirth from 1990 to 2003 was noticed among them. More women were involved in teenage childbirth in 2003 than 1990 (64.3% vs 60.9%). Information on respondent's place of residence shows that at least 60% of women have been living in urban areas than the rural areas in Nigeria since 1990s through 2003. This could be the effect of rural-urban migration that characterized less developed countries.

One important objective of the 2003 NDHS was to measure levels and trend of death among children. Proper medical attention and hygienic conditions for healthy delivery can reduce the risk of complication during and after birth for mothers and babies. It was discovered that the history of home delivery without medical attention in Nigeria refuses to change from its high rate. Table 1 revealed that almost 60% of Nigeria women reported home delivery during their first birth in 1990, while over 62% reported the same in 1999 and 2003. Unfortunately again, there is a considerable reduction in women who delivered in government hospital, government health centers and maternity centers from 1990s to 2003 (36.2% to 21%). Those who gave birth in traditional

birth attendants' homes and faith-based units also decrease over the years from about 6% in 1990 to less than one percent in 2003. Private hospital and clinic witnessed a high trend of Nigeria women's child delivery patronage within 1999 and 2003 from 13.2% to close to 16% in 2003.

Maternal age at first birth and some under-5 mortality risk factors (contributory factors)

Data and estimate from 1999 NDHS will no longer be considered again in the remaining sections of this paper because of the significant underestimation in the true mortality levels in the country that was recorded in the report (NPC/Macro, 2003, p108). Table 2 considers three categories of women: (a). Women of early childbirth experience (≤ 19), (b). Women of normal age of childbirth (20-34) and (c).Women with late childbirth experience (≥ 35).

Maternal education has been observed overtime as having a significant inverse relationship with under-5 mortality; Table 2 reveals a trend of higher proportion of low education (no education and primary) among Nigerian women across all ages at first birth. Antenatal care (ANC) services from a trained provider, proper medical attention have positive impacts in reducing the risks for mothers and child during and after birth. Though more than three-quarters of Nigeria women reported antenatal visit for pregnancy as shown in Table 2, there was a slight reduction in antenatal attendance among under 20 mothers within the two data sets (1990 and 2003); about 3% reduction among teenage mothers, more than 7% in the case of those who had their first birth within 20-34 years. As earlier revealed in Table 1, majority (more than 60%) of women in Nigeria had their first birth at home without medical assistance.

One of the preventive measures designed to improve child health and reduce morbidity and mortality among children is vaccination at different stages of their lives most especially within the first-twelve months of live. The record presented in Table 2 shows a great improvement in Nigeria women's response to vaccination taking for their children from 1990 to 2003. In 1990, more than half of women regardless of their age at first birth reported not to have taken vaccination for their first born while 13 years after (2003) majority of Nigerian women (more than 62%) had taken vaccination for their first born. The vaccination campaign strategy launched by the international and local stakeholders in most less developed countries could be responsible.

Table 2: Percent distribution of respondents' ages at first birth by infant and under-5 child mortality risk factors. ***Contributory factors (community, household and individual).***

Variables/categories	2003				1990		
	≤ 19	20 - 34	≥ 35		≤ 19	20 – 34	≥ 35
Educational level							
Low education	83.2	58.2	42.9		90.1	78.3	96.3
High education	16.7	41.7	57.5		9.9	21.7	3.7
Antenatal visit for pregnancy	41.2	20.0	33.3		38.7	27.3	76.5
No antenatal	58.8	80.0	66.7		61.3	72.7	23.5
Yes							
Place of delivery							
Home	72.3	44.7	50.0		64.3	47.9	83.4
Govt. hospital/health center	17.3	27.6	33.4		30.2	45.6	5.5
Private hospital	10.0	26.4	16.7		0.8	0.6	0.0
Others (traditional, faith etc)	0.5	1.4	0.0		4.6	5.9	11.1
Heard/Used of oral rehydration							
Never	82.6	74.6	80.5		84.9	84.9	100.0

Yes (used heard)	17.3	25.4	19.5	15.1	15.1	0.0
Source of drinking water						
Pipe water	15.6	18.1	14.3	27.5	33.7	18.5
Open well	35.5	23.2	14.3	39.0	28.4	33.3
Borehole/covered well	17.7	25.2	57.1	0.0	0.0	0.0
Surface water	22.7	22.3	14.3	29.3	31.5	48.1
Rainwater	0.7	1.4	0.0	0.5	0.5	0.0
Tanker water	6.2	6.7	0.0	3.5	5.7	0.0
Bottled water & others	1.6	3.1	0.0	0.1	0.2	0.0
Assistance in delivery: Doctor						
No	95.1	87.1	66.7	90.1	84.4	100.0
Yes	4.9	12.9	33.3	9.9	15.6	0.0
Ever had vaccination						
No	36.7	27.9	33.3	59.2	50.4	82.4
Yes	62.8	71.6	66.7	39.3	47.6	11.8
Do not know	0.4	0.5	0.0	1.5	2.0	5.9

Sources: Nigeria Demographic and Health Survey, 2003 & 1990.

Relationship between selected socio-demographic and environmental variables among women who suffer under-5 child death by mothers' age at first birth

The age at which childbearing begins has so many influences on the morbidity survival rate of infants. It often results to complications during and after birth. The relationship between age at first birth and some selected variables among women who lost the product of their first births before the child reached age 5 were observed and presented in Table 3. As earlier stated in this paper, maternal education has been observed as a significant predictor of child morbidity and mortality. As revealed in Table 3, the interplay between age at first birth and maternal educational level shows that more than 96% of Nigerian women who had low educational level (no education and primary) and at the same time experienced earlier childbirth lost their first born before age 5 as reported in 2003 data. To study the extent that maternal education determines child morbidity and mortality, Table 3 further reveals that 9 in every ten women who had first birth between age 20-34 years but with low educational status (no education and primary) lost their first birth before the product of such birth reached age 5 ($p<0.05$). Larger percentage of rural teenage mothers and those who had first birth within ages 20-34 years experienced under-5 children death (70% and 63.3% respectively).

Source of household drinking water being one of the determinants of diarrhea which is a major cause of death among children in Nigeria was examined. Table 3 shows that more than 6 in every 10 Nigerian women who experienced death of under-5 children reported well water (covered and uncovered) as the main source of the household drinking water. Proper household hygiene which is another determinant of diarrhea was measured with the use of household toilet facilities. Table 3 further reveals that vast majority of women with under-5 death experience resided in houses with pit latrine (68% among teenage mothers and 78.3% among those who had their first birth within 20-34 years of age) ($p<0.05$).

Antenatal care and eventual assistance by a medical doctor during delivery as stipulated by World Health Organisation (WHO) were also examined and presented in Table 3. It was revealed that 60% and 98% of teenage mothers who did not attend antenatal clinic and those who had no assistance from a medical doctor during delivery respectively experienced under-5 death ($P<0.01$). Vaccination of children is one of the many preventive measures to improve child health and reduce mortality among them. By WHO standard, a child has to undergo about 8 vaccines to be considered fully vaccinated. Vaccination of children across

different ages at first birth was examined. Table 3 shows that majority (not less than 63%) of women who experienced under-5 death claimed taken vaccination for children.

Table 3: Percent distribution of selected socio-demographic and environmental variables among women who lost under-5 child by age at first birth

Variables/Categories	≤ 19	20 - 34	χ^2	df
Educational level*				
Low education	96.2	90.0	7.633	3
High education	3.9	10.0		
Type of place of residence				
Urban	30.1	36.7	0.971	1
Rural	69.9	63.3		
Type of marriage union				
Monogamy	48.1	42.6	0.536	1
Polygyny	51.9	57.4		
Place of delivery				
Home	87.3	68.2		
Government hospital	6.3	18.2	9.265	2
Private hospital	6.3	13.6		
Source of drinking water				
Pipe	10.4	13.3		
Well water	61.8	61.7	3.788	3
Vendor & bottled	5.0	10.0		
Others	22.8	15.0		
Toilet facilities*				
Flush	4.2	3.3		
Pit	68.0	78.3	2.528	2
Bush/field/river	27.8	18.3		
Antenatal visit during pregnancy*** No	59.9	33.3	9.404	
Yes	40.1	66.7		1
Assistance during delivery: doctor				
No	97.5	95.5	90.484	1
Yes	2.5	4.5		
Ever had vaccination				
No	36.9	37.1	0.001	1
Yes	63.1	62.9		

* means at significant at $p < 0.10$

*** means significant at $p < 0.01$

Discussion and Conclusion

Under-5 mortality rate (201 per 1,000) as reported in NDHS 2003 and other evidences from this paper have shown a higher mortality rate than the 70 per 1,000 internationally adopted in the 1990 World Summit for Children. Evidences from the paper have shown that age at first birth *per se* was not the principal and sole predictor of under-5 death but some other contributory (socio-demographic, economic and environmental) factors, which were associated with teenage birth.

Despite series of complication and risk suffered by women during and after childbirth, the paper noticed a general high home delivery (62.4%) among Nigerian women. This dictates a low rate at which assistance by medical or other health professional is being sought during childbirth. Though, most of them reported staying in urban areas but majority stay in slum zone with unfavourable and unhygienic environmental conditions in those cities. In spite of the negative correlation between maternal education and child mortality as postulated by many studies in the past, over 60% of Nigeria women had low education (no or primary education). This is a pointer to the less reproductive health information access for women. Like education, women employment status is also a source of empowerment (NPC/Macro, 2003 p.30). This paper discovered that almost half of Nigeria women were not working as at 2003 NDHS survey. This could invariably limit their economic and political power and thereby hamper the power to take vital reproductive and other family health decisions that might have great and adverse implication on the survival of under-5 children.

Being an important issue in this paper, early motherhood by the investigation of 2003 NDHS revealed 64.3% of Nigeria women began childbearing before age 20. Study among the 64.3% teenage mothers showed the followings: more than eight out of every 10 had less than secondary education (none or primary). Sixty-four percent were not working in the 2 weeks that preceded the survey. In the view of reproductive and general child health matters (community and household), due to non- availability or proximity to health and other facilities almost 42% never attended antenatal care while more than 72% delivered their first birth at home. About ninety-five per cent never had assistance from a medical doctor during their first birth despite the recommendation of World Health Organization and close to forty percent of them reported never taken vaccination for their children either at birth or thereafter. Thirty-six percent reported well water (covered or uncovered) as the main source of household drinking water and finally about 83% of the teenage mothers claimed never heard or used oral rehydration for first child despite the high prevalence of diarrhoea in Nigeria. However, ninety-three percent reported never used mosquito bednet for their first born even with the high incidence of malaria among Nigeria children. Though the connection between under-5 death and early motherhood is strong and significant but a more comprehensive study of NDHS 2003 data revealed a greater relationship between under-5 mortality and some intervening factors among which were low maternal educational level, poor place of residence, and unhygienic child delivery which were associated with early childbirth. Others are poor source of drinking water, unhygienic toilet facilities, less or no antenatal visit during pregnancy, not usage of bednet for under-5 and not giving oral rehydration. They all contributed immensely to high under-5 mortality in Nigeria. The study invariably sees the need for Nigerian government and other stakeholders to intensify efforts at reducing the incidence of under-5 mortality. Also efforts should be made to improve both formal and informal maternal education most especially that of teenage mothers. This would enable mothers to keep abreast of issues on reproductive and child health.

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Household Headship, Household Size and Child Health in South-Western Nigeria

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Abstract
In most developing countries, the head of household usually decides upon the type of health care his or her household members should seek and what type of treatment option should be adopted in case of illness. This study examined the overall influence of household headship, household size and its socio economic status on the health care of the child in south western Nigeria. Findings in this study emanated from a survey conducted among 400 household heads which were randomly selected in Akure and Idanre areas of Ondo State, Nigeria. An eligible respondent in this study is a household head who could either be a male or a female. The immunization status of the child and how often the child falls ill were used to measure child health care while variables used to measure socio economic status (SES) include household size, household head education, occupation and religion. Listing of all the houses in the enumeration area in each of the study area was done and subsequently 25 houses were picked through systematic random sampling method. A household was selected from each house through lottery method and finally the head of the household (either male or female) was interviewed through self administered questionnaire. Significant association ($P<0.05$) between Household Head/ Household Size/SES measures and Child immunization status/ How often the child falls ill/ Where medical treatment was acquired for the child was investigated using Pearson Chi Square Tests. Results of this study revealed that the survival of the child is a function of good health care which is largely dependent on the headship of the household. Children from male headed households (MHH) are well and more vaccinated than those from female headed households (FHH).Household size is also a predictor of good child health care. The study showed that the smaller the household size, the better the child health care in terms of immunization and in getting adequate medical attention for the child when ill. Furthermore, SES measures such as occupation of household head and religion are significant predictors of child immunization and how often the child falls ill while education (another SES measure) is not. A child in MHH has a higher survival rate with regard to health care than those in FHH which suggests that women in FHH should be economically and financially empowered to enhance good child health care. Also, religion as an indicator of child health care shows the need for cooperation of religious leaders in enlightening their members of the importance of good child health care.

Keywords: Household Headship, Household Size, Socio Economic Status, Child Health, Immunization.

Introduction

In Nigeria, despite the intensifying efforts of the government to reduce infant mortality and mortality in under- five children, the problem has steadily been on the increase. One in seven children dies before his or her fifth birthday. It was reported by UNICEF (2000) that a baby born in a developing country is 30 times more likely to die before age five than one in an industrialized country. Child mortality in Nigeria is ranked 15th highest with one million children dying annually from preventable diseases and malnutrition. The child may be exposed to infectious and viral diseases such as malaria, diarrhoea and HIV/AIDS, poor household living conditions and malnutrition from household food security (Ogunjuyigbe *et al*, 2006; Bawah, 2001), thus, the household the child comes from play a great role in determining such child health care.

Household characteristics such as household headship and household size and their differences have been found to have great influence on the overall heath care of the child. (Wickrama and Keith, 1999). This is partly because the decision to use any health care services is made at the household level (Shareen Joshi, 2006; Aditi Iyer, 2005). These health care services pertaining to the child constantly take place in the form of seeking health care in the event of illness, child vaccination and general medical check-ups.

However, the effect of the sex of the household head on household health care attitudes has been debated. The head of the household plays an important role in deciding what type of medical attention is to be given to a household member who falls ill. The socio-economic and demographic characteristics of the household head may largely influence the overall health care of every member of the household, most especially that of the child. In African countries (as is the case in Nigeria), where men are mostly the head of households, the ability of other members of the household to seek health care in an event of illness could be restrained and sometimes denied completely, if the household head underestimates the seriousness of such illness and if health care must eventually be sought, permission must be granted to that effect.

Wickrama and Keith (1990) believed that female headed households are more likely than male-headed households to have a positive influence on health seeking behaviour of their household members, owing to the greater autonomy and decision-making power of the female and also because they are in control of household's resources, part of which could be devoted to seeking health services outside the home. Women are more likely to detect symptoms of illness in their children or in other family members through observation of changes in their body temperatures, playing or eating habits, physical appearance or emotional display composure (Kishuor and Neitzel, 1997; Momsem, 1991).

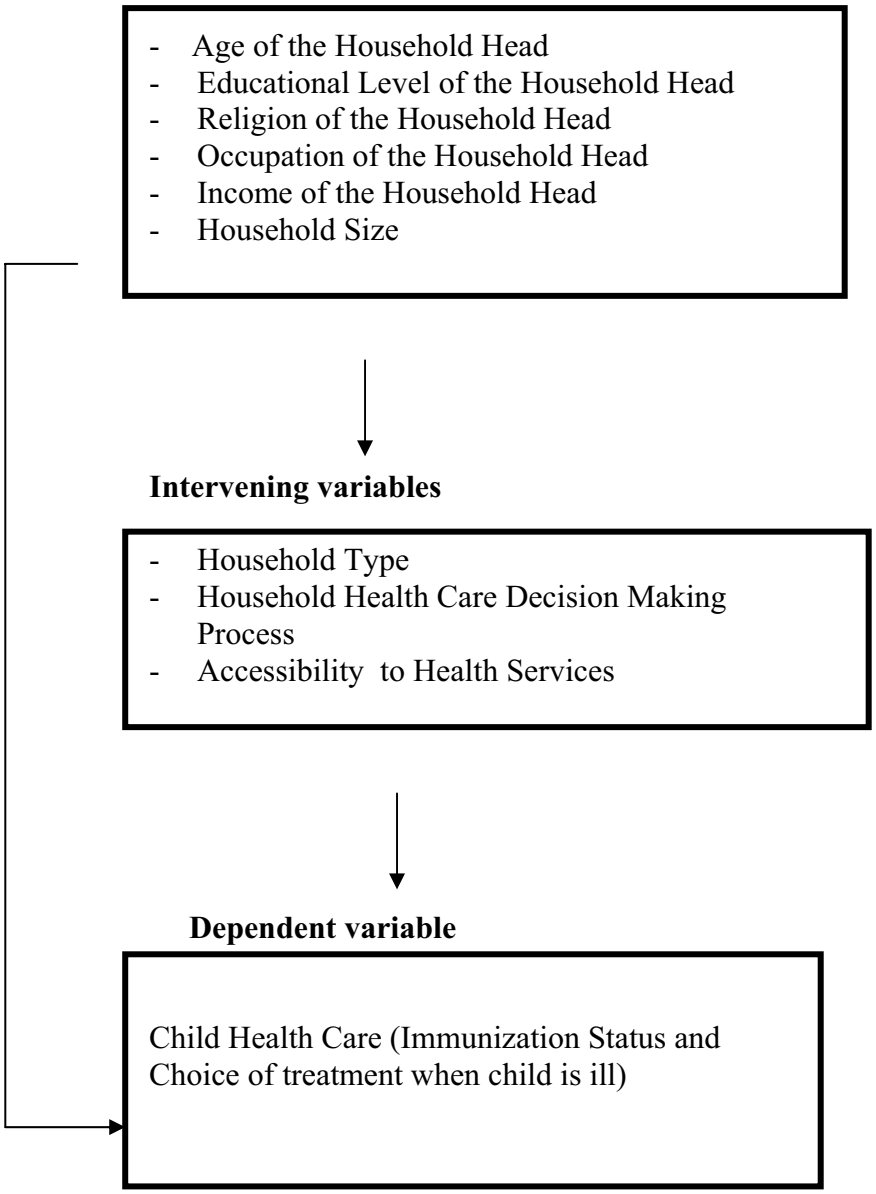
Furthermore, household size, an aspect of household composition, serves as a predisposing characteristic that has impact on child health. It has been shown that childhood survival or mortality greatly depends on the size of the household (Mannun'ebo *et al.*1994; Burstrom *et al.*, 1999). Children in larger families tend to use fewer services than their needs would indicate since there is the need to control household income. Farah and Preston (1982) cited by Bawah (2001) reported that larger households may have draining effect on the household's economic resources mainly because it has to be distributed among larger number of household members, thus having deleterious effects on children given the current economic situation in African countries.

On the basis of the above findings, the study hypothesized that: Socio-economic variables of the household head such as education and income is significantly related to well being of the child, child survival greatly depends on household size; and choice of health services has a direct relationship to child health care.

Methodology

The study was conducted in Akure South and Idanre Local Government Areas (LGAs) of Ondo State, Nigeria. The study areas were selected mainly to comprise a major urban area and a rural area. The choice of Akure and Idanre for this research work was because the two towns are heterogonous in nature, i.e., they have different categories of people of different backgrounds and beliefs. While Akure as the urban centre is rapidly developing, constituting many types of household among which are the single parent household, male/female headed household with other types of household, on the other hand, Idanre is fast losing its rural features due to its close proximity to Akure; but people in Idanre strongly believe in extended type of households partly due to the fact that majority of them are mainly farmers thus encouraging large households, with the presence of several in-laws and an elderly male as the head of the household.

Conceptual framework showing the relationship between household head socio economic variables and child health.



To determine the sample size, a health indicator was used, and the most important that was used in relation to this study is the vaccination of children. According to the 2003 Nigeria Demographic and Health Survey, the national rate of all the children who were vaccinated for the southwestern region (which includes Ondo-State) is 32.5%. After applying appropriate statistical formula, a total sample size of 400 was derived. Considering the issue of non-response which may arise from the study subjects, 10% of the actual sample size was allocated to the two areas altogether, totaling 440, out of which only 400 were found useful and analyzable after data cleaning and editing. A multi-stage sampling technique was used in the study to select the respondents. The first stage involved the selection of enumeration areas (EAs) which was done randomly from the National Population Commission's enumeration list of the two study areas. A total of 16 enumeration areas were selected. An enumeration area in this study comprises 25 houses each.

The second stage involved choosing of houses from each enumeration area, this was done through systematic random sampling method. A household was eventually picked from each house through lottery method. Consequently, an adult in the household be (either male or female) was interviewed. The instrument used in collecting data from respondents was questionnaire and the questions were both open ended and close ended. Analysis of the data was done at the univariate and bivariate levels. The three variables that were measured in the study were explanatory variables (independent variables), response variable (dependent variable) and intervening variables. The explanatory variables covered the socio economic and demographic characteristics of respondents such as their age, level of education, religion, occupation, level of income, household type, household size, household head while the response variable was basically the child health care which was measured by immunization status of the child and how often the child falls ill. The first level of univariate analysis gave the statistics of frequency distribution of respondents' socio economic and demographic characteristics. The second level revealed how bivariate analysis was done through cross tabulation to show the relationship that exists between the response and explanatory variables. Pearson Chi square test was used to test the significant association between the variables with $p<0.05$ significance level.

Results

Table 1 show that the highest proportion of respondents in both urban and rural areas in male headed households is found in age group 30-39 years (39.2%) while the least proportion of respondents is in age group 50 years and above (11.2%). On the other hand, in the two study areas, female headed households (FHH) have the highest proportion of respondents in ages 40-49 (42.6%) and the least proportion of respondents is found in age group 20 and 29 (11.1%). The overall mean and median age of the urban area is 38.5 and 38.0 respectively and that of the rural area is 36.4 and 35.0 respectively. Majority of the respondents obtained a higher level of education in the two study areas, both in male headed household (MHH) (79.7%) and female headed households (72.2%).

Furthermore, respondents who are farmers are more in FHH in the two study areas (25.9%) than in MHH (9.8%). However, almost the same proportion of respondents is into trading in MHH (42.0%) and FHH (42.6%) in the two study areas. More than three quarters of respondents in both study areas and in both male and female headed households are Christians, while others are Muslims. There are more Muslim respondents in FHH in both urban and rural areas (14.8%) than in MHH (8.7%). Table 4 further shows that, all the respondents in MHH in the urban and rural areas are married (100.0%), while only 16.7% of FHH respondents in the two areas are married. A large proportion of respondents from FHH in both study areas are divorced or separated (38.9%) and widowed (37.0%).

Respondents in FHH have larger household size of 1-4 and 5-8 in both study areas (48.1%) than their counterparts in MHH. In Akure, the mean household size is 1.64, while that of male headed and female headed households are 1.67 and 1.44 respectively. Relatively, the mean household size in Idanre is 1.58, while that of male headed and female headed households are 1.54 and 1.72 respectively.

Table 1: Percentage distribution of respondents' demographic and socio- economic characteristics by household headship

AGE GROUP	MALE HEADED			FEMALE HEADED		
	URBAN (%)	RURAL (%)	TOTAL (%)	URBAN (%)	RURAL (%)	TOTAL (%)
20-29	18.4	25.6	20.6	10.3	12.0	11.1
30-39	38.3	41.1	39.2	27.6	36.0	31.5
40-49	30.1	26.6	29.0	48.3	36.0	42.6
50+	13.3	6.7	11.2	13.8	16.0	14.8

Total	100.0	100.0	100.0	100.0	100.0	100.0
Mean Age	**38.2**	**35.6**		**40.7**	**39.2**	
LEVEL OF EDUCATION						
Low	25.0	10.0	20.3	27.6	28.0	27.8
High	75.0	90.0	79.7	72.4	72.0	72.2
OCCUPATION						
Farming	10.2	8.9	9.8	20.7	32.0	25.9
Civil Servant	48.5	47.8	48.3	37.9	24.0	31.5
Traders	41.3	43.3	42.0	41.4	44.0	42.6
RELIGION						
Christian	86.7	90.0	87.8	82.8	72.0	77.8
Muslim	10.2	5.6	8.7	10.3	20.0	14.8
Traditional& Others	3.1	4.4	3.5	6.9	8.0	7.4
Marital Status						
Single	0.5	0.0	0.3	10.3	4.0	7.4
Married	99.5	100.0	99.7	13.8	20.0	16.7
Divorced/ Separated	0.0	0.0	0.0	34.5	44.0	38.9
Widowed	0.0	0.0	0.0	41.4	32.0	37.0
Household Size						
1 – 4	43.9	54.4	47.2	55.2	40.0	48.1
5 – 8	46.4	37.8	43.7	44.8	52.0	48.1
9 – 10	7.7	6.7	7.3	0.0	4.0	1.9
11+	2.0	1.1	1.7	0.0	4.0	1.9
Mean Household Size	**1.67**	**1.54**		**1.44**	**1.72**	

SOURCE: Author's field survey.2006

Note:
Level of Education is denoted as: Low – 'No education' and 'Completed Primary education' and .High – 'Completed Secondary education' and 'Tertiary education'.

Table 2 presents distributions of respondents according to their health care seeking behaviour with respect to the child which is measured by use of health care, child vaccination, occurrence of child's illness in the past three months prior to the survey and choice of health care sought when child was ill by household heads. Other measures of health care included in the table are accessibility, how accessible is the health facility and to know if they faced financial difficulty in accessing health care. Respondents in male headed households used health care services than those in female headed households in both study areas while respondents in female headed households in the rural area used medical care than their counterparts in the urban area.

Data further reveal that a child in FHH in the urban area (62.1%) fell ill more than those in the rural area (48.0%). Across all households in both study areas, majority of the respondents vaccinated their children against infectious diseases but large percentages (28.0%) of children in FHH the rural area were not vaccinated. Majority of the respondents in MHH in the two study areas opted for modern health care when their child fell ill while 32.0 percent of FHH respondents opted for traditional herbs (32.0%) and self medication (24.0%) as a means of treating their children in the event of illness. Also, the data provide information on respondents' accessibility to health care services; the percentage distribution showed that in both study areas, majority of respondents had good access to health care facility. However, a significant percentage of respondents in FHH in the urban study area (20.7%) and rural area (28.0%) found health care facility not accessible. Finally, some respondents in the rural area faced

financial difficulty in raising money needed to provide health care services for their child/children both in MHH (17.8%) and in FHH (24.0%).

Table 3 presents the cross tabulation of proxy variables for health care seeking behaviour and some selected socio-economic variables by household headship. The health care proxy variables reflect how good the health care provided for the child is, child vaccination and where medical treatment was acquired for the child when the need arises. It also includes accessibility to health care facility and financial difficulty in obtaining adequate health care of the child. The respondents in male and female headed households with low education recorded the lowest percentage of child vaccination (19.1% and 31%, respectively) showing significance level of $p<0.003$ and $p<0.000$ respectively for male headed and female headed households .

The provision of good health care for the child depends greatly on where treatments are being acquired for the child in the event of illness. A large percentage of respondents with higher educational level in male headed (70.6%) and female headed (63.6%) households indulged in self medication as a means of treatment rather than to go to a modern health care centre. Christians in male headed and female headed households were more likely than those with other religions to vaccinate their children and use modern health care centre. Occupation was a significant predictor of child vaccination in male headed as well as female headed households with p value of $p<0.000$ and $p<0.02$ respectively. Household size was found to be positively and significantly correlated with child vaccination across all households; this implies that the smaller the household size, the better the quality of health care that will be provided for the child. It is revealed also that children from households where health care services are found accessible are likely to be healthy and have a higher chance of survival than those from households where health cares services are not accessible

Table 2: Percentage distributions of respondents selected health variables by household head

SELECTED HEALTH VARIABLES	AKURE		IDANRE	
	MHH	FHH	MHH	FHH
Use of Health Care				
Yes	95.4	82.8	94.4	76.0
No	4.6	17.2	5.6	24.0
Child Vaccination				
Yes	98.0	82.8	95.6	72.0
No	2.0	17.2	4.4	28.0
Has Child Been Ill in the last 3months				
Yes	50.5	62.1	41.1	48.0
No	49.5	37.9	58.9	52.0
Choice of treatment when child was Ill				
Modern	85.2	72.4	90.0	44.0
Traditional	8.7	10.3	4.4	32.0
Self Medication	6.1	17.2	5.6	24.0
Accessibility to Health Care Services				
Yes	88.3	75.9	94.4	88.0
No	11.7	24.1	5.6	12.0
How Accessible				
Very Accessible	62.8	58.6	76.7	48.0
Somewhat Accessible	22.4	20.7	23.3	24.0
Not Accessible	14.8	20.7	0.0	28.0
Financial difficulty in using health care services				
Big Problem				
Small Problem	5.6	6.9	17.8	24.0
No Problem	14.8	37.9	17.8	28.0
	79.6	55.2	74.4	48.0

SOURCE: Author's field survey.2006

Table 3: Cross tabulation of proxy variables for health care and some selected socio-economic and demographic variables by household headship.

VARIABLES	MALE HEADED					FEMALE HEADED				
	CHILD VACCINATION		CHOICE OF TREATMENT WHEN CHILD IS ILL			CHILD VACCINATION		CHOICE OF TREATMENT WHEN CHILD IS ILL		
	YES	NO	MOD.	TRAD	SELF MED	YES	NO	MOD.	TRAD	SELF MED
Education	P<0.003		P<0.3			P<0.000		P<0.6		
Low	19.1	62.5	16.9	52.4	29.4	31.0	16.7	28.1	18.2	36.4
High	80.9	37.5	83.1	47.6	70.6	69.0	83.3	71.9	81.8	63.6
Religion	P<0.3		P<0.4			P<0.000		P<0.04		
Christian	87.8	87.5	89.1	76.2	82.4	85.7	50.0	87.5	54.5	72.7
Muslim	9.0	0.0	8.1	14.3	11.8	14.3	16.7	12.5	18.2	18.2
Traditional& Others	3.2	12.5	2.8	9.5	5.9	0.0	33.3	0.0	27.3	9.1
Occupation	P<0.000		P<0.2			P<0.02		P<0.8		
Farming	8.6	50.0	8.5	19.0	17.6	23.8	33.3	25.0	18.2	36.4
Civil Servant	49.3	12.5	48.4	38.1	58.8	23.8	58.3	28.1	45.5	27.3
Traders	42.1	37.5	43.1	42.9	23.5	52.4	8.3	46.9	36.4	36.4
Income Earnings	P<0.03		P<0.1			P<0.5		P<0.5		
Low	32.7	75.0	31.0	57.1	47.1	31.0	25.0	25.0	27.3	45.5
Medium	32.7	25.0	33.5	23.8	29.4	42.9	33.3	46.9	45.5	18.2
High	34.5	0.0	35.5	19.0	23.5	26.2	41.7	28.1	27.3	36.4
Household Size	P<0.04		P<0.00			P<0.001		P<0.03		
1-4	47.8	25.0	46.4	61.9	41.2	50.0	41.7	56.3	18.2	54.5
5-8	43.2	62.5	45.6	19.0	47.1	47.6	50.0	37.5	81.8	45.5
9-10	7.2	12.5	6.5	19.0	5.9	0.0	8.3	3.1	0.0	0.0
11+	1.8	0.0	1.6	0.0	5.9	2.4	0.0	3.1	0.0	0.0
Access to H. C	P<0.01		P<0.1			P<0.01		P<0.2		
Yes	91.0	62.5	91.5	95.2	64.7	85.7	66.7	84.4	63.6	90.9
No	9.0	37.5	75.0	3.6	21.4	14.3	33.3	15.6	36.4	9.1

SOURCE: Author's field survey.2006

NOTES: Note that the choice of treatment when child is ill is denoted by Modern, Traditional and Self medication.

Low Income signifies income less than 5000; Medium Income means income between 5001 and 10000; while High Income refers to income 10001 and above.

Recommendation:

From the results of this study, it is recommended that parents should be more enlightened on the importance of engaging the services of qualified medical experts for their child(ren) rather than rely on home based treatments through self medication which could lead to severe health complications resulting from wrong prescription and dosage of drugs . Also, people should be sensitized more on the importance of immunization, as the study revealed some children in female headed households in the rural area are yet to be immunized. Lastly, health care services should be made more accessible with respect to affordability and the cost of acquiring modern health care services from government and private hospitals should be lessened because a large percentage of respondents in female headed households confirmed that they had a big problem in getting money needed to seek health care.

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Gender analysis of the knowledge, attitude and practice of HIV/AIDS preventive strategies among the youth in Nigerian farming communities

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Abstract
The study was designed to examine the gender differences in the youth's knowledge of, attitudes towards, and practice of HIV/AIDS preventive strategies in farming communities in Nigeria with the aim of inferring implications on agricultural development. The target group was youth between the ages of 13 and 30 years in the farming communities of Nigeria who were randomly selected on equal gender (100 sample size/ethnic group) based on the three major ethnic groups (Hausa, Yoruba, and Ibo) in Nigerian farming communities. The youths were interviewed by using structured questionnaire duly pre-tested before use. Majority of both male and female youth had knowledge of the HIV/AIDS preventive strategies such as total abstinence, safe sex, condom use, avoiding untested blood transfusion and use of sharp objects, while Sero-Status was not a popular preventive strategy among them. There was no significant difference in the male and female youth's knowledge (F=1.09; P=0.30), and practice (F=1.65; P=0.20) of the HIV/AIDS preventive strategies in Nigeria. However, there was a significant gender gap in youth's level of attitude (F=3.36; P=0.07) towards the HIV/AIDS preventive strategies at 0.10 level of significance. There was a strong association between the gender of the youth and; their knowledge about safe sex (P=0.00), condom use (P=0.00), avoidance of sex (P=0.05), sero-status check (P=0.04); their attitude towards avoiding sex (P=0.02); their practice of condom use (P=0.04) at 0.05 level of significance. The alarming rate of HIV/AIDS prevalence among Nigerian youth despite all the available preventive strategies is a product of the revealed gender gap in their attitude and practice of these strategies, thereby suggesting the need to introduce gender sensitive strategies to cub the menace of this social phenomenon in Nigeria. Failure to take this drastic step has negative implication on agricultural development in Nigeria because youth are the future prospective stakeholders in agriculture.

Keywords: Gender, HIV/AIDS, Preventive, Youth, Farming-communities

Introduction

The predominant labor-intensive system of agriculture practiced in Nigeria is responsible for the traditional use of children and youth as source of cheap labor for many agricultural practices. Equally germane, is the value placed on number of children possessed by an individual as a measure of prestige in the society. The rural – urban drift of youth for better living standard is negatively imparting on agricultural production in Nigeria, by reducing the major manpower employed in most agricultural production activities. The recent HIV/AIDS epidemic is aggravating the problem due to its high prevalence among the youth, majority of which live in major farming communities in Nigeria. Youth are the majority of the people living with HIV/AIDS in Nigeria (UNAIDS, 2004; Desalu, 2003;; Medlink, 2004). HIV is prevalent among the Nigerian youth of ages 15 – 24; out of which 4.4 to 5.9 percent were females and 1.7 – 3.3 present were males (Ashford, 2003; UNAIDS, 2000). Gender variation in the prevalence of HIV/AIDS is more predominant in the developing countries with traditional gender inequality, such as Nigeria. Afro (2001) submitted that strategies that are developed to address youth as homogenous group are inefficient. Youth are also believed to be social and economically independent, hence vulnerable to unfavourable conditions . Some of the common preventive strategies for HIV/AIDS includes total abstinence from sexual intercourse, condom use, sero status check (Mann*et al*., 1996; Berelson *et al.,* 2005; Rugalema, 2000), (Sabine *et al*., 2000); safe sex (Avert, 2005; Fhi, 2003); blood transfusion and in treated sharp objects (ACP, 2006). HIV/AIDS prevalence is gender specific and detrimental to Agricultural production. (Piwoz,2000)

Several strategies have been advocated and disseminated to reduce HIV/AIDS prevalence in Nigeria. These strategies include: total abstinence from sex ,condom use (Mann *et al*., 1996), safe sex (FMH, 2006), Sero status check (Sabine *et al*., 2000), avoiding sharing of sharp objects (FAO, 2000) and untreated blood transfusion.

Literature Review and Theoretical Framework:

HIV/AIDS prevalence among youth, especially in Sub-Saharan Africa, has been amazing point in every data on HIV/AIDS. This is not unconnected with the usual high risk and sexual behaviour that characterizes this age group. Medilinks (2004) reported that Nigerian youth account for over 30% of all HIV/AIDS cases in the nation. Desalu (2003) submitted that Nigerian youth have a prevalence rate of HIV/AIDS of 10%. In the same view, Nigeria has the lowest in Sub-Saharan Africa, but second highest cares among youth with about 838,000 – 1.3 million cases (UNAIDS, 2004.) UNAIDS (2004) projected that AIDS cases will increase from 250,000 in 2000 to 360,000 by 2010, with youth likely to be in the majority. UNESCO (2005) defined youth as age group between 15 – 24 years. Some other researchers employed factors such as behaviour, level of responsibility, attitude, status, and level of vulnerability to social and economic conditions to identify youth in the society. This concept of youth categorization was built on the notion that youth are usually less matured in behaviour and attitude, as well as reaction to situation than the adults. HIV/AIDS prevalence is impacting negatively on agricultural production in Nigeria, because of the reliance on child labour (Piwoz and Preble, 2000).

Effective preventive strategies involve awareness creation, which may result to general knowledge, positive attitude, and persistent practice of such strategies. The significance of preventive strategies in curbing the spread of HIV/AIDS was asserted in a report of an International AIDS conference, which states that if prevention effort is not expended, there will be 45 million new HIV infections by 2010, while 29 million of these could be prevented with the expansion of existing preventive strategies. The corner stone of successful primary preventive medicine programme include three main areas, viz: concentration period of health examination; period of immunization, and health counseling period. This highlights the focus of the major preventive strategies to HIV/AIDS prevalence in Nigeria: serostatus checks, total abstinence from sex, safe sex, condom use, avoiding untreated blood transfusion, avoiding sharing of sharp object.

The prevalence of HIV/AIDs has been traced to the behavioural pattern of the people within the society and is now considered a serious health issue. Hence, the theoretical background to this study is based on health believe theory. Health belief theory postulated to explain how behaviour and value expectancy of an individual is associated to the health status of such an individual. Universiteit Twente (2004) summarized health belief theory *inter alia*: "a person's health – related behaviour depends on the person's perception of four critical areas, such as the severity of a potential illness, the person susceptibility to that illness, the benefit of taking the preventive action, and the barriers to taking the action."

HIV/AIDS is gender specific, hence the importance of gender analysis in studying HIV/AIDS in order to identify gender – related factors that influence the youths knowledge, attitude, and practice of preventive strategies becomes imperative. The first case of AIDS was reported in Lagos in 1986 from the diagnosis of a 1.3 year – old girl. The prevalence grew steadily to 1.8 percent in 1992; 4.5 percent in 1994; 4.5 percent in 1996; 5.4 percent in 1999 (Desalu, 2003). The highest prevalence of 7.0 was recorded in

the North central region of Nigeria in 2003 (Federal Ministry of Health, 2003). HIV/AIDS prevalence is at an alarming rate all over the states in Nigeria nowadays, with youth being the majority of the victims.

Research Methodology

Nigeria is a multi-ethnic nation with different cultural norms and values. This study covered all the three major ethnic groups in Nigeria: Hausa, Yoruba, and Ibo. Youth in these three ethnic groups in Nigerian farming communities formed the population the population. One hundred youth, in equal gender proportion, were randomly selected and interviewed from each of the three ethnic groups resulting in a total of three hundred youth in equal gender proportion using structured questionnaire. Data collected was subjected to both simple and inferential statistical analysis.

Results and Discussion

Data in Table 1a show that majority of the male and female youth were aware of the preventive strategies such as; total abstinence (85.3%, 89.3%), safe sex (70.7%, 88.7%), and condom use (77.3%, 93.3%), respectively. Results also showed that sero-status checks was the least popular strategy, with 60.7 percent of male and 48.7 percent female indicating their lack of awareness of the preventive strategy. There was a high level of awareness about the HIV/AIDS preventive strategies among the male and female Nigerian youth in the faming communities, with sero-status check as the least popular preventive strategy. Lack of awareness of the HIV/AIDS preventive strategies might not be one of the major factors influencing the high prevalence of HIV/AIDS among the Nigerian youth in the farming communities. However, regular enlightenment campaign via modern information and communication technologies (ICT) about these preventive strategies are still recommended for continuous awareness which could enhance the adoption of these strategies among the Nigerian youth, hence contributing to the prevention of the spread of the social menace in Nigeria.

Table 1a: Percentage Distribution Of The Respondents By Their Knowledge About The HIV/AIDS Preventive Strategy.

	Male		Female	
	No	Yes	No	Yes
Total Abstinence(TA)	14.7	85.3	10.7	89.3
Safe Sex (SS)	29.3	70.7	11.3	88.7
Condom Use (CU)	22.7	77.3	6.7	93.3
Avoiding Untested Blood Transfusion (AU)				
Avoiding Sharing Sharp Objects (AS)	53.3	46.7	42.7	57.3
Sero-Status check (SC)	55.3	44.7	44.0	56.0
	60.7	39.3	48.7	51.3

Table 1b: Percentage Distribution of the Attitude of the respondents Towards The Effectiveness Of The HIV/AIDS Preventive Strategies

	Strongly Disagree		Disagree		Undecided		Agree		Strongly Agree	
	M	F	M	F	M	F	M	F	M	F
TA	2.7	2.0	2.7	2.0	48.7	52.7	26.7	30.7	19.3	12.7
SS	1.3	0	1.3	3.3	54.7	54.7	25.3	30.7	17.3	11.3
CU	0.7	0	1.3	0.7	60.0	60.7	28.7	30.0	9.3	8.7
AU	0	0	0.7	2.9	56.0	61.3	27.3	24.0	16.0	12.7
AS	0	0	2.0	5.3	62.7	67.3	22.7	22.0	12.7	5.3
SC	0	0	0.7	2.0	66.7	80.7	24.7	14.0	8.0	3.3

Table 1b shows that majority of both the male and female Nigerian youth are undecided about the effectiveness of the HIV/AIDS preventive strategies. However, very few males and females (2.7% and 2.0%, respectively) disagreed that total abstinence is an effective strategy of preventing HIV/AIDS infection, while none of the youth disagreed with the effectiveness of avoidance of untested blood transfusion, avoidance of sharp objects, and sero-status checks as effective strategies for preventing HIV/AIDS infection. Very few male youth (1.3 % and 0.7 %) and none of the female youth strongly disagreed with the fact that safe sex and condom use respectively could prevent HIV/AIDS infection. There was a general high level of reservation about perception on the effectiveness of the HIV/AIDS preventive strategies among the male and female youth as majority of them were undecided.

Table 2: Percentage Distribution Of Respondents By Level Of Practice Of HIV/AIDS Preventive Strategies

	Not at all		Less		Rarely		Often		Very often	
	M	F	M	F	M	F	M	F	M	F
TA	30.7	34.0	11.3	6.7	9.3	4.0	10.7	8.0	38.0	47.3
SS	42.0	56.0	8.7	9.3	6.0	4.0	15.3	7.3	28.0	23.3

CU	49.3	64.0	6.7	4.0	4.7	7.3	15.3	8.7	24.0	16.0
AU	36.7	38.7	8.7	6.7	6.7	8.7	14.5	14.5	38.0	36.7
AS	31.3	36.7	8.0	2.7	7.3	8.0	17.3	10.7	36.0	42.0
SC	39.3	48.0	10.7	4.0	8.0	8.7	12.7	10.7	29.3	28.7

As shown in Table 2, more female compared to male practice total abstinence (30.7%, 34.0%), safe sex (42.0%, 56.0%), condom use (49.3%, 64.0%), avoidance of untested blood transfusion (36.7%, 38.7%), avoidance of sharp object (31.3%, 36. 7%), sero status checks (39.3%, 48.0%) respectively as strategies for preventing HIV/AIDS infection in the Nigerian farming communities. In contrast, preventive strategies like safe sex (28.0%, 23.3%); condom use (24.0%, 16.0%); and avoidance of untested blood transfusion (29.3%, 28.7 %%) were more common among the male than the female youth in the farming communities of Nigeria.

Table 3: Analysis of variance (ANOVA) in the male and female youth knowledge, attitude, and practice of the HIV/AIDS preventive strategies.

Variables	**F**	**Significance**
Knowledge about the preventive strategies	1.09	0.30
Attitude towards the preventive strategies	3.364	0.07**
Practice of the preventive strategies	1.650	0.20

** Significant at 0.10

There was a significant difference in the male and female youth's attitude toward the HIV/AIDS preventive strategies ($P< 0.10$) as shown in Table 3.. This implies that there was a significant gender gap in the attitude of the male and female youth towards the HIV/AIDS preventive strategies. Hence gender specific program will be required to enhance the positive attitudes of the Nigerian youth in the farming communities for effective eradication of HIV/AIDS pandemic in Nigeria.

Table 4: Chi-square test of the association between the respondents' knowledge, attitudes and practice and each of the HIV/AIDS preventive strategies.

Preventive Strategies	Knowledge	Attitudes	Practice
TA	0.298	0.554	0.117
SS	0.000*	0.204	0.075
CU	0.000*	0.840	0.042*
AU	0.064	0.518	0.920
AS	0.050*	0.071	0.101
SC	0.037*	0.016*	0.189

* Significant at 005 level of significance

Significant associations between the gender of the Nigerian youth and their knowledge about safe sex, condom use, avoidance of sharp objects, and sero status checks as HIV/AIDS preventive strategies ($P< 0.05$) are shown in Table 4. In addition there was a significant association between the gender of the youth and their attitudes toward sero status check as an HIV/AIDS preventive strategy in Nigerian farming communities ($P< 0.05$). Likewise, the data in Table 5 show that there was a significant association between the gender of the youth and their practice of condom use as a strategy for preventing HIV/AIDS infection ($P< 0.05$).

Conclusion and Recommendations

The study concludes that:

i. There was a popular knowledge about all the HIV/AIDS preventive strategies except the sero status check among the male and female youth in the farming communities in Nigeria.

ii. Most of the male and female youth were undecided in their attitudes toward the effectiveness of each of the HIV/AIDS preventive strategies.

iii. Lesser male youth than females were not practicing each of the HIV/AIDS preventive strategies.

iv. There was a significant difference between male and female youth attitudes toward the effectiveness of the HIV/AIDS preventive strategies.

v. There were significant association between the gender of Nigerian youth and their knowledge about safe sex, condom use, avoidance of sharp objects, and sero status check as HIV/AIDS preventive strategies.

vi. There was a strong association between the gender of the Nigerian youth and their attitudes toward sero status, as well as their practice of condom use as HIV/AIDS preventive strategies.

It is recommended that gender sensitive strategies should be employed in educating the Nigerian youth on the effectiveness of the HIV/AIDS preventive strategies so as to alleviate the spread of the epidemic among the Nigerian youth. This is necessary in order to forestall the future negative impact of HIV/AIDS on Nigerian agricultural development, since youth are the potential leaders of tomorrow and future prospective stakeholders in agriculture.

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Farm Youth and Usage of HIV/AIDS Prevention Strategies: Implication for Food Security in Nigeria

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Abstract
Sequel to the reported mutually reinforcing linkages existing among HIV/AIDS infection, depletion of agricultural labour and food insecurity in agrarian communities, this study investigated the usage of HIV/AIDS prevention strategies among the Nigeria's farm youth with a view to drawing its implications for food security. Specifically, it examined the youth's knowledge about HIV/AIDS vis-à-vis mode of transmission; determined their perception about its prevention strategies; categorised the type of prevention strategies available in the study area; and identified the determinants of its usage. A set of pre-tested interview schedule was used to source information from 120 respondents between the ages of 15 and 24 years randomly selected from eighteen worse hit communities. Results showed, among others, that higher percentage of respondents had wrong notion about HIV/AIDS mode of transmission and prevention. Also, the study revealed that at $p \leq 0.01$level of significance, knowledge score (b = 0.523), level of awareness (b = 0.503), perceptional score (b = 0.516), income (b = 0.492), number of sources of information (b = 0.314), and age (b = 0.198) explained 79.0 percent ($R^2 = 0.790$) of the total variation in farm youth usage of prevention strategies. But then, only HIV/AIDS prevention strategies that focus typically on changing sexual behavioural outcomes were the most common among the respondents. Therefore, it concluded that high incidence of HIV/AIDS infection, depletion of agricultural labour and food insecurity among others, which HIV/AIDS has bequeathed upon sub-Saharan Africa, would continue except the present individual based HIV/AIDS prevention strategies are complemented with interventions that would address some of the prevailing cultural and structural dynamics associated with the spread of HIV.

Keywords: Farm Youth, HIV/AIDS, Prevention Strategies, Food Security.

Introduction

Nigerian food situation for mass consumption is precarious! A fairly large proportion of people in Nigeria, as never before, have become hungry and live in a state of permanent food shortage, starvation and malnutrition (Torimiro *et al.*, 2008). Moreover, some women have thrown their children into dustbins due to their inability to feed them, whilst a perceptible number of Nigerians are physically and mentally sick as a result of insufficient food supply (Oyenuga 1991 and Torimiro *et al.*, 2008). Worse still, the depletion of agricultural labour that underpinned the food crisis in Nigeria has assumed a dangerous dimension (Ajayi *et al*., 2008 and Torimiro *et al.,* 2008). While the loss of agricultural labour through rural-urban migration is not a child of recent birth, the scourge of HIV/AIDS, which claims farm income, land, farmer and labourer is a new disaster plaguing Nigeria's agricultural sector. In line with this view, Gillespie and Haddad (2002) wrote that though rural-urban migration of youth and climate change have been reducing food production, HIV/AIDS remains the most dangerous and recent threat to food security in sub-Saharan Africa.

The mutually reinforcing linkages existing among HIV/AIDS infection, depletion of agricultural labour and food insecurity waxes stronger daily because AIDS pandemic is multidimensional, long-term, and phased phenomenon. The pandemic begins with HIV infection, followed by opportunistic infections, and later by AIDS illness and death (Gillespie and Kadiyala, 2005). In other words, when an individual becomes infected with HIV, the progression of the disease and the person's worsening nutritional status occasioned by food insecurity reinforces each other in a downward spiral that ends in death. The consequent loss of an individual member of a farm family, most especially the adult usually triggers a chain of events that poses a seemingly insurmountable challenge to food security both at the microcosm and macrocosm

Arguably, the long-wave, intergenerational nature of AIDS pandemic is already lurking at Nigeria's agricultural sector because agricultural labourers and women formed the majority of the 400,000 lives, which HIV/AIDS claimed in Nigeria in 2007 (NACA, 2008). Farm youth , that is, individuals between the ages of 13 and 30 years, constitute the bulk of agricultural labour (Torimiro *et al*., 2008), which has come under the great threat of HIV/AIDS. This category of individuals represents the flower of manhood of agricultural sector; the bridge between its present and future. But then, adventurous sexual behaviour and ignorance have made the youth more susceptible to HIV/AIDS than any other category of agricultural workers. For instance, Torimiro *et al*. (2007) posited that despite the alarming rate of HIV infection reported among Nigerian youth, only a few are aware of their infection. Also, majority of farm youth dwell in rural area, where some cultural practices that enhance the thriving of HIV/AIDS still hold sway. In essence, the contribution of farm youth to food production, processing and security is being undermined by HIV/AIDS, which has penetrated the sexual network and cultural practices wherein the youth are actively involved.

This invariably, underscores the need for putting in place appropriate prevention strategies. In this regard, Koop (2004) opined that preventive medicine is an investment to be leveraged rather than a cost to be justified. In essence, the cost of preventing a disease compared to that of its cure, or the consequences of otherwise, can never be too high. The resources required for creating and implementing effective HIV/AIDS prevention programmes are substantial, yet they are cost effective relative to the cost of managing HIV/AIDS infection and the opportunity cost when a farm youth becomes unable to contribute to the family as a result of the illness or eventual death. Block (2004) reported that except the prevention effort is expended, there will be 45 million new HIV/AIDS infection by 2010, with sub-Saharan Africa and Asia, being the worst hit.

Over the past two decades, when the first of case of HIV infection was reported in Nigeria, prevention effort has been geared towards individual based preventive interventions. It concerns with changing behavioural outcome rather than changing the mould that produces the out come. Individual based or behaviuoral interventions deal with individuals, one by one. It adopts the view of behaviour as personally motivated or resulting exclusively from a person's conscious decisions. Even so, the Nigeria's grim statistics on HIV/AIDS remains the same. This may be due to an overwhelming focus of interventions on changing individual behavior rather than changing norms, values, and power relations that reproduce and perpetuate risky behaviours through collective systems of meaning. In other words, the emphasis was on changing the individuals within their sexual networks and cultural practices rather than changing their economic and socio-politico-cultural milieu. Also, individual based preventive interventions often require a lot of staff, time and reach a limited number of persons. Furthermore, individuals who do receive interventions (like abstinence from sex, be faithful to one partner, use condom - ABC, among others) may face pressures to continue high-risk behaviours from their peers who do not receive the interventions. Finally, little is known about their long-term impact (Blankenship *et al.*, 2006). These have made the integration of structural, cultural and individual based preventive interventions desirable.

Structural interventions are defined as interventions that work by altering the context within which health is produced or reproduced in the social, economic, and political environments that shape and constrain individual, community and societal health outcomes (Blankenship *et al*., 2000). Cultural interventions are a subset of structural interventions addressing social systems of meaning. For instance, gender based cultural interventions seek to transform social constructions of masculinity and femininity and

the unequal distribution of power implicit in their definitions (WHO, 2003). Structural interventions are governed by the assumption that they locate, often implicitly, the cause of public health problems in contextual or environmental factors that influence risky behaviour, rather than in characteristics of individuals who engage in risky behaviours (Blankenship *et al*., 2006). Hence, they address the origin of HIV risk from a broader perspective and are not limited to an individual's psychology which requires persuasion to change behaviour (Parker, 2001). They may relate to economic, social, policy, organisational or other aspects of the environment (Sumartojo, 2000). Of significance is that they include interventions that may not be obviously associated with HIV risk, but still may influence it. Arguably, harmonious integration of structural, cultural and individual based interventions may engender a remarkable impact on sub-Saharan Africa where the battle to promote food security, adolescent sexual and reproductive health continues to rage but with very little evidence of victory (Blankenship *et al*., 2006).

But then, the positive effect of the integration appears to be mediated by several critical factors including human and non human resources. Also, while researchers have begun to incorporate structural and cultural arguments into theories on the spread of HIV, it is not clear if interventions have taken note of this development, most especially in Nigeria. Moreover, while some efforts have been made toward unraveling the inverse relationship between HIV infection and availability of labour in some sectors, little is still known about the nexus between farm youth's usage of preventive strategies and food security in Nigeria.

The foregoing, therefore, informed this study which investigated the usage of HIVV/AIDS prevention strategies among the Nigeria's farm youth with a view to drawing its implications for food security. Specifically, it examined farm youth's knowledge about HIV/AIDS vis-à-vis mode of transmission; categorised the type of prevention strategies; determined their perception about the prevention strategies; and identified the determinants of its usage.

Conceptual framework

Food security remains the greatest form of security on earth! In fact, the wellbeing of any nation does not lie in its military intelligence and prowess but in the food and nutrition security of its citizenry. Food security, which is contextually considered as the physical and economic access to food of sufficient quality and quantity, and nutrition security which is referred to as food security coupled with a sanitary environment, adequate health services and adequate care to ensure a healthy life, provide good lens through which the progress of a given social system can be mirrored. In line with this view, Gillespie and Haddad (2002) wrote that it is not coincidence that the maps of HIV/AIDS prevalence and malnutrition overlap. This invariably reflects the nexus among food insecurity, malnutrition and HIV/AIDS infection. Gillespie and Kadiyala (2005) posited that not only does HIV/AIDS precipitate and exacerbate food and nutrition insecurity, but the spread of the virus is accelerated when people –because of their worsening poverty – are forced to adopt ever more risky food provisioning strategies. For instance, a religious leader in Malawi as quoted by Bryceson *et al*. (2004) remarked thus, *In fact, it is hunger that is leading to the rise in HIV infections in this area.*

Indeed, the HIV/AIDS pandemic in sub-Saharan Africa has become increasingly intertwined with issues of food and nutrition. On the one hand, malnutrition and food insecurity may force households to adopt livelihoods that heighten the risk of HIV/AIDS infection, such as transactional sex. Food insecurity also, enhances mother-to-child HIV/AIDS infection (Gillespie and Kadiyala, 2005). On the other hand, HIV/AIDS may exacerbate malnutrition and food insecurity by depletion of agricultural labour;

disruption of domestic-productive labour interface –diverting to caring for persons with AIDS; depletion of asset base; and loss of agricultural knowledge, skill and practice (Topouuzis, 2003). Hence, Gillespie and Kadiyala (2005) reported that breaking the vicious cycle between food insecurity and HIV/AIDS infection would change the grim statistics of sub-Saharan Africa, where the battle to promote higher standard of living, adolescent sexual and reproductive health continues to rage but with a very little evidence of victory. Accordingly, the thesis of this study is that breaking the mutually reinforcing linkage between food insecurity and HIV/AIDS infection requires integrated prevention strategy, which transcends individual based interventions (ABC) but also embraces structural and cultural. This is because cultural and structural forces shape vulnerability to HIV. For instance, modern marriage in Nigeria, despite its appearance of greater equality, places many women in positions in which they cannot easily confront their husbands about infidelity or protect themselves from possible HIV infection. So, in Nigeria, married women's greatest risk of contracting HIV is through sexual intercourse with their husbands (Smith, 2007).

Structural interventions, however, change economic and socio- politico-cultural environments in ways that help many people either married or single, all at once — perhaps without their even knowing it, to protect selves from being infected (Friedman and McKnight, 2003). Structural interventions may contribute to change that is longer lasting (Blankenship *et al*., 2006). The individual based interventions are prevention strategies that focus typically on changing the sexual behavioural outcome of an individual rather than altering the mould, that is, social norms, especially gender norms that shape the individual's sexual behaviour from childhood through puberty to parenthood (Torimiro *et al*., 2007). Structural and cultural interventions are gender segregate programmes; gender sensitive programmes; gender transformative programmes; and empowering programmes (Mlangwa and Meier, 2007). Gender segregate programmes are interventions that provide separate programming for men and women. Such programmes avoid doing harm by offering different services for women as compared to men when their needs differ, but they also ensure that services do not treat women and men differently when their needs are the same. When men and women's needs are the same, yet they do not receive the same services, harm may be done. For example, programmes that focus on mother to infant transmission of HIV for married or partnered women by targeting the pregnant women can be harmful because they do not include men or discussions about the male role in influencing their partner's thoughts, attitudes, or behaviuors. Other gender segregate interventions offer separate programmes for men and women on condom use, but do not address the relational aspects of the sexual exchange (i.e. engaging the sexual partner).

However, programmes for the use of microbicides and female condoms are separate and sensitive to female's different needs, hence they can work as gender segregate programmes. For example, the latter programmes can work in circumstances where women can decide to practice safe sex (i.e. sex work). Gender sensitive programmes are interventions which recognize that the prevention, care, treatment, and support needs of men and women are often different, not only because of physiological differences, but more importantly, because the context of gender roles and relations substantially influences how men and women will respond to initiatives designed to reduce risk or vulnerability or to alleviate the impact of AIDS (WHO, 2003). Educational messages about prevention that recognize the gender power imbalance are one example of this type of programming. Programmes that promote the development of female-controlled prevention technologies are also examples of gender sensitive approaches. While gender sensitive programmes address gender by acknowledging differences in power, they usually do not attempt to change the conditions that create gender-related differences in the first place (WHO, 2003). Gender transformative programmes seek to transform gender roles and create more gender equitable relationships. These programmes extend gender sensitive approaches because they seek to change the underlying conditions that cause gender inequities

(WHO, 2003). They consider both men and women important in combating HIV/AIDS, and they attempt to reach both. An example of a gender transformative programme is one that uses drama to stimulate discussions among participants about challenging dominate norms of masculinity and femininity (WHO, 2003). These types of programmes directly address relational contexts that evoke hegemonic gender beliefs which influence people's sexual relationships and their evaluations of themselves and others in gender typical ways. Finally, empowering programmes are those that seek to equalise the gender balance of power in areas outside the domain of sexuality in order to ultimately reduce vulnerability to HIV (WHO, 2003). For example, micro finance projects for women seek to enhance their status in society by helping to generate income. It is believed that this general increase in power will diffuse to their relationships with men, and eventually increase women's power in matters of sexual decision making.

The study therefore, examined the availability and usage of structural, cultural and individual based HIV/AIDS preventive strategies among the farm youth. It is strongly believed that combining the three categories of preventive strategies would definitely break the vicious cycle of HIV/AIDS and food insecurity in Nigeria as shown in Figure 1.

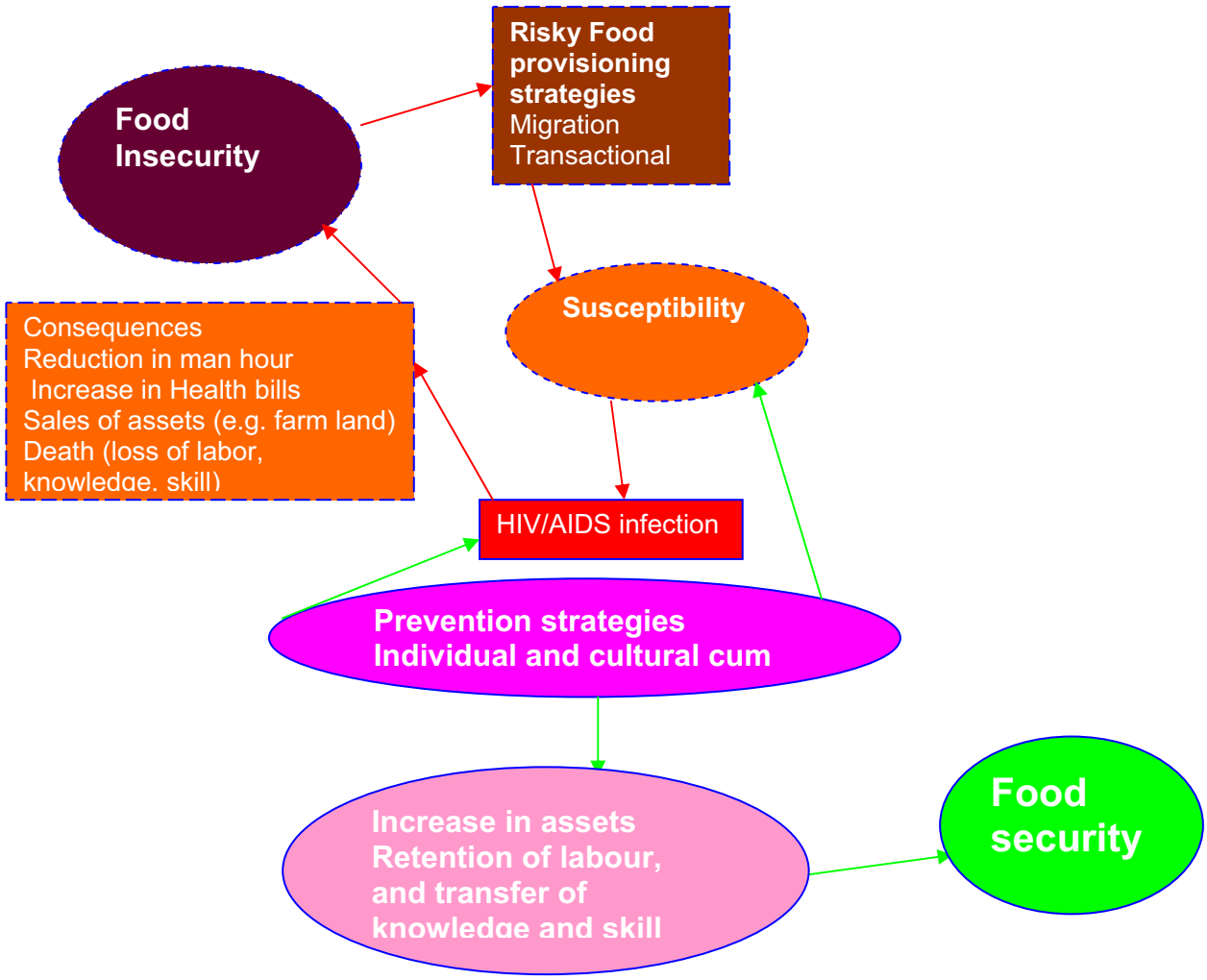

Figure 1: Showing the relationships among food security, prevention strategies, infection and food insecurity.

Methodology

Multiple sampling Six Local Government Areas (LGAs), viz, Odo – Otin, Egbedore, Ife – Central, Atakunmosa West, Ejigbo and Iwo were purposively selected from the 30 LGAs in the State to represent the areas of high (Ejigbo and Ife – Central), medium (Egbedore and Atakunmosa West) and low (Odo – Otin and Iwo) HIV occurrences as reported by Resident HIV Surveillance Commission in the State. From the six LGAs, twelve communities were randomly selected based on the prevalence of HIV/AIDS from which proportionate sampling technique was used to select 120 farm youth between 15 – 24 years, were selected from every other house. Data collected through the use of interview schedule and focus group discussion (FGD) were described using means, standard deviation and petrcentages while Chi – Square and Correlation analyses were used to test for relationships and associations. The data collected were analysed using SPSS. Frequency, percentage, means, and standard deviation were used to describe the data, while multiple regression analysis was used to make deductions.

Results and Discussion

Socio-demographics of the Respondents

Data presented in Table 1 showed the result of selected personal and socio-cultural and economic characteristics of the respondents. The mean age of the respondents was 17.6, with standard deviation of 4.5. While 70.0 percent of the respondents was between the ages of 15 and 19, 30.0 percent was between 20 and 24 years. This implies that majority of the respondents were in their teenage years, a period characterized by the appearance of secondary sex characteristics and composed of a set of gradual transitions. It is associated with notable changes in mood sometimes known as mood swings. Cognitive, emotional and attitudinal changes which are characteristic of youth, often take place during this period, and this can be a cause of conflict on one hand and positive personality development on the other. Because the youth are experiencing various strong cognitive and physical changes, for the first time in their lives they may start to view their friends, their peer group, as more important and influential than their parents/guardians. Moreover, peer pressure may sometimes cause the youth to indulge in risky behaviours (Ryan *et al.*, 2003).

Although higher percentage (62.5%) of the respondents was single, 33.3 and 4.2 percents were married and divorced, respectively. This implies that 7.5 percent of married or divorced respondents were teenagers, since only 30.0 percent was between the ages of 20 and 24 years. Marital status according Smith (2007) has a strong influence on the use condom in Nigeria. This also, suggests that 7.5 percent of respondents was involved in early marriage, which has been variously reported as a risk factor in the spread of HIV/AIDS among youth, especially young women in Africa (Bruce, 2005; and Clark, 2004). While 62.5 percent of the respondents could read and write in any language, some (37.5%) could not. This indicates that 37.5 percent of the respondents might not have accessed prevention information in written form. This will invariably influence their perception and usage of prevention strategies. While about 59.3 percent of the respondents claimed to be Christian, 25.9 and 14.8 percents were Muslim and Traditional Worshipers, respectively. These indicate that the respondents were highly religious. Hence, their various religious beliefs might have influenced their usage of HIV/AIDS prevention strategies. For instance, Hollos and Larsen (2004) reported that religion is a determinant of contraceptive usage in Tanzanian.

The mean farm income per month of the respondents was $ 85.0 with a standard deviation of $7.5. Many (54.2%) of the respondents had less than $58.14, few (37.5%) realised between $58.14 and $174.42 from their farms, whilst only about 8.3 percent eked greater than $174.42 from farming activities. This shows that majority of the respondents earned below the minimum wage. This may invariably influence their usage HIV/AIDS prevention strategies. The mean of the number of dependents was 2.0 with a standard deviation of 0.57. Half of the respondents had less than 2 dependents, some (41.7%) had between 2 and 4 whilst 8.3 percent had more than 4. This indicates that the respondents had social responsibility which is a sort of financial commitment.

Table 1: Distribution of respondents by sociodemographics n = 120

Variables	Frequency	Percentage	Mean & Standard deviation
Age			
15 – 19	84	70.0	X =17.6 sd =4.5
20 – 24	36	30.0	
Literacy			
Cannot read & write in any language	45	37.5	
Can read and write in any language	75	62.5	
Religion			
Christians	70	59.3	
Islam	30	25.9	
Traditional	20	14.8	
Marital Status			
Single	75	62.5	
Married	40	33.3	
Divorced	5	4.2	
Farm Income			
< $58.14	65	54.2	
$58.14-$174.42	45	37.5	
>$174.42	10	8.3	X =$ 85 sd =7.5
Number of dependents			
< 2	60	50.0	
2 – 4	50	41.7	
> 4	10	8.3	

Source: Field survey, 2007. X = Mean, sd = Standard deviation

Respondents' knowledge of the causes of HIV/AIDS

As regard to the causes of HIV, 54.1 percent agreed that *People that have multiple sex partners are highly at risk* just as 41.7 percent said that having unprotected sex could get one infected. These imply that 45.9 and 59.3 percents of the respondents never saw having multiple sex partners and unprotected sex, respectively, as risk factors in the spread of HIV/AIDS. This invariably would influence the use of individual based HIV/AIDS prevention strategies (e.g., condom) in the sexual networks to which the higher percentage (59.3%) of the respondents might be involved. Only about 29.0 and 26.7 percents of the respondents accepted that sharing un-sterilized sharp objects and transfusion of untested blood, respectively, could lead to the spread of HIV/AIDS. Moreover, very few (8.3%) of the respondents had known that *Having unprotected sex with a person that looks healthy* as well as

Poor nutritional status could heighten the risk of contracting HIV/AIDS. Also, only about 8.3 percent of respondents had known that an infected pregnant mother could got the baby infected during delivery or nursing.

Worse still, fewer percentages (7.5%, 5.8%, 5.0%, 5.0% and 4.2%) of respondents had known that the spread of HIV/AIDS could be worsen by the following *Men's extramarital sex*; *A powerful herbalist's un-sterilized blade for circumcision and ritual scarification*; *Wife inheritance*; *Girl's early marriage with older men* and *Gender inequality*. These indicate that more than 90.0 percent of the respondents were ignorant of the fact that the theses practices are precursors for the spread of HIV/AIDS. But then, the youths' palpable ignorance with regard to the likelihood of infection inherent in these practices may not be unconnected with the secretive and mythological as well as constitutional and cultural underpinnings associated with the practices. For instance, the Constitution of the Federal Republic of Nigeria read thus: *Nigerian men are more flirtatious than women*… This offers implicit encouragement to men's extramarital sex as well as polygamy. More so, the mythological and presumed mystical operations of herbalists or native doctors make it difficult for an unenlightened to suspect that *herbalist's un-sterilized blade for circumcision and ritual scarification* that is intended to provide protection could spread HIV/AIDS. Furthermore, wife inheritance, girl early child marriage and gender inequality as cultural practices reflect patriarchal social system wherein the respondents were brought-up.

Table 2: Distribution of respondents by knowledge of the cause of HIV/AIDS

*Knowledge	Frequency	Percentage
People with multiple sex partners are highly at risk	65	54.1
Having unprotected sex	50	41.7
Sharing un-sterilized sharp objects	35	29.0
Transfusion of untested blood	32	26.7
Poor nutritional status heightens the risk	10	8.3
Having unprotected sex with a person that looks healthy	10	8.3
Infected mother to child	10	8.3
Men's extramarital sex	9	7.5
A powerful herbalist's un-sterilized blade for circumcision and ritual scarification	7	5.8
Wife inheritance can enhance the spread	6	5.0
Girl's early marriage with older men	6	5.0
Gender inequality increases the risk	5	4.2

*** Multiple responses; Source, Field Survey, 2007**

The summary of Table 2 is presented in figure 2. Data in Figure 2 showed that majority (51.8%) of the respondents had inadequate knowledge as regard to the spread of HIV. About 30.0 and 8.4 percents had inadequate and fairly adequate knowledge about the cause of HIV/AIDS infection, respectively. Only about 5.2 and 4.6 percents of the respondents had adequate and very adequate knowledge about the behviours and practices that enhance the spread of HIV/AIDS. The apparent inadequate knowledge about transmission of HIV/AIDS might definitely influence the youth's usage of the preventive strategies.

Respondents' awareness of HIV/AIDS prevention strategies

Data in Table 3 showed that 30.0 and 80.0 percents of the respondents never heard that abstinence and faithfulness to uninfected partners, respectively are HIV/AIDS prevention strategies. Although, many (45.5) of the respondents claimed to have heard that condom is a prevention strategy, only about 27.5 and 8.3 percents claimed to have seen and had an experience with condom, respectively. Higher percentage (80.0%) of the respondents never heard that testing and voluntary counseling is HIV/AIDS prevention strategy. However, 3.7 percent of the respondents claimed to have experienced blood screen as HIV/AIDS prevention strategy. Also, about 8.3 percent agreed to have heard of programmes addressing mother-to-infant whilst 5.7 percent claimed to have experienced with a drama challenging cultural practices associated with HIV. But then, none (0.0%) of the respondents had ever heard of any programme that promotes the development of female-controlled prevention technologies, and addresses gender inequality. These imply that the level of awareness about the prevention strategies is very low, most especially awareness about the structural and cultural interventions.

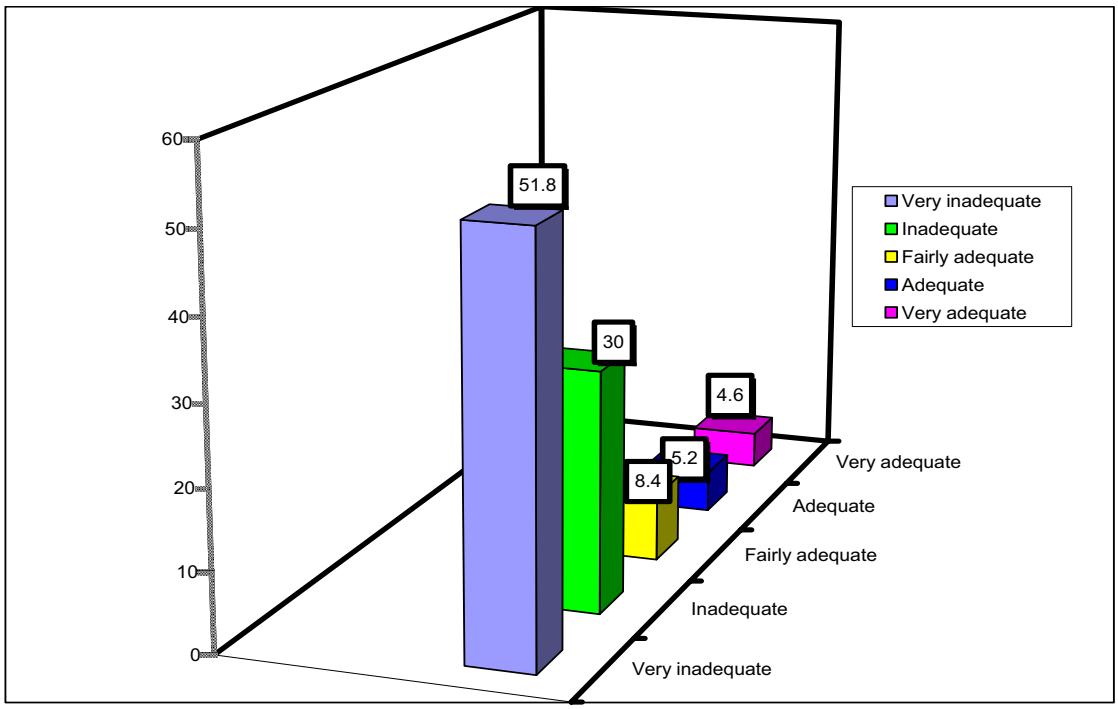

Figure 2: Showing distribution of the respondents bylevels of knowledge about the means of contracting HIV

Table 3: Distribution of respondents by awareness of HIV/AIDS prevention strategies

Prevention strategies	Never heard of it	heard of it	seen it	experienced it
Individual based				
Abstinence	36	60	20	4
	(30.0)	(50.0)	(16.7)	(3.7)
Faithfulness to Uninfected partner	97	12	8	3
	(80.8)	(10.0)	(6.7)	(2.5)
Condom	20	57	33	10
	(16.7)	(47.5)	(27.5)	(8.3)
Testing and voluntary counseling	96	17	7	0
	(80.0)	(14.2)	(5.8)	(0.0)
Blood screening before transfusion	60	45	11	4
	(50.0)	(37.5)	(9.2)	(3.7)
Structural cum cultural based				
Programmes that focus on mother-to-infant transmission of HIV	98	22	0	0
	(81.7)	(8.3)	(0.0)	(0.0)
Programmes that promote the development of female-controlled prevention technologies	120	0	0	0
	(100)	(0.0)	(0.0)	(0.0)
Drama challenging cultural practices associated with HIV	113	0	0	7
	(94.3)	(0.0)	(0.0)	(5.7)
Programmes addressing gender inequality	113	0	0	0
	(100)	(0.0)	(0.0)	(0.0)
Micro finance projects for women to enhance their status	100	20	0	0
	(83.3)	16.7)	(0.0)	(0.0)

Field Survey, Source, 2007.

Farm youth's perception about HIV/AIDS prevention strategies

Data presented in Table 4 showed the rank order of various statements reflecting the respondents' perception about HIV/AIDS prevention strategies. The statements "*Enhancing economic status of women can reduce transactional sex and HIV infection* and *Structural interventions on inequality can reduce the spread of HIV"* had weighted mean scores of 4.7 and 4.5, and were accordingly, ranked first and second, respectively. The weighted mean scores of 4.2 and 3.7 were recorded for the statements "*Abstinence is good but not possible* and *I don't like using condom though it may prevent HIV*," and thus they were placed third and fourth, respectively. Also, the statements "*A combination of prevention strategies could reduce infection* (3.6*), Condom and abstinence are enough to check HIV/AIDS"* (1.5) and "*Voluntary counseling and testing can prevent HIV infection"* (1.3) were ranked fifth, sixth and seventh, respectively. These indicate that respondents favourably perceived structural cum cultural interventions over individual based prevention strategies. This may not be unconnected with the fact that the former unlike the later changes the respondents' socioeconomic and politico-cultural milieu. Arguably, this implies that the respondents may be more receptive to structural cum cultural interventions, relative to individual based strategies.

Table 4: Farm youth's perception about HIV/AIDS prevention strategies

Statements	Weighted mean score
Enhancing economic status of women can reduce transactional sex and HIV infection	4.7
Structural interventions on inequality can reduce Abstinence is good but not possible	4.2
I don't like using condom though it may prevent HIV	3.7
A combination of prevention strategies could reduce infection	3.6
Condom and abstinence are enough to check HIV/AIDS	1.5
Voluntary counseling and testing can prevent HIV infection	1.3

Field Survey, Source, 2007

Farm youth's usage of HIV/AIDS prevention strategies

Data presented in Table 5 showed the distribution of the respondents by the use of HIV/AIDS prevention strategies. While higher percentage (56.7%) of the respondents never practised abstinence, only 2.5 percent practised always. This imply, that majority (97.5%) of the respondents was sexually active. But then, out of 83.3 percent of the farm youth that had heard of condom, only about 23.4 percent claimed to have always used it. This indicates that 74.1 percent if it had not happened, was at the verge of contracting HIV/AIDS through sexual intercourse. The infection of over seventy percent of farm youth with HIV/AIDS will invariably, worsen the precarious food situation in Nigeria (*Torimiro et al*., 2008).Also, only 4.2 and 5.8 percents of the respondents claimed to have always and often used *Testing and voluntary counseling*. Moreover, some (35.8%) of the respondents had always used screened blood during transfusion whilst 5.7 percent agreed to have been involved in drama challenging some cultural practices associated with HIV/AIDS. Although, 8.3 percent agreed to be aware of programmes addressing mother-to-infant., none (0.0%) of the respondents had ever been involved in the programmes that focus on mother- to-infant HIV/AIDS transmission; programmes that promote the development of female-controlled prevention technologies; and addressing gender inequality as well as micro finance projects for women to enhance

Table 5: Distribution of respondents by usage of HIV/AIDS prevention strategies

Types	Frequency of use/involvement: never	rarely	often	always
Individual based				
Abstinence	68 (56.7)	42 (35.0)	7 (5.8)	3 (2.5)
Condom	27 (22.5)	46 (38.3)	19 (15.8)	28 (23.4)
Testing and voluntary counseling	104 (86.7)	4 (3.3)	7 (5.8)	5 (4.2)
Blood screening before transfusion	13 (10.8)	29 (24.1)	35 (29.2)	43 (35.8)
Structural cum cultural based				
Programmes that focus on mother to infant transmission of HIV	120 (100)	0 (0.0)	0 (0.0)	0 (0.0)
Programmes that promote the development of female-controlled prevention technologies	120 (100)	0 (0.0)	0 (0.0)	0 (0.0)

Drama challenging cultural practices associated with HIV	113 (94.2)	7 (5.7)	0 (0.0)	0 (0.0)
Programmes addressing gender inequality	120 (100)	0 (0.0)	0 (0.0)	0 (0.0)
Micro finance projects for women to enhance their status	120 (100)	0 (0.0)	0 (0.0)	0 (0.0)

Field Survey, Source, 2007

Determinants of usage of HIV/AIDS prevention strategies

Data presented in Table 6 showed that six variables explained 79.0 percent (R^2 = 79.0) of the total variation in the farm youth's usage of prevention strategies. In terms of the relative importance of the variables in explaining the farm youth usage of HIV/AIDS prevention strategies, the standardised regression coefficient termed beta weight was used. Data in Table 6 revealed the order from the most to the least important as follows at $p < 0.01$: knowledge score (b = 0.523), level of awareness (b = 0.503), perceptional score (b = 0.516), income (b = 0.492), number of sources of information (b = 0.314), and age (b = 0.198), In addition, the analysis of variance for the regression analysis yields an F-value of 2111.008, which is significant at 0.01 level of significance.

Table 6: Determinants of usage of HIV/AIDS prevention strategies

Variables	Unstandardized Coefficients B	Standardized Coefficients Std. Error	Beta	t	Sig
Knowledge score	0.511	0.067	0.523	7.585**	0.000
Perceptional score	0.520	0.067	0.516	7.747**	0.000
Age	1.142	0.260	0.198	4.398**	0.000
Income	5.098E-04	0.000	0.492	3.775**	0.002
Level of awareness	0.285	0.073	0.503	3.775**	0.004
Number of sources of information	0.834	0.228	0.314	3.662**	0.003

Model Summary R = 0.889, R Square = 0.790, Adjusted R Square = 0 .765, Std. Error of the Estimate = 12.10314, F = 2111.008, Sig. = 0.000

Implications for food security in Nigeria

Nigeria's agriculture is dominated by smallholder farmers whose production account for 80.0 percent of the national food supply. Farm sizes are generally small and scattered; farming is often of the subsistence variety, characterised by simple tools and intensive use of human energy. Farm labour is provided by the nimble fingers of able bodied young men and women whose fiercely insistent hormones, ignorance and some cultural practices have made more susceptible to HIV/AIDS. Since labour saving technology in Nigeria is currently evolving at a pace that inspires no hope (Torimiro *et al.,*2008) the national food supply, thus depends solely on the nimble fingers of farm youth. In order words, the condition of national food security is in a way tied to the farm youth's state of health. Hence, the scourge of HIV/AIDS among farm youth has a grave implication for Nigeria food security. For instance, when a farm youth becomes infected with HIV, the youth becomes sick, the number of man hours in the

farm is reduced, replacement of labour may be imported from relations, healthcare expenses rise, assets are sold, debt increase, children may stop schooling, household food production and consumption fall. The decline in the household food production leads to insufficient national food supply (Oyenuga 1991; Kolawole and Okorie, 2007; and Torimiro *et al.*, 2008). The upshot of insufficient national food supply is food insecurity. Conversely, prevention of HIV/AIDS among the farm youth will in no small measure influence the national food supply and security. Integrated prevention strategy is required in order to address the bahavioural and cultural as well as structural dynamics that underpin the spread of HIV/AIDS among the youth.

Recommendations

1. Incorporation of HIV/AIDS prevention interventions into National Food Security Program in order to preserve agricultural labor (farm youth).
2. Incorporation of literacy intervention into National Food Security Program for farm youth
3. Legislation to refine some cultural practices associated with HIV/AIDS spread
4. Mainstreaming of farm youth's HIV/AIDS interventions into agricultural extension.
5. Complementing individual based HIV/AIDS prevention strategies with interventions that would address some of the prevailing cultural and structural dynamics associated with the spread of HIV

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Emergency Contraceptive Use among Secondary School Adolescents in Ile-Ife, Osun State, Nigeria.

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Abstract

This is an exploratory descriptive study that was conducted among 250 senior secondary school adolescents in Ile-Ife, Osun State, Nigeria. Subjects were drawn from Senior Secondary Class 2 (SS2) and SS3 from two main public schools with a response rate of 98% making the study sample to be 246. Study was aimed at examining the sexual practices of these adolescents and, assessing their knowledge and use of emergency contraception (EC). A semi-structured questionnaire which was pilot tested among 40 senior secondary school adolescents in a separate school from the study schools yielded a correlation co-efficient of 0.75 at test-retest method of reliability. Questionnaires were administered under examination condition in order to ensure confidentiality and free responses to questions. Findings revealed 26 (11%) early adolescents, 93 (38%) middle adolescents and 127 (52%) late adolescents. About 61 (25%) adolescents were sexually active, majority of who had their sexual debut at the early adolescent stage (29; 48%). Fort-two (69%) out of the sexually active adolescents (61; 100%) reported weekly sexual intercourse with the opposite sex but, frequency of sex is higher among males (50; 20%) than females (11; 4%) and, gender significantly influenced the frequency of sex of the adolescents (P = 0.000). When determining their knowledge of EC, significant number of the adolescents (174; 71%) had poor knowledge but, Chi Square test results indicated that mothers' occupation (p = 0.265), fathers' occupation (p = 0.242), age group (p = 0.723) and gender (P = 0.989) did not significantly influence their knowledge. However, in a multiple response questions on EC methods adopted by the adolescents, 90 (17%) males prescribed non-conventional methods to their female sexual partners while 45 (7%) females used non-conventional methods of EC. Several non-conventional methods were stated by these adolescents which included the use and mixture of 7up (scheweps, or crest), alcohol, lime, potash, hot water, salt, gynaecoside, menstrogen and others. Recommendation is towards the establishment of adolescent-friendly reproductive health clinic in and out of school environment with the involvement of school nurses in information dissemination and reproductive health service provisions among adolescents.

Key Words: Adolescent-friendly reproductive health clinic, Adolescents' sexual practices, Emergency contraception, School Adolescents, School Nursing.

Introduction

In the present world history, available evidence has shown the largest generation of adolescents who constitute 1.2 billion of the world population (United Nations Population Fund,, 2003). Adolescents of age group 10-24 years constitute 31.6% of the Nigerian population (Online Nigeria Daily News, 2008). Adolescents have been noted to be sexually active (Aziken *et al*. 2003; Bodrick, 2007) which has consequently made them to have a high prevalence rate of unwanted pregnancy and induced abortions which are performed in an unsafe environment (Ukpani, and Ukpani, 2000; Ikpeme, 2001; Aziken *et.al*. 2003; Herrick ***et.al***. 2004; Encyclocentral, 2008). However, Otoide *et al*. (2001) have reported that induced abortion currently accounts for 20,000 of the

estimated 50,000 maternal deaths that occur yearly in Nigeria and that a higher percent of the incidences occurs among young women. Emergency contraception (EC) has been linked with reduction of unwanted pregnancies most especially among adolescents who engage in sporadic and occasional sexual intercourse (World Health Organization, 2005).

The potential of EC to prevent unwanted pregnancy in developed country has also been described (Encyclocentral, 2008) but, EC has been reported to be largely underutilized world wide and has been referred to as one of the best kept secrets in Reproductive Health (Ebuehi *et al*. 2006). In Nigeria, despite the fact that EC is included in the national family planning guideline (International Federation of Planned Parenthood, 2006), there is limited awareness of this method and use among women most especially among adolescents (Otoide *et.al*. 2001; Orji and Esimai, 2005; Bodrick, 2007). Recently, the Planned Parenthood Federation of Nigeria and a Lagos-based Non-governmental Organization –Society for Family Health- recommended EC as the option to preventing unwanted pregnancy among young women in Nigeria (Bodrick, 2007).

Few studies that had been conducted on EC in Nigeria among post secondary school adolescents, especially among undergraduates in various universities (Adekunle, 2000; Arowojolu and Adekunle, 2000; Azike *et al.*, 2003; Ikeme *et al*. 2005) and health workers (Adekunle *et al*., 2000; Ebuehi *et al.*, 2006) had revealed low level awareness and use of EC. However, data on the use of EC among adolescents in secondary institutions in Nigeria are scanty. The questions this study had tried to answer are; don't secondary school adolescents use EC? If they do, what is their knowledge base and what EC methods do they adopt?

Methodology

This is a cross-sectional descriptive study which was meant to determine the sexual practices of senior secondary school adolescents, assess their knowledge of EC and, determine the various EC methods adopted by them after an unprotected sexual intercourse. The study was conducted among adolescents in senior secondary schools 2 (SS2) and SS3 from two public schools in Ile-Ife; a semi-urban town in Osun State, Nigeria. Adolescent age group for this study was taken to be between 10 and 24 years according to the Federal Ministry of Health, Nigeria (2007) specification for adolescents' age group in Nigeria. Sample consists of 250 subjects calculated from the sample size formula for single proportion using prevalence rate of 20%. This prevalence rate was deduced from the findings of Okonta et.al., 2003 which indicated that 18% female undergraduates in Nigeria knew about EC and it's correct timing. Subsequently, multistage sampling technique was adopted to select the samples. Semi-structured questionnaires were administered to the adolescents under examination conditions to allow for free and unbiased responses to the questions that were asked. Only 246 questionnaires were returned giving a response rate of 98%. This instrument was initially pilot tested among 40 randomly selected senior secondary school adolescents in another school different from the study schools and was also examined for face validity. Reliability test at test-retest method yielded a correlation coefficient of 0.73. Ethical consent was sought from the authorities of the two schools involved in the study and each of the respondents was educated on the purpose of the study and their consent gained before the administration of the questionnaires.

Analysis was done using the 11.0 version of Statistical Package for Social Sciences (SPSS). For the purpose of this study, adolescent age group was classified as: early adolescent stage; 10-13 years; middle adolescent stage; 14-17 years and late adolescent stage; 18-24 years (Kozier *et al*., 2000). Postinor 2 which is the common EC method adequate for adolescents in Nigeria was referred to as conventional method in this study while methods that are not internationally recognized as EC methods

were referred to as non-conventional methods.

Results

Demographic information about these adolescents revealed; 26 (11%) early adolescents, 93 (38%) middle adolescents and, 127 (52%) late adolescents. Their mean age was 16.3 (±2.21) years with age range of 10 - 22 years. One-hundred and thirty (53%) were males while 116 (47%) were females. Results showed that 61 (25%) out of the 246 (100%) adolescents were sexually active with 29 (48%) having their first sexual intercourse at early adolescent stage, while 23 (38%) and 9 (15%) had their sexual debut at middle and late adolescent stage, respectively. Out of these sexually active adolescents, 41 (68%) had more than one sexual partners (Table 1). Interestingly, 42 (69%) had weekly sexual intercourse and majority of these were those that had their sexual debut at early adolescent stage (25; 41%) (Table 2). Assessing their gender in relation to their frequency of sex, more males were sexually active (50; 20%) and they had higher frequency (36; 15%) for weekly sexual intercourse than females. More importantly, there is a significant difference (P = 0.000) between frequency of sex and gender of these adolescents.

Assessing their sources of information on EC, majority reported that they heard from the media (80: 33%), 49 (24%) heard from friends, 40 (20%) heard from parents while, 31 (13%) heard from teachers. In a multiple response to eight questions to determine their knowledge of EC, many of them (206; 84%) indicated that confidence pills are used for EC, 150 (61%) responded that EC is a method used before sex to prevent pregnancy but, very few of them (45; 18%) indicated that EC is used within five days of unprotected sexual intercourse. In all, 174 (71%) had poor knowledge of EC while 72 (29%) had good knowledge of EC. Using Chi square test, at a significant level of P≤0.05, mothers occupation (P = 0.265), fathers occupation (P = 0.242), adolescents' age group (P = 0.723) and, gender (P = 0.989) did not significantly influence their knowledge of EC. In a multiple responses of the contraceptive methods adopted by the adolescents, 90 (17%) males indicated that they prescribed various non-conventional methods to their female sexual partners, while 45 (7%) females adopted non-conventional methods of EC. Interestingly 250 (47%) indicated that their friends adopted the non-conventional methods. In all, 142 (47%) responses on Postinor 2 was given as the conventional method adopted by few of the adolescents (Table 3). The lists of all the various non-conventional methods are listed in Table 4.

Table 1: Adolescents' number of sexual partners according to their age at sex debut

No of sexual partners	**Age at sex debut**			
	Early adolescents	**Middle adolescents**	**Late adolescents**	**Total**
One	7(11%)	8 (13%)	5 (8%)	20 (33%)
Two	5 (8%)	6 (10%)	3 (5%)	14 (23%)
Three	9 (15%)	2 (3%)	1 (2%)	12 (20%)
Four and above	8 (13%)	7 (11%)	-	15 (25%)
Total	29 (48%)	23 (38%)	9 (15%)	61 (100%)

Table 2: Adolescents' frequency of sexual intercourse according to their age at sex debut

Frequency of sex	Age at sex debut			
	Early adolescents	Middle adolescents	Late adolescents	Total
Weekly	25 (41%)	15 (25%)	2 (3%)	42 (69%)
Monthly	1 (2%)	5 (8%)	4 (7%)	10 (16%)
More than a month	3 (5%)	3 (5%)	3 (5%)	9 (15%)
Total	29 (48%)	23 (38%)	9 (15%)	61 (100%)

Table 3: E. C methods adopted by the adolescents

Methods	Male	Female	Friends	Total
	Freq (%)	Freq (%)	Freq (%)	Freq (%)
Conventional	30(6%)	22 (4%)	90(17%)	142 (27%)
Non-conventional	90 (17%)	45 (7%)	250 (47%)	385 (73%)
Total	120 (23%)	67 (13%)	340 (64%)	527 (100%)

****Multiple responses allowed**

Table 4: List of Non-conventional Methods as adopted by the adolescents

Non-conventional methods	
Lime+Potash	Paw-Paw leaf
Alum + Potash	Concoction
Alabukun +lime +7uP(or Schweppes or crest)	Mango branches and leaves
Hot water +salt	Raw egg + potash +salt
Andrew liver +salt	Confidence tablets
7up +lime +salt	M and B capsule
Potash + water	Menstrogen
Lime + alcohol	Gynecoside
Epa Ijebu	Over-dosage of any drug
Condom	

Discussion

This study is a pointer to the fact that adolescents in secondary educational institutions in Nigeria are sexually active which has corroborated the findings of other researchers (Anochie and Ikpeme, 2001; Orji and Esimai, 2005). It is surprising to note that majority of the adolescents had their sex debut at early adolescents stage and out of this group with early sex experience, 36% of them had more than one sexual partner while 41% engaged in weekly sexual intercourse. Yet, majority of these sexually active adolescents were males. Findings of Slap ***et al***. (2003) on sexual behaviour of adolescents in Nigeria, showed that males were more sexually active than females, but in Switzerland girls were found to be more sexually active than boys (Ottesen *at al*. 2002). Izugbara (2007) has indicated that Nigerian adolescent males have associated multiple sexual practices to boosting their sense of maleness, acceptance and ranking among peers. Male adolescents who have more than one sexual partner pose a danger to the society because they can easily enhance the spread of sexually transmitted infections (STI) including HIV/AIDS and ultimately create the problem of unwanted pregnancy at an early age.

Previous studies have documented that sources of information on EC have been mostly through the media and friends (Byamugisha *et al*., 2006; Arowojolu, 2000).and this study has confirmed these reports. A parent as source of information on EC is still very low because, African culture abhors discussion on sexuality education between parents and children (Izugbara, 2008). This lends credence to the finding that there is no association between parents' occupation and adolescents' knowledge of EC. In contrast, Ottensen *et al*. (2002) found out in Switzerland that, there was a positive relationship between parent education, scholastic curriculum of the respondent and adolescents' knowledge of EC. Parents should be seen as important factors in sexuality education in Nigeria and they must be encouraged to take up these responsibilities among their children and in the community. Breaking the African culture of not discussing sexual and reproductive health issues with children will go a long way to increase awareness on reproductive health issues most especially on EC among adolescents.

This study discovered that the adolescents use various drug and non-drug formulations that have no relationship with contraception to serve as EC methods. For example, Menstrogen, and Gynaecosid are drugs that are used for treating secondary amenorrhea while M&B capsule is used as wound healing agent. However, Confidence tablets are the morning after pill containing 0.3 mg norgestres with 0.03mg ethinyl estradiol which are commonly available as over the counter regular contraceptive pills in Nigeria while, Alabukun are powdered drugs that could be used for colds and aches. Interestingly, Potash, alum and alcohol are substances that have no relationship with EC but, they could be dangerous to health if ingested in large quantity. Similarly, "Epa Ijebu", paw-paw leaves, mango branches and leaves are herbal products in which their efficacies have not been ascertained and, discussions with traditional pharmacists showed that there have not been any known relationship(s) between these substances and EC. Other non-conventional methods such as raw egg mixed with salt, 7up and lime or hot water and other substances have not been proven to be effective as EC methods. Surprisingly, over-dosage of any drug (which might have deadly consequences) as stated by some of these adolescents to be EC methods showed that these adolescents have taken EC to be synonymous to abortion which is illegal in Nigeria except for medical reasons.

Within the frame work of human rights, the adolescents also have rights which include gender equality and the rights to education and health; including reproductive and sexual health information and services appropriate to their age. In Europe (Glasier *et al*. 1996) EC had been introduced to the adolescents while Uganda introduced EC in 1998 (Byamugisha *et al*., 2006). It is essential to appreciate that, despite the fact that adolescents are exposed to ABC (Abstain, Be faithful, Use Condom) educational methods of HIV/AIDS prevention, data abound on increased incidence of teenage pregnancy and induced abortion. Adolescents, most

especially those in their early stage of development should be educated and encouraged on the use of EC pills after an unprotected sexual intercourse. Inability to introduce these adolescents to conventional method of EC will perpetuate the use of unsafe and dangerous methods among them which may be transferred to future generations. It is high time that individuals, governmental and non-governmental organizations established Adolescent Friendly Reproductive Health Clinics (AFRHC) as recommended by the World Health organization (1999) in strategic places and in schools in the country. These clinics will serve as information and service provision centers for adolescents' reproductive health services thereby reducing incidence of reproductive health problems among them.

As majority of adolescents are found in schools, school nurses are therefore encouraged to get involved in delivering quality and effective sexual and reproductive health services to adolescents with emphasis on Emergency Contraceptive use among them. Establishment of school nursing in Nigeria is of paramount importance as nurses are in strategic positions to effectively deliver sexual and reproductive health services among school adolescents. It is recommended that this study be replicated in another culture and environment to determine EC methods used by adolescents after unprotected sexual intercourse. Further research works on the effectiveness of these non-conventional methods are also recommended.

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Conflict Theory, Revenue Allocation and The Niger Delta Crisis

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Abstract

The paper examines the crisis in the Niger Delta region of Nigeria, focusing on explanations of the conflict and policy options in addressing the problem. Analysing different theories of conflict, the paper discusses the extent to which these theories provide adequate basis for explaining the Niger Delta crisis. Furthermore, it analyses the link between the revenue allocation system in the country and the Niger Delta crisis in the light of these theoretical tools. The paper employs both primary and secondary sources of data collection. With respect to the former, reliance is based on the interview technique of data collection. Sample is drawn from activists on the Niger Delta question as well as from other knowledgeable individuals that possess expertise relevant to the Niger Delta issue. Data from secondary sources are drawn from published relevant materials. The data are analysed using appropriate analytical technique. Among other things, the paper contends that the revenue allocation system has, over the decades, been structured in a way that laid the foundation for crisis in the Niger Delta. In addition, it argues that while elements of criminality may be identified in the crisis, the characteristics of state repression, disarticulated and inappropriate policies, incompetence and corruption on the part of some critical operators of the state have combined to provoke and deepen the crisis. The paper concludes by raising issues that must be addressed if an enduring solution is to be found.

Introduction

The Niger Delta crisis, no doubt, represents one of the major challenges confronting the Nigerian state. Many studies, reports and commentaries on the crisis have given varied interpretations of the crisis (Kemedi, 2003; Ojo, 2002; Ibeanu, 1997; Imobighe *et al*., 2002; Obi, 2001). This paper focuses on explanations of the conflict and policy options in addressing the problem. Analyzing different theories of conflict, the paper discusses the extent to which these theories provide adequate basis for explaining the Niger Delta crisis. In addition, it analyses the link between the revenue allocation system in the country and the Niger Delta crisis in the light of these theoretical tools. Fifty people were interviewed for the purpose of this research. These included ten members of the security agencies operating in or with relevant knowledge of the Niger Delta crisis, ten Niger Delta activists, ten community leaders and twenty other people in the Niger Delta area with good understanding of the issues in the Niger Delta. Data obtained from this primary source were complemented by secondary sources. In the sections that follow, the paper discusses conflict theory; the relationship between the revenue allocation system in Nigeria and the Niger Delta crisis; and the examination of the Niger Delta crisis. Thereafter, the paper reviews some critical issues arising from analysis in the previous sections and on the crisis in general. This is followed by the conclusion.

Conflict Theory

Conflict has been generally defined as a condition in which one group of persons is engaged in conscious opposition to another group(s) of persons because of the pursuit, by these groups, of incompatible goals or what appear to be incompatible goals. According to Coker (1956), conflict involves "struggle over values and claims to scarce status, power, and resources in which the aims of the opponents are to neutralize, injure, or eliminate their rivals". It should be noted however that conflict may also be geared towards obtaining compromises from opponents. Sociologists such as Karl Marx, George Simmel and Ralf Dahrendorf have viewed conflict as serving social purposes in a positive way. While conflict is generally regarded as inevitable in any society,

there is no consensus as regards the nature and function of conflict. While some social scientists regard conflict as functional, others see it as irrational and dysfunctional. Broadly, two contending theoretical approaches to the study of conflict have been identified, viz micro theories of conflict and macro theories of conflict (Cunningham, 1998). Micro theories, also known as the behaviourist school, believe that the root causes of war are in human nature and behaviour. This school sees a strong connection between interpersonal conflict and the conflict that pervades the external social order. The school tries to understand whether human beings possess biological or psychological characteristics that predispose them to aggression and conflict.

Macro theories are essentially concerned with group interaction. These groups could be national, ethnic, class, institutional, etc. Power is a central concept of macro theories of conflict. This school (also called classical theories) basically assumes that the roots of conflict are to be found in group competition and the pursuit of power and resources. While these theories provide understanding of some of the dimensions of the conflict in the Niger Delta, they are not sufficient in explaining the entire conflict. The human needs theory provides an important additional theoretical tool for explaining the Niger Delta crisis. The theory provides a holistic explanation of human behaviour and is based on the hypothesis that human beings have basic needs that must be met in order to maintain stable societies (see Cunningham, op cit). According to this theory, persons in conflict situation seek to satisfy primordial and universal needs such as security, identity, recognition, and development and strive to gain the control of their environment necessary for the satisfaction of these needs (Burton, cited in Cunningham, op. cit). Burton (ibid) stresses that unless "identity needs are met in multi-ethnic societies, unless in every social system there is distributive justice, a sense of control, and prospects for the pursuit of all other human societal developmental needs, instability and conflict are inevitable."

The implication of this theory for the Nigerian situation is the recognition that each section of the country has legitimate needs that need to be met. The attainment of these needs do not have to be a zero sum game. The prevention of any group from pursuing these needs inevitably creates crisis. It is largely in this context that the Niger Delta crisis can be located.

The Nexus between Revenue Allocation and the Niger Delta Question

The seeming impracticability of Wheare's financial autarky in a federal state makes it inevitable for issues of intergovernmental financial relations to be addressed in federal systems. Wheare's model of a federal state provides for political arrangement in which the central government and component units are each financially autonomous (Wheare, 1963). The inability to attain this goal makes the issue of revenue allocation necessary in a federal state. The importance of revenue allocation is accentuated in the Nigerian case given the pattern of revenue mobilization and allocation. Beginning from the late 1960s, important revenue sources have been embedded in the federally collected revenue and the principle of derivation which hitherto dominated revenue allocation waned considerably in importance, particularly since the 1970s. In its stead, such principles as population and equality of state have taken a prominent place in revenue distribution (Obiyan, 2004). High revenue retention by regions and derivation principle held sway before the dominance of oil in Nigeria's economy. For example, the 1963 Constitution provided that: 100% of import duty on motor spirit/diesel oil, 100% of import and exercise duties on tobacco and 100% of export duties on produce, hides and skins were to be paid to the region of origin or destination. Similarly, the constitution provided for the payment of 50% of royalty from minerals and mining rents to the regions. Thus, in Nigeria's pre-oil dominated economy, revenue sharing arrangement between the central governments and regional governments was characterized by a high level of revenue retention by regions on the basis of contribution to the federation account.

By the late 1960s, oil had assumed great importance. At that time, revenue became centralized through various decrees and the derivation principle suffered increasingly from that period (see Table 1 for revenue distribution from 1981 to 2008 and Table 2 showing the recommended principles of revenue allocation by various commissions in Nigeria). By the 1970s the contribution of oil to national revenues was over 70 percent while its share of the country's foreign earning was over 80 percent.

Table 1: Vertical Allocation of the Federation Account 1981-2008

RECIPIENTS	1981 ACT	1989	JAN 1990	JAN 1992	JUNE 1992 TO MAY 1999	MAY 1999 TO 2004
(i) Federal Government	55.0	55.0	50.0	50.0	48.5	48.5
(ii) State Governments	30.5	32.5a	30.0	25.0	24.0	24.0
(iii) Local Governments	10.0	10.0	15.0	20.0	20.0	20
(iv) Special Funds	-	25	5.0	5.0	7.5	,
a. Fed. Cap. Territory	-	-	1.0	1.0	1.0	1.0
b. Stabilization	-	-	0.5	0.5	0.5	1.5
c. Savings	-	-	-	-	-	
d. Derivation	2.0	2.0b	1.0	1.0	1	
e. Development of Mineral Producing Areas	1.5	1.5	1.5	1.5	3.0	
f. General Ecology	1.0	1	-	-	2.0	2.0
g. Development of Natural Resources						
Total	100	100	100	100	100	100

Notes:

(a)What is shared among states is 32.5 percent of the Federal Accounts, less 2 percent of the mineral revenue component of the 32.5 percent of the Federation Account.

(b)This 2 percent is not of Federation Account but of the mineral revenue component of the 32.5 percent of the Federation Account.

Following the decision of the Supreme Court which ruled that sharing of money from the Federation Account is only among the three levels of government, the Revenue Mobilization, Allocation and Fiscal Commission (RMAFC), in January 2003, revised its earlier sharing proposal as follows: Federal Government 46.63 percent; State Government 33 percent; Local Government 20.37 percent. This proposal was submitted to the National Assembly by the President but later withdrawn. Another revised version was, however, later reported to have been submitted to the National Assembly in 2004. It is yet to be passed into law. But on June 29, 2004, the Chairman of the RMAFC, Engineer Hamman Tukur, stated that a new proposal would soon be sent to the President

of the country. It is instructive to know that up till now, a new revenue allocation formula is yet to be passed into law. Recently (in 2008), a new proposal on revenue allocation was reportedly being put in place.

*13 percent of revenue from minerals is paid to the mineral producing states in compliance with the 1999 Constitution.
Sources: Adapted from Danjuma (1994: 103); Saberu (2004: 36); Obiyan (2004: 112).

Table 2: Principles of Revenue Allocation in Nigeria (1946-2008)

COMMISSION	YEAR	PRINCIPLES
(i) Phillipson	1946	1. Derivation 2. Even Progress
(ii) Hicks-Phillipson	1951	1. Derivation 2. Needs 3. National Interest
(iii) Chick	1953	1. Derivation 2. Fiscal Autonomy*
(iv) Raisman	1958	1. Derivation 2. Distributable Pool Account (DPA) (a) Continuity (b) Minimum Responsibility (c) Populated (Need) (d) Balanced Development
(v) Binns Same as Raisman	1964 but enlarge funds in DPA	Tax effort* Financial comparability*
(vi) Dina	1968	1. States Derivation Account (SDA) 2. States Joint Account (SJA) a. Need or National Budget Gap b. Minimum Standards c. Balanced Development 3. Special Grant Account (SGA)
(vii) Federal Military Governments Decrees	1970-78	1. Equality of all States 2. Population
(viii) Aboyade (not accepted)	1977	1. Equality of access to development opportunity

		2. National minimum standard for national development 3. Absorptive capacity 4. Independent revenue and tax efforts 5. Fiscal efficiency
(ix) Okigbo	1980	1. Equality of States 2. Population 3. Social Development Factor 4. Internal Revenue Effort
(x*) Allocation of Revenue (Federation Account, etc)	1981	1. Financial comparability 2. Population
(xi*) National Revenue Mobilization, Allocation and Fiscal Commission	1989	On-going

Source: See Obiyan, 2004: 113.

Note:

It can be seen from the table that the principle of derivation was virtually discarded from the late 1960s. Indeed, key decrees promulgated by the Federal Military governments (Decree No 51 of 1969 and Decree No 9 of 1971) reinforced the enhanced position of the federal government in revenue allocation. While Decree No 51 of 1969 vested ownership and control of petroleum in the federal government, Decree No 9 of 1971 placed all offshore oil revenue in the federal government.

THE CENTRALISATION PROCESS IN REVENUE ALLOCATION SYSTEM IN NIGERIA

There are several contending views on the reasons for the centralization of national revenue. These reasons include a shift in the sources of major resources, inter-regional disparity in resource endowment, state creation, the military factor, the civil war and the fear of domination by the northern political elite, among others (Oyediran and Olagunju, 1979; Ojovbaire, 1978; Ayoade, 1997; Ayoade, 1988; Mbanefoh, 1986; Afrigov, 2000). But while scholars, practitioners and commentators quibble over why high regionalization of revenue has given way to increased centralization, there is no dispute that increased centralization of revenue and dominance of the federal government have not always been the characteristics of the revenue allocation system in the country.

Prior to independence in 1960 and in the post independence era up to the late 1960s, the regional governments occupied prestigious positions in fiscal relations through the retention of "domestic revenues" and also through the dominant application of the derivation principle. This procedure ensured that the regions not only harnessed resources in "their domain", but also were able to promote development in line with the set priorities of each region.

Enemuo rightly captures the then prevailing fiscal situation. According to him:

The revenue distribution arrangements that operated during the First Republic allowed each region to retain much of what it generated in revenue. This gave the regions the wherewithal to compete among themselves and

to initiate major socio-economic development projects, in education, communication, infrastructure, etc. This, in fact, may be regarded as one of the positive aspects of federalism during this period (Enemuo, 2000: 74).

By the late 1960s, and especially from 1970, there was a process of drastic change in the nature of fiscal relations. Essentially, the new fiscal relations undermined the position of the subnational governments while the federal government asserted its dominance. Incidentally, the period also coincided with a change in the structure of the Nigerian economy, as oil supplanted agriculture as the main stay of the country's economy.

What therefore accounted for this transformation of fiscal relations? In his argument, highlighting the centralizing consequence of state creation in Nigeria, Yaqub (2000: 94), agrees with scholars who argue that the centralizing trends in Nigerian federalism have manifested in different forms since 1954 and particularly since independence. But he argues that "these manifestations of the process of centralization in federalism would not have been probably so entrenched had the military not simultaneously intervened in the country's politics" (Ibid: 95). Yaqub's argument, in this context, relates generally to the centralization trends in Nigeria federalism. But it seems appropriate to similarly argue in the context of fiscal relations in Nigeria that while other suggested factors for fiscal centralization in Nigeria's intergovernmental fiscal relations may not be irrelevant, the military factor cannot be rightly ignored. The rigidly hierarchical nature of the military, coupled with its centralization made military rule and political organization led by the military to tend towards centralization.

More importantly, and with respect to fiscal centralization, it can be argued that the relatively close nature of the decision making process under the military and the military's `courage', even if someone negative courage, in taking though decisions perhaps facilitated the process of fiscal centralization. This process was also possibly further adopted by the political circumstances of the time.

First, serious political crises resulting finally in the civil war strengthened the hands of the military leadership as decisions are less likely to be vehemently opposed or even seriously questioned at emergency periods. Besides, the oil producing areas appeared further weakened at the time because of the war and its outcome.

Arguing in similar vein, Oyovbaire (1978: 243-245) highlights the role of several factors in the post 1970 reforms of the fiscal system. Among these factors, he identifies the location of the new major source of income (oil), which was not evenly spread across the states, and the enormous revenue from oil. The huge revenue assured great disparities in state revenues with the application of the derivation principle. On the other factors leading to the centralization of the fiscal system, Oyovbaire argues:

The other contributory factor was the civil war and the changes it engendered in the structure of consensus and conflict. Victory in the civil war did not merely keep Nigeria intact: it put the federation on quite a different footing. The pre-war political system was characterized by a weak centre denuded of authority and vitality by a conflicting set of Regional interests. The configuration of forces in the post war situation was quite different…The most obvious change was the enhanced status of the Federal Government, which had undertaken the mobilization of the country's resources during the war…The most obvious manifestations of the growth of central power were the much higher levels of Federal expenditure. The system remained federal in character but the Federal Government had assumed an unprecedented authority of its own (Oyovbaire,1978: 244).

Some authors tend to also link fiscal centralization to state creation. The argument is that the multiplication of states made it necessary to centralize revenues and then redistribute such revenues using certain criteria. However, it is difficult to see how multiplication of states makes revenue centralization inevitable.

The most plausible arguments that can be made between fiscal relations and state creation, it can be argued, are essentially two fold. One, the proliferation of states tends to further deplete the quantum of revenues that accrue to each state, thereby further aggravating the dependence of states on the federation account revenues and on the federal government. In essence, it entrenches the dominance of the federal government in fiscal relations.

The centralization of revenue and the relegation of the derivation principle in revenue determination have been linked to the emergence and dominance of oil by several other scholars. For example, Soremekun and Obi (1993), note that the attempt to control oil revenue led to the centralization of the collection of oil revenue in the federal government dominated then by the Northern and Western factions, and the determination of how revenue is to be shared. Hence Decree No. 51 of 1969 which vested ownership and control of petroleum in the federal government (Ibid: 219). This centralization was further consolidated through Decree No. 9 of 1971, by placing all offshore oil revenue in the federal government. According to them, "(t)his move finally cut off the minorities from direct oil revenue, and reinforced the dependency of the minorities on the majorities for a share of the oil wealth" (Ibid: 220). The consequence of this development was the politicization of the revenue allocation formula: the principle of derivation as a basis for revenue allocation gave way to the principles of equality and population (Ibid: 220).

Emphasizing the political undertone in the shift from the derivation principle in revenue allocation; they posit:

Clearly, the new principles were a response to the change in the shift of wealth of the nation from agriculture to oil, and the desire by the majorities to continue to retain the larger chunk of national revenue. The changes in intergovernmental revenue sharing were seen by the oil producing communities as a strategy to deprive them of the benefits of oil (Ibid: 220).

Fiscal centralization, they contend, has increased the premium on political power at the central level and creates "geo-national constraints in the structure and process of Nigeria's federalism" (Ibid: 221).

Sagay's (2001) analysis also highlights the intrigues, politics, controversies and group character that attend revenue allocation in Nigeria. The long quote, below, from Sagay's work reveals these issues. According to Sagay:

Even a superficial political analysis of the situation will reveal that the fate of the mineral resources of the Niger Delta minorities particularly the trend from derivation to Federal Government absolutism, is itself a function of majority control of the Federal Government apparatus. In 1960, there were no petroleum resources of any significance. The main income earning exports were cocoa (Yoruba West) groundnuts, cotton and hides and skin (Hausa/Fulani) and palm oil (Ibo East). Therefore, it was convenient for these majority groups usually in control of the Federal Government to emphasizes derivation, hence its strong showing in the 1960/63 constitutions. However, by 1967 and certainly by 1969, petroleum, particularly the mineral oil, was becoming the major resource in terms of total income and foreign exchange earnings in the country. It was therefore, not difficult for the majority groups in the Federal Government to reverse the basis of revenue allocation with regard to petroleum resources from derivations to Federal Government exclusive ownership.

Indeed, the trends in the revenue allocation system show that the downward movement of the derivation principle coincided largely with the increased importance of oil mineral in the country. And the process of fiscal centralization was intensified.

Sagay, thus attributes the decline of the derivation principle to the manipulation of the fiscal system by the dominant groups. As he further puts it:

They were in control of the Federal Government and their control of the mineral resources by virtue of that fact effectively means that the resources of the Niger Delta were being transferred to the majority group in control of the Federal Government at any point in time. Again, these oppressive measures are not the results of accidents or errors. They are deliberate acts of policy implementation founded in the belief that the owners of the petroleum resources being minorities can be deprived of their resources without any consequence. This is the attitude and mentality that led a senior Federal permanent secretary in a memorandum concerning Federal expropriation of the resources of the Niger Delta to make the following Freudian Slip, some years ago: "Given however the small size and population of oil producing areas, it is not cynical to observe that even if the resentments of the oil producing states continued, they cannot threaten the stability of the country nor affect its continued development (cited in Igbuzor, 2003: 11).

Sagay's analysis emphatically acknowledges the relevance of political control of the central government in the determination of the revenue allocation system. It, thus, demonstrates superiority over the argument of a majoritarian conspiracy. Rather than construing it purely as a conspiracy by the majority ethic groups, it can be argued that it is a coalition of the forces of the less resource-endowed areas to gain a sizeable portion, or even dominate the oil proceeds. Given the relative numerical strength and historical advantages – since the colonial era – of these groups, they have controlled the power and politics of the country since independence. And, considering the centrality of power in policy determination, it has been relatively easy for them to secure for themselves, a vantage position in revenue allocation issues.

In any case, Ayeni and Olowu (1988: 198) may be right in their observation that revenue allocation involves a power-game in which the actors depend on their reserves of influence and resource. And the relative distribution of these reserves impact on the bargaining power of each actor and the ability to impose or interpret the rules of the game to its advantage.

Regardless of the trends and diversity of arguments pertaining to the centralization of revenues, what is clear is the denial of due recognition to resource rich states in the distribution of revenues beginning from the period of oil dominance in Nigeria's economy. This development laid the basis for the emergence of agitation for resource control which has now assumed various dimensions.

The Niger Delta Crisis

While the situation in the Niger Delta has assumed different dimensions, there appears a strong link between the pattern of revenue distribution over the decades and the crisis. Indeed, virtually all the activists in the Niger Delta interviewed argued that derivation was discarded because the major resource, oil, was significantly located in the minority areas. They contended that the centralization of revenues and the lack of recognition given to derivation principle was a political strategy by the dominant elite to indirectly control the resources that are located outside their territories. They believe that if the derivation principle was not downgraded, it would have been difficult for the militants in the region to create the current situation. This view was largely held by the overwhelming majority of people interviewed. This position further underscores the link between the pattern of revenue allocation and the struggle for resource control in the Niger Delta, including the crisis situation.

Added to the above factor are the tremendous environmental degradation caused by oil exploration with its attendant consequences on farming and fishing (see the pictures in the Appendix); misapplication of public funds; near absence of basic infrastructures; illegal oil trade by some powerful individuals in power over the decades; deprivation of political power; and repression by the state. Respondents confirmed these factors as elements in the Niger Delta Crisis. These factors have combined to create the current situation in the Niger Delta where militant groups are challenging the legitimacy of the Nigerian state.

The data collected through the interview method confirmed some existing commonly held views on the situation in the Niger Delta region while further interesting revelations were made. Analysis of the data shows that while it will be erroneous to dismiss the crisis in the Niger Delta as a product of criminal activities, it will also be too simplistic to reduce the whole activities to that of just struggle for equitable distribution of resources.

It was found out that some of the dimensions in the Niger Delta situation include struggle for territorial control and dominance by different armed groups, the use of armed groups by some political actors to gain political advantage over their opponents, and the use of armed groups to facilitate illegal oil bunkering by both local and international actors, including top ranking government officials in many successive administrations in Nigeria.

Other dimensions include kidnapping for sheer personal monetary benefits, among others. These varied dimensions of the situation were generally confirmed by respondents, including security operatives. Interestingly, it was also generally reported that some members of the Nigerian military were fully involved in extracting private gains in the region either through direct participation in illegal oil bunkering or by partnering with local armed operators. The use of armed group for election rigging in more recent times further worsened the security situation in the region.

One of the respondents reported that he had a friend with whom he grew up in Rivers State. This respondent gained admission into a university in South West Nigeria. Two years later, when he met his friend in Port Harcourt, he was living in affluence. According to the respondent, his friend had under his control a group of armed men from which he provided security to politicians in return for money. This illustrates a dimension to the conflict and why any attempt to control the situation will require more than a surface – scratching approach.

Thus, there is no doubt that the situation in the Niger Delta region has assumed different dimensions. Indeed, the situation has reached a frightening stage that except it is effectively checked it may degenerate to a level that dangerously tend towards the Colombia of the 1990s were control of national territory was split between the state and several drug barons.

While these dimensions in the Niger Delta conflict exist, it can be argued that they are fundamentally a manifestation of the failure of the Nigeria State. The direct consequences of the huge revenues from oil exploration in the Niger Delta have been deepening poverty, lack of social infrastructures and severe environmental degradation in the area. While the state of oil producing communities represents the worst form of human habitation, oil workers' settlements in the region denote affluence in the extreme. These negative consequences are a product of the misapplication of oil funds. Over the decades, corruption at all levels of governments have combined to deprive the people of decent living.

The staggering state of underdevelopment in the oil producing communities in the Niger Delta, no doubt, indicates the non-responsiveness of the Federal Government of Nigeria; but it is largely a representation of the general failure of the Nigerian State to positively respond to the needs of the citizenry in different parts of the country.

Many oil communities do not have portable water, electricity and roads. The rivers are largely polluted by oil spillage thereby making fishing unattractive; similarly farmlands are constantly devastated by oil spillage (See the pictures in the appendix

which show different forms of environmental and human degradation orchestrated by oil exploration activities). While oil companies have often identified sabotage as the factor in oil spillage, many respondents reported that the major problems pertain to weak pipes due to old age, laying pipes close to the surface, laying pipes in wrong places and lack of adherence to general best practices.

It can be argued, though, that while the Federal Government has failed to respond to the needs of the Niger Delta people, the lower tiers of government, particularly state governments have, tragically, failed in large part to identify with the people's aspirations. Understandably, there have been some constraints on the capability and efficiency of state governments for which it will be inappropriate to blame the indigenes of the area. First, for the most part of Nigeria's history, the military have held sway in governance. Given the practice of the military, especially from the second period of military intervention, to post non-indigenes as military governors of states, many of these governors probably did not see compelling reasons to fully identify with the people.

Secondly, the centralization of national revenues and the dominance of the Federal Government in revenue allocation, coupled with the general erosion of the federal principle, reduced the latitude and capability of states to act. Inspite of these constraining factors, evidence suggests that some of the state governments have not effectively and efficiently deployed state resources to address the people's needs. This is particularly so beginning from 1999 when the revenue being allocated to the oil producing states increased, following the adoption of the 13 percent derivation principle. (The 13 percent derivation principle was originally adopted by the 1994/95 Constitutional Conference under General Sani Abacha's government).

There is no doubt that the oil producing states have enjoyed high revenue from the federation account relative to the non-oil producing states in recent times. This has been particularly so in respect of the major oil producing states of Akwa Ibom, Bayelsa, Delta and Rivers states. For instance, while the respective allocation to these from the federation account in the month of February 2006 were 6,336,748,082.19; 7,845,321,710.10; 6,849,395,705.27; and 9,971,325,099.16 billion Naira, each of the non-oil producing states received less than 2 billion Naira except Kano and Lagos states which allocations were 2,333,916,206.97 and 2,205,524,916.14 billion Naira respectively (see FMF, 2006).

It is instructive to note that most of the former governors of the Niger Delta States, like some of their counterparts elsewhere, are being prosecuted for corruption. Indeed, in spite of the enhanced revenue, some of the states in the oil producing areas have nothing to show for it. Thus, what has happened in the Niger Delta has been a holistic systemic failure of the state at various levels.

The implication of this is that if this trend continues, even if the principle of derivation is increased from 13 percent to 100 percent, it may not lead to a significant change in development. It is therefore necessary that the problem of corruption be effectively tackled as well. In addition, leaders from these states need to show a sense of commitment to the upliftment of their people.

The foregoing is certainly not meant to exonerate the Federal Government from the underdevelopment of the Niger Delta region. For, given the status of the region as the main stay of the country's economy and the difficult nature of its terrain, it ought to have been accorded a special status that would have involved the positive transformation of the region.

The nature of the terrain in many parts of the Niger Delta presents the region with even a very great challenge. For instance, many of the communities are linked by water. This makes the provision of infrastructures such as (especially) roads and construction of buildings to be very expensive relative to many other parts of the country. Thus, a complementary and collaborative effort of all tiers of government is necessary for meaningful transformation in the area.

Some Critical Issues Arising

The Nigerian problem posed by the Niger Delta crisis is fundamental and deep rooted. The crisis is not just a challenge to the competence and character of the Nigerian state or even the composition of its governing elites but more fundamentally a wholesome disenchantment with the structural arrangement of the country.

Generally, the problem of internecine struggle for political and economic power among sectional elites in the country is not new. It has however assumed different degree of prominence at different historical epochs. The emergence of Chief Olusegun Obasanjo as president of Nigeria in 1999 was to pacify the south west in an attempt to control the political upheaval generated by the annulment of the June 12, 1993 presidential election acknowledged to have been won by Chief M.K.O. Abiola. It can also be argued that the need to rein in the forces of resistance in the Niger Delta facilitated the emergence of Dr Goodluck Jonathan as vice president of Nigeria since "power needed to return to the north". Conceding offices in this manner is hardly a coherent, balanced and stable way of addressing what has come to be perceived as fundamental flaws in the political and economic arrangements of the country.

The Niger Delta struggle, while one may disagree with certain dimensions, is a logical and predictable response to the failure of the Nigerian state, which activities have significantly negated the basis of the social contract that brought about the state in the first place.

There is pervasive disenchantment among the masses in the country, not restricted to the Niger Delta. Two circumstances seem to set apart the Niger Delta: (i) the significant erosion of the basis of livelihood occasioned by extensive oil exploration with its attendant consequences of spillage and environmental degradation, and (ii) the realization that a set of dominant elites and some foreign partners reap monumental benefits from the economic and environmental degradation of the region.

Equally worse is the perception that the Nigerian political system is manipulated in such a way as to undermine the effective participation of the region in the political process as a means of perpetuating the dominance of the dominant ruling elites. As Ikime (2008) puts it, the people of the Niger Delta were the dominant people before the advent of colonialism; the new political and economic arrangements transformed these people into the dominated group. In his view, the struggle in the Niger Delta is a reaction to this development; in fact, a product of the people's anger to this brutal marginalization.

Indeed, it can be argued that decades of economic exploitation, political marginalization and suppression, violent political repression as well as the squalor and poverty engendered by misapplication of oil funds, sheer corruption and maladministration at virtually all levels of government have combined to undermine the legitimacy of state authority in the region. These factors were confirmed by data gathered from respondents. Indeed, references were made to the brutal repression of activists in the region in the pre armed militancy era by successive military governments.

Conclusion

It is significant to note that the core issues in the Niger Delta crisis do not revolve around inter-ethnic conflict. Rather, those core issues revolve around fundamental opposition to state's authority. It is symptomatic of the general despondence and suspicion by the citizenry against the Nigerian state. As a militant leader, Jomo Gbomo remarked:

Politicians in the Delta are no different from politicians elsewhere in Nigeria. The rot is right at the top and has spread right down. Nigeria will only be free when all citizens resolve to take drastic action to rid our society of these criminals who have imposed themselves as rulers over a helpless citizenry (Gbomo, 2007: 5).

As contended in this paper, the Niger Delta crisis is largely explained by the human needs theory, which recognizes the imperative to satisfy needs and the fact that in the absence of distributive justice and prospects of societal developmental needs, instability and conflict are inevitable. Any approach that seeks a lasting solution to the Niger Delta question must, of a necessity, deal with the fundamentals of the crisis which pertain to issues of appropriate determination of resource allocation, extent of local self governance (political self determination) and the participation of the generality of people in the governance process. These are not far from the issues in the Nigerian national question itself. These issues revolve around the need for the institution of a true federalism in the country.There is no doubt that the struggle for equitable distribution of resources is the central issue in the Niger Delta crisis. The seemingly dominant perception of brazen marginalization and the failure of the Nigerian State to promote the welfare of the people have eroded confidence in the state. This situation has created a conducive ambience for some criminal elements that have nothing to do with the just struggle to thrive. To successfully tackle the criminal aspects, it is imperative for the state to regain the confidence of the people. Massive infrastructural transformation, developmental strides and empowerment of the people are necessary in this regard. It is also important that the issue of appropriate determination of revenue in the country be firmly and fairly dealt with by reviewing upward the percentage assigned to the derivation principle. The people of the region must then ensure that they hold their leaders accountable.

It is important to note that while the problems associated with oil exploration have been applicable to all the nine oil producing states of Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers, and the struggle for resource control has been visible in most of these states, the problem of armed militancy and associated problems have been more pronounced in Rivers and Bayelsa states. While the two states are among the leading oil producing states in the country, it is still unclear why violent conflicts have been particularly identified with the two states.

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Oil and Youth Restiveness in the Niger Delta: Economic and Socio-politico-cultural Implications and Imperatives for Rural Community Development

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Abstract

Although, the Niger Dealt crisis is not a child of recent birth, but its new dimensions have generated a lot of concerns both within and outside the shores of Nigeria. The foregoing informs this paper, which, among others, specifically categorizes youth restiveness; documents the varying depths and dimensions of youth restiveness; examine the various interventions of government in the area; draws out the economic and socio-politico-cultural implications and imperatives for Niger Delta's community development. Historical methodology was employed. Interview schedule and group focused discussion guide were used to elicit information from 288 respondents who were selected through multistage sampling procedure from 12 oil producing communities. Also, secondary data were sourced from literature. Frequency, mean and standard deviation were used to summarize the data while Analysis of Variance was used to make deductions. The results revealed among others that 50.7 percent of the respondents that claimed to have had formal education could neither read nor write in any language. Worst still, majority (74.0%) of the respondents was unemployed. Moreover, youth restiveness was found to be supported by environmental degradation which depleted farm land and engendered unemployment as well as some soldiers and politicians who connived with the militant youths and international agents to perpetuate oil bunkering and election rigging. Also, kidnapping as a new dimension of the restiveness was revealed to be on the increase, since 2006 till date (22nd August, 2008). For instance, there were 65.0 % and 100.0 % increases in the numbers of Nigerians and foreigners, respectively, kidnapped in 2007, while there were significant differences in the number of Nigerians kidnapped between 2006 and 2007 ($F = 12.87$) , the number of foreigners kidnapped between 2006 and 2007 ($F = 13.19$), the number of Nigerians kidnapped between 2007 and 21st August 2008($F = 16.75$), the number of foreigners kidnapped between 2007 and 21st August 2008($F = 8.61$) , amount of money demanded as ransom between 2006 and 2007($F = 7.56$) and amount of money demanded as ransom between 2007 and 2008($F = 8.95$) at $p < 0.01$ level of significance. While unemployed male were into kidnapping, their female counterparts were involved in sea-shore prostitution with oil workers. Also, the study revealed that government interventions were being assessed by the amount of money allocated to the region, rather than human development index as enshrined in the principle of participatory rural community development. Since the progress of Nigeria State is tied to Niger Delta, It, therefore, concluded that the development of Niger Delta through participatory rural development approach is an investment to be leverage rather than a cost to be justified.

Keywords: Oil, Youth Restiveness, Niger Delta, Rural Community Development

Introduction

The crisis in Nigeria's Niger delta is not a phenomenon of recent origin. History indicates that the crisis in the region antedate Nigeria. The area had always been a resource base for different historical era and the dialectics of the times had consistently promoted a contestation between contending forces. The struggle in the region has evolved through fives stages. First, it served as an outlet for the Slave Trade in the 16th century. The trade contained the dialectics of its history and generated resentment among the common men of the area against the overlords who superintended the trade. The second stage occurred in the late 19th and early 20th centuries, when the indigenous communities fought against attempts by British traders (backed by the imperial government) to seize control of the trade in palm oil and other produce. The consequences were that communities like Nembe, Opobo and Akassa were attacked by British gunboats and their chiefs deposed and exiled. The mid-1960s' declaration of Niger Delta Republic by Isaac Adaka Boro heralded the third stage. Boro accused the post-independence governments of the period, controlled by Nigeria's major ethnic nationalities, of oppressing the minorities in the Delta. His republic was soon overrun by

government forces and he was thrown into prison. Boro was released from prison to fight on the federal side in the Nigerian/Biafran War and died in action (Dike, 2001).

The struggle entered its fourth stage in the early 1990s, when Ken Saro-Wiwa and other Ogoni leaders gave birth to the Movement for the Survival of the Ogoni People (MOSOP). At this stage the struggle was focused on reversing structural, economic and environmental injustice. MOSOP changed the character of the struggle by organizing on the basis of an entire ethnic nationality rather than as separate clans and villages, as had been the case in the past. MOSOP started asserting the rights of Nigeria's constituent ethnic nationalities within the Nigerian Federation rather than simply agitating for increases in compensation payments. In creating a mass movement of the Ogoni people, which for the first time included the unemployed and disaffected youth, MOSOP radicalized the struggle in the Niger Delta. It challenged the old conventions where issues in dispute were settled between the oil companies, the Government, the chiefs of some communities and a handful of others. Elite accommodation no longer did the trick! MOSOP made its campaign an international one, ensuring that foreign NGOs and the media kept the problems of the Delta in the spotlight. Also, communities were agitating to secure better compensation from the oil companies for the land they acquired and for the environmental damage arising from their activities. But then, in some instances, communities in dispute with oil companies were brutally repressed by the military regimes of the time – as with Umuechem, a little village in the Rivers State. Eventually, the military junta led by late Sani Abacha hung Ken Saro-Wiwa and other leaders of MOSOP. Even so, the struggle persisted and advanced to its present stage- fifth stage. While palm oil ignited the second conflict, the present is driven by crude oil, its exploitation, processing, products and pollution. The defining characteristics of the present struggle if unchecked can undermine the sovereignty of Nigeria state. Indeed, the present stage is far more militant in nature than the previous stages. Unlike the second stage wherein only the appearance of British gunboat on the sea put the indigenous communities to flight, the indigenous forces have remained undaunted in the face of heavily armed federal and international forces (Ake, 1996; and Williams and Okorie, 2008). Also, while the second, third and fourth stages had limited number of supporters drawn from basically one state- River State, the present comprises an army of able-bodied young men and women, intellectuals as well as unlettered drawn from over nine states of the federation and from outside the Nigeria State. Also, many groups like Niger Delta Liberation Forces, Niger Delta People Volunteer Forces, among others have thrown their weights behind the current struggle. Relative to the fourth stage's strategies, the present stage's combines both international campaigns with guerrilla war.

The guerrilla war in the oil rich creeks has, more than any other crisis, left much causality both in the federal cum internationals' camp and in the militants'. However, though the military and militant youths have suffered a great loss of members and resources, the rural and suburban civilians remained the worst hit. These categories of individuals suffer assault on two fronts as their means of livelihoods are damaged by pollution emanating from activities of oil companies, whilst they are brutalized and raped by the military and robbed by the militant youths. Indeed, they suffer greater hardships as many are victimized, subjected to rape, military prostitution, and physical abuse and forced to flee their homes in distress. So, the rural dwellers in the oil rich zone in the process of fleeing their homes for safety loose invaluable properties, and subsequently become the poorest of the poor for whom survival is the main issue (Ake, 1996). With regard to prostitution and rape, the latter has become a ritual amongst the occupying military and armed police forces as well as security personnel employed by the oil companies (Ake, 1996). Women in villages, farms or fishing grounds that are located close to oil facilities are at most risk of sexual abuse (Williams and Okorie, 2008).

Although, the oil in the region has been exploitated for over 45years and accounted for over 80.0 percent of Nigeria's economy, the south-south geopolitical zone, which is the core Niger delta occupies the last but one position on the ranking of levels of living in Nigeria (FOS, 1999). Hence, the economic situation in the zone presents a startling paradox - abject poverty amidst plenty. The paradox of the region is too evident and appalling. For instance, while a litre of Premium Motor Spirit sells for ₦70.00 in many areas in Nigeria, the same quantity sells for ₦250 or ₦300 in Amasoma, which is an oil producing community in Bayelsa State (Kalu, 2008). Accordingly, several scholars believed that youth restiveness in the zone is a by-product of its abysmal economic paradox (Ojakorotu, 2007; and Dike, 2001). The restiveness of the youths in the zone has reached a worrisome dimension as various interests groups are strategizing for war. The federal government has lost over $12.0billion, despite its investment of over $ 2.0billion in acquisition of marine weapon to curb youth restiveness in the zone (Vanguard, 15th June, 2008). Also, Federal Government has signed a pack with British Government towards providing Nigeria with military assistance to checkmate the restiveness. But then, the Nigerians in Diaspora have staged a protest in London aimed at nullifying the pack.

In essence, mutual recrimination and wars of attrition have ensued among the various interest groups in the area. The indigenous communities alleged that the various governmental interventions only prolong existence in the milieu of privation and poverty just as the Nigeria State claimed that saboteurs are behind the under development of the zone. However, as the debate ranges, concerted efforts are being made to prevent the struggle from entering its sixth stage, which many believed will be a full blown civil war or succession! It is towards contributing to the on-going genuine effort gear towards preventing the escalation of the restiveness that this paper addressed the following research questions: What are the sociodegraphics of youths in Niger Delta? What are the causes of youth restiveness in the region? What are the social consequences of oil and its workers on the region? What are the varying dimensions of the restiveness in the area? Specifically, it described the sociodemographics of youths in the studied area; categorized youth restiveness; documented the varying depths and dimensions of youth restiveness; examined the various interventions of government in the area; drew out the economic and socio-politico-cultural implications and imperatives for Niger Delta's community development.

Conceptual Framework

History is replete with evidence indicating that economic pursuit and conflict of interests are the bane for world's peace. Nations of the world have been drawn into blood shed over resource- its ownership, exploitation, processing, and pollution as well as distribution and consumption. The progress of any social system is dependent on the management and consumption of resource whilst the gap between the haves and have-nots reflects the deferential gap in resource management. Accordingly, the discovery of resource of great importance usually attracts myriads of economic interest (Rodney, 1972). In this regard, the discovery of oil in Niger Delta has drawn various economic interests from all over the globe, in the same way a bar magnet attracts iron fillings. However, unlike the homogeneity of iron fillings, the various economic interests in the region vary in content, and thus contradict one another. It is the contradictions of the varying economic interests that have turned Niger Delta into a real tinderbox. Therefore, the crisis in the region can be better understood as a long drawn out historical process, itself propelled and animated by complex international socioeconomic and political dynamics and which the indigenous communities have been trying to comprehend, resist or turn to their own advantage these past hundred years with varying degrees of success and failure. In other words, it is a case of power and resistance to it; of alien and imposed authority and attempts to indigenize it and make it accountable to the people it purports to rule. Indeed, it is an epic tale of ordinary men and women battling against vastly more superior forces threatening to

take the bread from their mouth and destroy their way of life into the bargain. The people who had hitherto been known farmers and fishermen and therefore eked out a living from their farms and sea foods but had lost virtually everything especially their farmlands, water among others, after the advent and exploitation of the oil, with little or no compensation from the multinational companies and the successive military governments (Ojakorotu, 2007). Hence, the running battle between the youths and the government and their oil company allies is the resumption of the struggle of the ordinary people to have a say in the way they are governed and in the way in which the wealth they help generate is allocated. In other words, the local communities are interested in bring the development of the region at par with the developed parts of the country if not at the same level with other regions of the world that have crude oil.

But then, mutually reinforcing relationship exists between underdevelopment and conflict. So, no meaningful development can be accomplished in an atmosphere of violence and strife (Okorie, 2008). More so, sustainable development begins and ends with man. Owing to degree of rurality of Niger Delta, the thesis of this paper is that participatory community development holds the key to peace and transformation of the region. Participatory community development is a movement to promote better living for the whole community, with active participation and if possible on the initiative of the community but if this initiative is not forth coming, techniques can be used for stimulating and arousing it in order to secure the active and enthusiastic response of the people to the movement (Ekong,2003). Participatory community development has become a vital instrument in unifying a social system with pluralistic ethnic groups and in resolving conflicts (Milbun, 1954). Nonetheless, for participatory community development approach to be utilized as an instrument of peace and development in Niger Delta, the varying depths and dimensions of youth restiveness and governmental responses must be clearly understood. The study therefore, documented the varying depths and dimensions of youth restiveness and examined the various interventions of government in the area; drew out the economic and socio-politico-cultural implications and imperatives.

Methodology

Niger Delta of Nigeria was studied (Figure 1). It is defined officially by the Nigerian Government, to extend over about 70,000 km² and makes up 7.5% of Nigeria's land mass. Historically and cartographically, it consists of present day Bayelsa, Delta and Rivers States. In the year 2000, however, the Nigerian Government expanded it's definition to include Abia State, Akwa Ibom State, Cross River State, Edo State, Imo State and Ondo State (Niger Delta Development Commission, 2002). Thus, the area has about 20 million people of more than 40 ethnic groups, speaking some 250 dialects with the Ijaw, Igbo, and Ibibio being in the majorities. The livelihoods of the local people in the region are basically fishing, peasant farming, small-scale trading and local income generating projects. The forest builds the spirituality of the people; it is their link to their gods. Most of the forests in the Niger Delta are considered sacred. They are untouched, preserved and served. The plants, animals, trees, birds, fruits are regarded as sacred. Same attitude is applied to certain streams and rivers. No body is allowed to fish in these streams and rivers. The rivers and streams do not only provide water for life, drinking, washing and bathing, they not only provide fish for food, they are also sacred and are bound up intricately with the life of the community, of the entire Niger Delta people. The women care for the family; they trade, fish and undertake peasant-farming activities. Their tasks are both productive and reproductive, while the men are mostly involved in palm wine tapping, building canoes and speed boat driving. About 2 million barrels per day are extracted in

the Niger Delta. Since 1975, the region has accounted for more than 80.0 percent of Nigeria's export earnings (Niger Delta Development Commission, 2002).

Historical methodology was explored whilst multi-stage sampling procedure was used to select the respondents. At the first stage, Bayelsa, Delta and Rivers States were purposively selected because of historical and cartographical evidences which indicated that the three states were the original Niger Delta before the year 2000 (Wikipedia,2008). More so, relative to other states in the region, Bayelsa, Delta and Rivers have witnessed more youth restiveness. At the second stage, four oil communities were randomly selected in each of the selected states. At third stage twenty-four youths were randomly selected and divided into three groups for the Focused Group Discussion (FGD) in each of the selected communities. Hence, a total of 288 respondents participated in the discussion. Information on the sociodemographics of the participants was sourced through interviewed schedule. Also, secondary data were sourced from literature.

FGD guide was used to elicit copious qualitative information, which afforded multiple thematizations. All discussions were audiotaped and transcribed into English with the help of the field assistants. Transcripts had the light editing needed to render spoken into written language. To achieve what Burnard (1991) called "immersion in the data," transcribed texts were then read several times, and memos were written on the general themes arising from the data. The research team analyzed the content of the memos developed from the data, relying on the grounded theory, with three linked stages. The initial stage involved open coding to identify themes emerging from key sentiments captured in the expressions, responses, ideas, words, and phrases used by the responding youths. This process continued until all ideas had been absorbed into themes. The second phase involved the exploration of theme properties and relationships. During this phase, themes and connections between them were elaborated to identify crosscutting ideas, issues, and scripts. The categories that emerged were then contrasted with one another to guarantee the mutual exclusivity and specificity of their properties. Qualitative data were presented in boxes. Frequency, mean and standard deviation were used to summarize quantitative data and presented in tables and figures, while Analysis of Variance (ANOVA) was used to make deductions

Results and Discussion

Socio-demographics of respondents

Data presented in Table 1 showed the socio-demographics of the respondents. The mean age was 18.6 years with the standard deviation of 6.7. Many (41.6%) of the respondents were in the age range of 13 and 19 years just as 30.6 percent was between 20 and 26 years. About 27.6 percent of the respondents was between 27 and 35 years. These indicate that all the respondents were still in their active age, and thus represent a potential force in development. While 49.0 percent of the respondents were females 51.0 were males. This implies that male to female ratio in the region is 51 to 49 , which has only a marginal deviation with the national male to female ratio, that is, 72 to 68(National Census Report, 2006). With regard to educational status, about 10.4 percent of the respondents had no formal education, 11.5 percent had uncompleted primary education, while only 8.3 percent completed primary education. Also, about 2.3 percent of the respondents had uncompleted secondary education whilst 34.7percent completed secondary school. About 3.4 percent of the respondents completed tertiary education. Although, majority (89.6%) of the respondents claimed to have had various levels of formal education, higher percentage (55.6%) of the respondents could neither

read nor write in any language. This implies that 50.7 percent of the respondents that claimed to have had formal education could neither read nor write in any language. In other words, half of the youths that went to Western school perhaps were distracted during teaching-learning process. While only 5.2 percent of the respondents was employed, some (20.8%) had casual job. Worst still, majority (74.0%) of the respondents was unemployed. High level of unemployment among the youth could perhaps account for high rate of crime and increasing youth restiveness in the region as unemployment has been associated with crime. In fact, according to Centre for Economic Policy Research (2006) a drop of two percentage points in unemployment would mean a 9.0 percent decline in burglary, 14.0 percent in rape and robbery and 30.0 percent in assault.

Table 1: ***Sociodemographics of the Respondents***

Frequency		**Percentage**	
Age			
13 -19	120	41.6	
			X =18.6
20-26	88	30.6	
27- 35	80	27.6	sd =6.7
Sex			
Male	147	51.0	
Female	143	49.0	
Educational status			
No formal education	30	10.4	
Uncompleted Primary	33	11.5	
Ongoing primary	4	1.3	
Completed primary	24	8.3	
Uncompleted Secondary	80	27.8	
Ongoing Secondary	7	2.4	
Completed Secondary	100	34.7	
On-going tertiary	10	3.4	
Completed tertiary			
Literacy			
Cannot read & write in any language	160	55.6	
Can read and write in any language	128	44.4	
Total	288	100.0	
Religion			
Christians	280	97.2	
Traditional	08	2.8	
Marital status			
Single	243	84.4	
Married	45	15.6	
Employment status			
Permanent job	15		
Causal job	60	20.8	
Unemployed	213	74	

Source: Field survey, 2008. X = Mean, sd = Standard deviation

Causes of Youth restiveness

The words *youth* and *restiveness* have gained notoriety in usage especially in the Nigerian context as related to matters of agitation by the youths in the Niger Delta. With a region as rich in natural endowment that oils the wheels of Nigeria's economy; the poser

is, why are the youths in the region restive? Certainly, the discovery and exploitation of oil as well as the distribution of wealth and waste generated from oil in the region have altered its socio-politico-cultural landscape. Niger delta Youths who represent the flower of manhood and the future of the region have become cannon fodder for pursuance of both genuine and illegitimate ends. Indeed, the consequent generational cultural gap is imminent. However, although youth restiveness in region is already at its crescendo, it is imperative to note that the restiveness is not a natural phenomenon, but rather a human error, whose solution begins with clear understanding of the remote and immediate underpinnings. The complex economic and socio-politico-cultural dynamics which propel and animate youth restiveness in the region were explored during Focus Group Discussion (FGD) session is presented in Box 1.

Box 1: Unemployment and meta problems of environment as the causes of youth restiveness

Do you know that when the oil spilled into a nearby stream, the fire will burn until all the water is dried, and you know that we fetch drinking water from the streams. If you were the one wouldn't be angry? – **A participant from Amasoma in Bayelsa State**

You see, people say that youth in Niger Delta are violent and mad, but the incessant fire outbreaks that destroyed almost every available farm land has brought it. So who will not be angry after losing his /her jobs and livelihoods to fire? Oil companies count their gains annually and we endure the pains emanating from their gains daily. **A participant from Idjerhe in Delta State**

Look, the issue is this, a hungry man is an angry man, an angry man is sad man, a sad man is mad man and a mad man is a violent man! We are hungry; we are sad; we have lost everything to fire outbreak, even corrugated iron roofs can not last for ten years before leakage! No job! Haba! Even a goat, when chased to the wall will bite its oppressor! - **A participant from Bori-Ogoni in River.**

I would say that the crisis in the Niger Delta is indeed a response to the paradox of doom in the midst of plenty; unemployment and poverty in a region that have many companies, which produce wealth. …It is just that some people don't want the truth to be told… we in Niger delta and its surroundings are suffering: the land and rivers are destroyed by oil-spillage; the air and rain water are polluted by gas flaring. So, man and animal are in great danger… **A participant from Obigbo in River State.**

Many of our people even those who are involved in this discussion are unemployed. When the land is destroyed even agriculture which provides employment becomes impossible. *Do you know that rain water if kept covered in container for three days would change to another thing entirely different from water?-* **A participant from Eleme in River State**

…They say we should go back to farming, but where can one farm, when the land, river and even the air we breathe are polluted?- **A participant from Delta State**

Although, I am not a doctor, but common sense suggests to me that the rate at which small children are dying here may just be a reflection of the level of environmental pollution.- **A participant from Nemebe in Bayelsa State** *You see, people asked why linking youth restiveness with environmental degradation? But you know that farmlands are polluted, taken away forcefully without adequate compensation. Also, buildings are destroyed without adequate compensation. …Consequently, our people are left with next-to-nothing. No land, no house, no food! Look at it now! The boys have nothing to eat! Do you think we just fold hands and die?* **A participant from Abiama in River State**

For forty five (45) years the Nigerian State in collaboration with Foreign Multinational Companies have been criminally carrying out crude oil exploration and exploitation activities in the Niger Delta region, leaving in their trail a tale of woe, exacerbated by environmental and ecological disaster, abject poverty, disease ***A participant from Agge community in Bayelsa State***

What you have is an evolving criminal economy and that criminal economy is evolving because people are unemployed and people are poor, neglected and abandoned. I have told the Shell audience, if all of us are working in Shell, who will have time to leave Shell and go to kidnap somebody? ***River State Governor, culled from Vanguard 20/5/08***

Neglect, Corruption and Oil Bunkering

Although, Niger Delta is the host of Multinational oil and gas companies operating in Nigeria, and supplies about 90 percent of crude oil and gas resources, which form the bulk of the Nigeria's mono-cultural economy, it is riddled with paradoxes - the region lacks basic amenities while meta-problems of environment precipitated by oil and gas exploration activities are mounting daily! The ecosystem is susceptible to seasonal changes and tidal influences, hence natural phenomena such as devastating flood, organic pollution, water hyacinth and oceanification, defined as the encroachment of the Atlantic Ocean are common occurrences. But what have added a dangerous dimension to all these hazards are gas flaring and frequent oil spillages resulting activities of Multinational oil Companies (MNC). More than ever, the region conjures a magnified picture of instability occasioned by pervasive poverty, stagnation, environmental degradation and neglect. Even so, the sorry state of the region enhances illegal activities such as oil bunkering and corruption. In fact, it is believed that kidnapping has become a lucrative business in the region because it provides a means of spending money without proper accountability! Neglect, corruption and oil bunkering as prime

Box 2: Neglect, corruption and oil bunkering as the cause of youth restiveness

Agitations have continued in the region because of the failure of successive governments to make a meaningful development. Why is it that today nothing is different even when the budget is higher. …Resources are there for these aspirations to be met, why are they not met? … Our government and community leaders should be held accountable. The failures in this regard has created room for criminal activities in the region – ***A participant from Amasoma in Bayelsa State***

You can recall that over 229 illegal refineries were shunt down by Joint Military Task Force (JTF). However a bloody clash is now looming as the operators of illegal refineries in the creeks are warming up to do battle with JTF. Already armed youths who are beneficiaries of the illegal oil operation, drawn from different locations in the creeks, are moving gun boats and other sophisticated weapons to neighboring communities around Agge to engage the JTF... ***A participant from Agge community in Bayelsa State***

*The neglect here is blindingly obvious- the Okordia-Isampou axis of the East-West road the route linking the oil rich states is at the verge of cutting off. Also, Okosi Bridge on the same route is gradually sinking and is on the verge of collapse due to the rising volume of water from the river and adjoining creeks in the area**. While this disaster is looming government is busy spending $2.5b on marine ammunition to fight perceived militants-*** **Participant from Oloibiri Bayelsa State**

The word peace has become a chameleon word in Niger Delta; the poser is - is it peace of Niger Delta in terms of its development? Or quietness among the impoverished people whi Participantsle the government and its allies continue to milk the land dry?Participant **Wari Delta State**

I think the government wants to prolong the peace process so that the ruling class would continue to line their pockets with oil money… So that is why today one hears about 'proposed summit", tomorrow 'dialogue' and so on so that they continue to steal oil in the region. **Participant from Amukpe, Delta State**

Box 2: Neglect, corruption and oil bunkering as the cause of youth restiveness Contd

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I am glad that time has brought the plight of the people of the Delta region to the attention of the world. While Nigeria's oil industry has produced billionaires, mostly from majority ethnic groups, the people of the Delta are left in penury. All the wealth is stolen and controlled by the majority tribes, who look down on the people of that region as inferior. It is the oil that Nigeria values, not the people. What the Nigerian state does to the people of the Niger Delta is abhorrent and pathetic. Akanimo Akan

The word peace has become a chameleon word in Niger Delta; the poser is - is it peace of Niger Delta in terms of its development? Or quietness among the impoverished people while the government and its allies continue to milk the land dry? ***A participant from Amasoma in Bayelsa State***

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Government said it has no money to provide infrastructure and basic amenities but it has money to lay pipelines! **Participant from Okirika River State**

The prevailing thinking is that the bunkering business is a survival strategy, only for the frustrated youths and self-seeking militants in the region. However, this study revealed otherwise as documented in the box 3

Categories of youth restiveness

Niger Delta problem as a social cause has attracted myriads of actors – empathizers and sympathizers as well as opportunists. The beginning of each actor's or group's activities adequately fits into a typology of genuine agitators, vengeance-bound and self-seeking individuals. Basing the defining characteristics of the various actors in the region on their first activities is necessary as most of the groups usually lose their focus or got hijacked. For instance, even some soldiers sent to the area to stop oil bunkering, ended up as bunkers (Amaize, 2008).

Genuine agitators: the youths in this category see the present socio-economic balance as skewing negatively against the interest of the people of the region. This group of youths started using dialogue option and fronted the

followings as their grievances, which are the issues: Total disconnection between the people, the oil industries and the government in terms of infrastructural development; Poverty; unemployment and economic banditry of the region as well as unfaithful implementation of welfare programmes and MOUs, Illegal oil bunkering, abandonment of political thugs who possess very sophisticated equipment and destruction of the eco-system through gas flaring, petroleum products' pipelines vandalism, pipelines'

rupture, which have rendered farmlands and rivers barren, to the extent that the youths have no other sources of veritable livelihood, Infrastructural decay of educational and health institutions, among others. However, these youths not satisfied with the pace and quality of developmental projects started organizing different groups for peaceful protests. This led to a gradual use of confrontational strategies, which often times brought them to direct confrontation with law enforcement agents. The hardliners in their ranks soon took over the centre stage because; they saw no significant improvement in their living conditions and well being. The hardliners emerged because of the lacunae created in the dialogue process by the actors. They became more aggressive and confrontational. They cite failure of the dialogue process from the times of the great King Jaja to his abduction in 1887, the Wilkins Commission of 1958, the 1992 Rio-De Janeiro 1st Earth Summit and between 1991 and 1998 when the Ijaw National Congress (INC) dialogued on various platforms, lack of trust in the government's engagement process and perceived insincerity on the part of other actors. Examples are MOSSOP, Ijaw National Congress (INC), etc.

Self-seeking: This group also claims to be pursuing the interests of Niger Deltans, but their modus operandi does not give credence to this assertion. They actively work in consonance with active connivance of godfathers, security agencies and insiders in the oil companies for their own selfish ends. For instance, how else can one rationalize the disappearance of a cargo on illegal bunkering business under security watch without clue? Government Task force members have been implicated in these activities and known to have actively aided and abetted petroleum pipelines vandalism (Vanguard Newspaper, March 29, 2006). These are militants who place multi million Naira ransoms on kidnapped Oil workers, expatriates and recently the relations of political office holders. They use dynamites on crude petroleum pipelines, overrun oil platforms, wreck havoc on oil workers, vandalize and cart away equipment. The proceeds from these activities are not deployed to any known developmental projects in the region or for any other purpose of benefit to the Niger Delta people. This group is pursuing a selfish personal agenda. A group that sets out to self aggrandize cannot be said to be working for the good of others.

Vengeance-bound: Those in this category are very ferocious and deadly in their operations because they perceive society as being unfair and unkind to them. In this group are those who have been used at one point or the other as thugs by various groupings against their political, social and economic opponents. Their sponsors got them armed for deadly assignments and when their principals met their set targets and objectives, the youths were dumped and left in the cold to care for their needs. Worst still is the seething corruptive tendencies of office holders who used the youths to cow and intimidate their opponents only to turn round to flaunt their ill gotten wealth in a society where three square meals have eluded the common man. The smugglers and illegal bunkerers carry out their activities within the purview of these psychologically traumatized youths whose land these wealth is gotten. This gets them angrier with a resolve to reclaim what they believe is theirs.

In all these scenarios, however, it is increasingly difficult to separate the group(s) genuinely fighting for the dignity of the region from the self serving ones as they operate in a commando like and similar fashion and living in the swamps far from the maddening crowd. The situation becomes more compounded with the various youth groups demanding for the immediate release of their leaders that have been arrested and in government's custody as a pre-condition for a cease fire. For instance, even when Alamesiegha and Dokubo were released, hostage taking and pipelines vandalism have not ceased (Alabi, 2008).

Varying depths and dimensions of youth restiveness

According to Okpara *et al*. (2008) the floodgate of kidnapping activities opened on 12th January, 2006, when members of the Movement for the Emancipation of Niger Delta (MEND), captured Patrick Landry (USA); Nigel Watson-Clark (Britain); Harry Ebanks (Honduras); and Pat Crawley (Bulgaria) at Shell platform in Ekeremor Local Government Area of Bayelsa State. For over three weeks, all efforts to secure the release of the hostages yielded no positive result, as MEND refused to budge. Worst still, the military in attempt to release the hostages lost 14 soldiers on 15th January, 2006. At the burial of the late soldiers on 11th February, 2006, the Commander remarked thus, *It is unfortunate that the 14 soldiers were brought down prematurely, not by enemies, but by their fellow brothers, who had chosen to pursue personal interest through violence* (Okpara *et al*., 2008). Unfortunately, the commander's words failed to make any impact as the spate of kidnapping assumed a more dangerous dimension, and spilled over to states of the federation. Data presented in Figure 2 revealed that about 29 Nigerians, 85 foreigners were kidnapped in 2006, while $506.96 million was the total ransom demanded. Also, about 32 soldiers were killed whilst 10 were injured in 2006. Worst still, there were 65.0 % and 100.0 % increase in the numbers of Nigerians and foreigners, respectively, kidnapped in 2007. More so, there was 100.0 % increase in the total ransom demanded in the 2007. The sudden increase in the demanded ransom may not be unconnected with the class of Nigerian citizens who were kidnapped. For instance, the wife of an oil manger and the mother of ex-governor were kidnapped in the year 2007. Although, neither has the year (2008) ended nor has solution been found to the orgy of youth restiveness and violence in the region, the numbers of Nigerians and foreigners kidnapped as at August 21st , 2008, were 100.0 % and 26.5 %, respectively, higher than those of 2007. Also, there was 85.0 % increase in the ransom in 2008 relative to that of 2007. The increase at a decreasing rate in the number of foreigners kidnapped could be linked to the exodus withdrawal of foreign oil workers and investors from the region and its environs , which has a grave consequence for rural development in particular and national development at large. The apparent increase in the number of Nigerians kidnapped in 2008 could be a reflection of the gradual but determined adoption and entrenchment of kidnapping as a political strategy among the ruling class. For instance, Mrs Felicia Chioma, the mother of one of the members of River State House Assembly was kidnapped, but rather than demanding for money the kidnappers demanded for resignation of the house member (Vanguard, 29th April, 2008). Hence, the restiveness is gradually pushing the Nigeria's nascent democracy to the precipice.

In addition, Data in Table 2 showed that at $p < 0.01$ level of significance that there were significant differences in the number of Nigerians kidnapped between 2006 and 2007 ($F = 12.87$) , the number of foreigners kidnapped between 2006 and 2007 ($F = 13.19$), the number of Nigerians kidnapped between 2007 and 21st August 2008($F = 16.75$), the number of foreigners kidnapped between 2007 and 21st August 2008($F = 8.61$) , amount of money demanded as ransom between 2006 and 2007($F = 7.56$) and amount of money demanded as ransom between 2007 and 2008($F = 8.95$). The foregoing revealed that kidnapping as a new dimension of the youth restiveness is on the increase and is becoming a means of livelihood as many incidences have been reported in other states such Lagos, Enugu, and Anambra. More so, many youths have adopted it as strategy for getting money from their relations. For instance, arrested female kidnappers made the following confession: "*We were three that organized the kidnap but I am the mastermind. I am a 400 level student of Edo State University. I will soon graduate but my aunty has not been assisting me in my education. I needed money to complete my project that was why I organized the kidnap, because I know she is rich, after all, she is a banker* (Sun Newspaper, 22nd August, 2008). The gender dimension of the youth restiveness and social consequences of oil exploration in the region were explored and presented in box 4

Box 4: Gender dimension of the youth restiveness and social consequences oil in the region

The presence of oil and its workers are great distraction to our youths' education. Our girls and boys are abandoning school for casual job which at the long run impede social development. **Participant from Oloibori Beyelsa State**

Almost all the States in Niger Delta fall into educationally less developed area. This is because the oil workers use their money to lure our girls out of school into motherhood, and our boys are seduced into the pursuit of immediate gratification. **Participant from Aleto, River State**

Teenage pregnancy is on the increase because of what the oil workers and their contractors are doing! You see, a man who has only three months to spend here will come deceive school girls with a promise of marriage. Of course, when the girls become pregnant, even before delivery, the man would have gone his way. So, here we have many children whose biological fathers will never be found! **Participant from Amukpe, Delta State**

While male youths who are not employed are involved in arm robbery, sea pirate and other vices, their female counterpart are into sea-shore prostitution with oil workers. ***Participant from- Okirika, River State****.*

Everyday and night our women and girls are being harassed and raped by soldiers who are illegally occupying our land. At various check points, our people are harassed and molested for wearing anything green. For instance, a face cap that was given to me by a pilgrim who just returned from Jerusalem was taken away from me by an army lieutenant at an army check point near Daewoo in Yengoa. He never knew me but I just had to let go—**Sargent Werinipre N. Digifa, the Chairman Supreme Council of Egbesu Assembly Ijaw Rights Activist; culled from The News 11August, 2008.**

Table 2: ANOVA result

Variables	F-value	Level of Sig
Number of Nigerians kidnapped between 2006 and 2007	12.87	0.0012**
Number of foreigners kidnapped between 2006 and 2007	13.19	0.0008**
Number of Nigerians kidnapped between 2007 and 21st August 2008	16.75	0.0041**
Number of foreigners kidnapped between 2007 and 21st August 2008	8.61	0.0034**
Ransom between 2006 and 2007	7.56	0.0012**
Ransom between 2007 and 2008	8.95	0.0049**

Source: Analysis of data from national dailies between 2006 and 21st August, 2008.

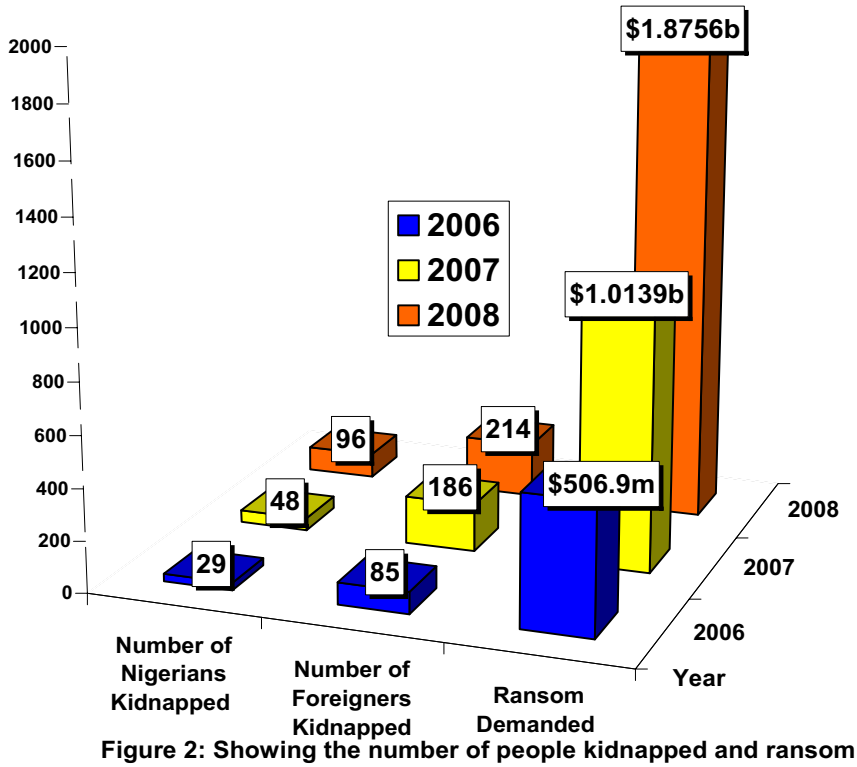

Figure 2: Showing the number of people kidnapped and ransom demanded per year
Source: Analysis of data from National Dailies between 2006 and 21st August, 2008

Economic and socio-politico-cultural implications

The grave consequence of youth restiveness in the region transverses the economic and socio-politico-cultural spheres of Nigeria. According to Omiyi(2008) Nigeria has lost $14.4billion in royalty and taxes as result of the violence. An average of 300,000 barrels per day valued at $458.3 billion is lost to youth restiveness in Niger Delta. Also, the vandalizing of Shell's Utorogbu/Ughelli pipeline led to a lost of 800 megawatts in Egbin Power Station in 2007. In fact, the negative implication of the restiveness for power sector is blindingly obvious. Thus, Lukman, (2007) remarked that *the hope for reliable power supply to the citizenry will remain a pipe dream until the restiveness in Niger Delta is resolved.* Moreover, Angola has over taken Nigeria, which for the past 50 years had remained the number one oil producer in Africa. Worst still, the restiveness has produced unfriendly investment environment as the investors are now leaving the region and its environs in droves. Again some thousands of workers are losing their jobs with the oil companies because of decreased production and harsh operating environment. More so, the erosion of traditional culture of the people has been accelerated by youth restiveness. For instance, kidnapping of aged men and women as well as violation of womanhood are cultural profanations, which the restiveness has bequeathed upon the region.

Interventions of government in the area

The challenge of reversing the fortunes of a people who have suffered deprivation for so long, people whose sources of livelihood have been threatened, and people whose food chains have been broken through a period of 50 years of uninterrupted oil

exploration and exploitative activities is enormous. The Niger Delta region presents a difficult physical environment challenge that was recognized as far back as 1957 by Henry Willink's Minority Commission. The conference in which the Niger Delta people under the umbrella of the then Rivers State Chiefs and Peoples Conference headed by the late Dr. Harold Dappa Biriye, then Mr. J. R. Wilcox convinced the colonial government on the special development challenges in the region. The Commission in one of the paragraphs of their report stated that "it is not easy for a government or a legislature operating from a far inland to concern itself or even fully understand the problems of a territory where communications are so difficult, building so expensive and education so scanty." This has made Federal Government to undertake some interventions which include Niger Delta Development Board (NDDB) in 1961, Oil Mineral Producing Authority Development Commission (OMPADEC) 1992, Directive to some Oil companies to employ a specified number of graduates with concentration from the Niger Delta region. 13% derivation to the Oil producing states. Also, the Federal government in an attempt to get a full grasp of the land and sea rights to enable it get full control over the region had at one time or the other decreed or enacted the following legal and institutional framework, Mineral/Petroleum Act of 1969, Land Use Act of 1978, Oil Pipelines Act of 1990, The Petroleum Act of 1991, The Lands (title vesting) Act of 1993, The National Inland Waterways Authority Act of 1996. But then, positive impacts of these interventions were mediated by some critical factors. For instance, Niger Delta Development Board 1961 was swept out at the dissolution of the First Republic (Alabi, 2008). Moreover, the Niger Delta River Basin Authority, 1976 that was to undertake comprehensive development of both surface and under ground water resources for multi-purpose use was place in category D, which received little or no fund (Akindele and Adebo, 2004)

The recent intervention is Niger Delta Development Commission (NNDC) 1999, which is expected to kick start the implementation of 15 years Master Development Plan for the region. Although, NDDC claimed to have executed three hundred and thirty four projects across the region, the region is still parading pervasive poverty and neglect. This may not be unconnected with the fact that evaluation of performance of projects in the region has been based on amount of money allocated to the projects and the amount spent. This has invariably made figures of budgetary allocations the measure of development which has become a provocative abstract term to the people of the Niger Delta. Therefore, the principle of participatory rural community development that makes man the index of development is desirable in the Niger Delta. In other words, the various governmental interventions which for too long, had sought to assess performance in the resolution of the crisis by the quantum of money going into the Niger Delta should be reversed. This is because in spite of the supposedly big budgetary allocations, virtually all surveys on human development index in the country have returned a damning report on the Niger Delta (FOS, 1999). While the national average index in these surveys are unacceptable, the return for the Niger Delta is most appalling when contrasted to the resources the nation daily derives from the area. Education, health and youth development are crucial to a successful transformation of the population from one that holds the nation in suspect to one that collaborates with the state for security and rapid development. In essence, emphasis should be on the percentage of children of school age who are in school; percentage of employable youths who are gainfully employed, percentage of improvement in infant mortality rate, reduction in the population of citizens living with HIV/AIDS;- rather than the millions or billions of naira going into the Niger Delta.

Imperatives for Niger Delta's community development.

Majority of people in Niger delta live in rural areas. Over eighty percent of the rural dwellers live in poverty (Ekong, 2003). The region has repute for lack of adequate transportation, health, education or other infrastructure as a result of decades of neglect by

the central governments and petroleum prospecting companies (Wikkipedia, 2008). The local population engages in farming and fishing on a subsistence and commercial level). The landscape is filled with thousands of young men and women who have been made jobless by the degradation of the environment, making farming or fishing impossible. Infrastructural development is almost absent. Poverty virtually walks the street. Children mostly scantily dressed and in clear need of better nutrition dot the landscape. These make rural development in the region imperative. Development is a multi-dimensional concept. Nonetheless, it is herein viewed as the process by which member of a society increase their individual and institutional capacities to mobilize and management resources to produce sustainable and justly distributed improvements in quality of life consistent with their own aspirations (Carley and Christie, 1992). Also, rural community development is construed as the transformation of a rural community into socially, economically, politically, educationally, orderly and materially desirable condition, with the purpose of improving the quality of life of the rural population (Jibowo, 2002). So, to achieve rural development and peace in the region, each stakeholder must fulfill the following conditions numerated during FGD sessions presented in box 5.

Conclusion

This study accentuated the adage that says that *infractions arises in a society in response to a certain degree of chronic deprivation; reduce privations and the demeanor diminishes accordingly*- donkey's years of neglect in Niger delta whilst farm lands, houses, sea food amongst other means of livelihoods were and are being swept away by oil exploration and pollution, were found to be causes of youth restiveness. It showed that the restiveness is supported by some soldiers and politicians who connived with the militants and international agents to perpetuate oil bunkering and election rigging. But then, the consequent loss in terms of human and non human resources has resulted in the Nigeria State's slouching towards abyss. Also, the study revealed that government interventions were being assessed by the amount of money allotted to the region, rather than human development index as enshrined in the principle of participatory rural community development. Since the progress of Nigeria State is tied to Niger Delta, It, therefore, concluded that the development of Niger Delta through participatory rural development approach is an investment to be leverage rather than a cost to be justified.

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Selected Fuel Properties of Biodiesel Produced from Shea Butter Oil and Palm Kernel Oil

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Abstract
Tranesterification reaction was carried out on raw shea butter oil (SBO) and palm kernel oil (PKO) to separate the ester from glycerol using ethanol in the presence of potassium hydroxide as catalyst. The properties of bio diesel (ethyl ester) obtained from varying proportions of diesel were experimentally determined and compared with that of conventional diesel. Four blends (10, 20, 25 and 30%) of SBO and PKO by volume with diesel oil were used. The properties determined are viscosity, relative density, cloud point, pour point, flash point and specific gravity. The experimental result shows that viscosity and relative density of PKO and SBO are higher compared with that of conventional diesel. The specific gravity of PKO (0.8950) and SBO (0.8940) are higher than that of diesel fuel (0.8616). The cloud point obtained at ambient temperature for PKO 5^{o}C is the same with diesel fuel while similar value of 6^{o}C which was 20% higher than that of diesel fuel was obtained for SBO. The viscosities of the blends increase as the oil content in the blends increase at 40 ^{o}C but viscosities decreases with increase in temperature. The specific gravity of the blend 10, 20, 25% of PKO and SBO are in the same range with the diesel fuel except for blend with 30% of PKO and SBO which was relatively higher than that of conventional diesel. The flash point obtained for all the blends are higher than that of conventional diesel. Based on the findings of this study, blend with 10, 20 and 25% of PKO and SBO content were found to have acceptable fuel properties for use in internal combustion engine.

Keywords: Diesel, shea – butter oil, palm kernel oil, biofuel

Introduction

Diesel is an important working fluid of most power machines such as tractors, trucks and earth moving equipment due to the advantage of longer life of engines, maximum power output, fuel economy and its working efficiency, These factors have made the demand of diesel fuel very high throughout the world. Diesel oil used as fuel is one of the fractions of crude oil which are regarded as fossil fuel.

In 1973 the oil producers of Middle East who supplied a large portion of crude oil used in the western world decided to cutback production of crude oil and at the same time greatly increased its price overnight thus a cheap and abundant raw material became expensive and unsecured. Long term effect of burning fossil fuel from human activities on earth's climate has remarkable impact on the global, world. Industrial development is accompanied and made possible by the exponential growth in energy consumption, which in turn has resulted in pollution, concentration of carbon dioxide and other green house gases that act to keep the planet warm and are increasing rapidly.

Ever since then, there has been a search on the way and means to reduce this pollution from the exhaust of automobile as well as their effects. In 1911 Rudolf Diesel practicalised and confirmed the possibility of using vegetable oil as fuel for diesel engine. This has given challenges on trying different types of vegetable oil, some of which include the use of soybean oil which was used to run diesel engine (Ali *et al*., 1995., Neihouse *et al*., 1986., Schlantman *et al*., 1986; varde 1984; Gearing and Fry, 1984). Cotton seed oil has also been used to run a single cylinder engine (Mazed *et al.* 1985, Masjuku and Saupuan 1993). Some other oils such as

rapeseed oil, sunflower oil, coconut oil have also been tested. Ethanol has also been identified as one of the possible alternative fuels (Yahya and Goering, 1977).

Biodiesel

Biodiesel is an environmentally friendly alternative diesel fuel consisting of the alkyl monoesters of fatty acids. It is obtained from triglycerides through the transesterification process. It is completely soluble in commercial petroleum-based diesel fuel, therefore biodiesel can be used as a blend and one fuel tank can be used for storage of both fuels. This makes the vehicle flexible. This is a unique advantage compared with most other alternative fuels, as no extra cost for engine modifications is avoidable. Biodiesel has been standardized by ASTM standard D 6751-02 in 2002 and in Europe DIN V 51506 in 1994. Many large engine and car manufacturers have included biodiesel fuel in their warranties (Korbitz, 1999). Depending on the trade-off between cost and its environmental benefits, biodiesel is most commonly used in the United States as a blend with No. 1 or No. 2 diesel fuels.

The advantageous features of biodiesel result from the fact that biodiesel has different physical and chemical properties from petroleum-based diesel fuel. Eleven percent of biodiesel is oxygen by weight and this appears to result in more complete combustion. Also, it has a higher cetane number that makes the combustion smoother and the engine is less noisy. However, biodiesel has higher values of viscosity, density, speed of sound, and bulk modulus that may cause changes in the injection system and combustion system behavior (Tat and Van Gerpen, 1999; Tat and Van Gerpen, 2000a; and Tat *et al*., 2000b). Fuel quantity, injection timing, and injection spray pattern in the combustion chamber are directly affected by these parameters. Biodiesel's lower heating value is about 12% less than petroleum-based diesel fuel and this causes a power loss that must be compensated for by increasing the injected fuel amount. When injecting this greater quantity of fuel, some fuel injection systems start the injection earlier and hold the injection needle open longer, changing the fuel injection timing and the start of combustion timing. These differences in physical properties may shift the engine timing settings from their optimized factory settings, leading to earlier combustion. Biodiesel is renewable, biodegradable, non-toxic, and typically produces about 65% less n

Shea Nut

Shea nut (vitellaria paradox) is of a botanical family *sapoteceae* and has a botanical name Butryospermum parkli. Other names are Karite (French), Nku (Ghana), Igba (Nigeria), Shea butter tree and bambuk butter tree. The tree can be found growing naturally in the southern region of the sahel and the northern regions of the Guinea Zone. It thrives in savanna areas where oil palm cannot grow due to low rainfall (GTZ, 1986). The major producing countries are West African countries (Mali, Burkina fasso, Benin, Senegal, Ivory Coast, Ghana and Nigeria). Shea butter is basically composed of fatty acids, stearic acids and oleic, which together account for 85-90% of the total fatty acids. Shea butter with a higher oleic content is known to be softer than one with a lower oleic content. The oleic content and stearic content of West African Shea Nut Butter ranges from 37 to 55% and 25 to 50% respectively (Maranz *et al*., 2004). Once the shells are removed, the shea kernels are dried and if properly done, the dried kernels have a shelf life of 5 years or more (Maranz *et al*., 2004).

The equipment for primary processing include pan for boiling water, drying mat, hammers, pestles, winnowing basket, and claypot. The pulps of the harvested berry are being crushed under foot after fermentation. This berry (almond) sticks to the shell wall. To separate them, the nuts are immersed in boiling water and sun dried for a few days (Alonge and Olaniyan, 2007). Shelling of the nuts is traditionally carried out using stone, hammers and pestles. This process can also be carried out mechanically. Winnowing is achieved by holding basket filled with nut at arm length and gradually emptying them. The number of times the winnowing is done depends on the prevailing wind speed (Fleury, 2000). The shelled almonds are dried again from a moisture content of 40- 50% to 6-7% prior to extraction (Godwin and Spensley, 1971).

Oil extraction can be done in two ways; a traditional village process and mechanically. Figure 1 shows the stages involved in traditional method. This method, which is predominant in Nigeria, is time consuming and human energy-sapping. Some of the problems inherent in the traditional methods are those involving mesocarp removal, drying, shelling, winnowing, crushing, mixing and temperature control (Babatunde and Olaoye, 1997; Alonge and Olaniyan, 2007). A mechanized method, which is less time consuming and having only 4 stages, has been developed by the Royal Tropical Institute in the Netherlands (Fig. 2). In this method, the kernels are pounded to a fine powder and then heated to a temperature of 100°C. It is then kept hot in a hot air oven for 1 hour before being pressed in a hydraulic press.

Palm kernel

Palm kernel oil production as a whole consists of seven readily defined unit operations namely: palm-nut drying, palm-nut cracking, palm-kernel roasting, palm-kernel crushing, PKO sifting and PKO bottling/pumping. PKO is a white to yellowish oil of vegetable origin which is solid at normal temperatures and is obtained from the kernels of the oil palm (*Elaeis guineensis*). The heating value of PKO is about 39.7 MJ/kg. From a previous work (Jekayinfa and Bamgboye, 2004, 2007), it was reported that the fossil energy requirement in the production of PKO is between 0.1 and 0.16 MJ/l depending on the category of the PKO mill. The percentage of oil extracted per kilogram of kernels is between 19.5% and 21.5%. Three distinct categories of PKO mills exist in Nigeria (Jekayinfa and Bamgboye, 2008). These are small, medium and large scales based on their production capacity and mechanization level of their operations. Table 1 shows the past performances of Nigeria in world production of palm-kernel

The objective of this work is to study the fuel properties of shea butter oil and palm - kernel oil blended with diesel fuel and compare these properties with those of the conventional diesel fuel.

Materials and methods

Experimental materials and procedures

Samples of shea butter oil and palm kernel oil used for the experiment were purchased at a local market in Ogbomoso, Nigeria. The oil samples were subjected to frying to allow them loose most of their absorbed moistures. The samples were then filtered to remove dirty particles. 100g each of SBO and PKO was used for tranesterification process. The ethanol used for the experiment was also obtained from the same source and it was made from sugar cane. The ethanol used is 99% pure and has a boiling point of 78°C. The KOH used was also an analytical grade. Materials used in the course of the study include a dry and wet mill blender,

scales, measuring beakers, translucent white plastic container with bung and screw on cap, funnels, PET bottles, duct tape and thermometers.

Four blends of diesel fuel with SBO and PKO were used. They were obtained by mixing the oil and diesel by volume in the following proportions:

I 10 percent oil and 90 percent diesel

II 20 percent oil and 80 percent diesel

III 25 percent oil and 75 percent diesel

IV 30 percent oil and 70 percent diesel

The properties of SBO without the addition of diesel were also tested. Laboratory KOH catalyzed transesterification tests were then carried out using ASTM standard.

Results and discussion

Specific Gravity

This is one of the most basic and important properties of fuel because of it is connected with some other important properties of fuel such as cetane number and heating values (Tat and Van Gerpen, 2000; Ajav and Akingbehin, 2002; Alamu *et al*., 2007), and fuel storage and transportation (Yuan *et al.*, 2004). The specific gravity values for diesel, SBO and PKO are presented in Table 2, while similar values for biodiesel of SBO and PKO are presented in Tables 3 and 4 respectively. These results revealed that the specific gravity values recorded for the PKO and SBO biodiesel are higher than the values obtained for the petroleum diesel. These results agree with earlier reports by several workers on the subject matter (Peterson *et al*., 1990; Graboski and McCormic, 1998; Yuan *et al*., 2004; Alamu *et al.*, 2007).

The specific gravity values at PKO/diesel ratio of 1:9, 1:4, 1:3 and 3:7 are 0.869, 0.867, 0.868 and 0.889 respectively. Similar values for SBO/diesel are 0.860, 0.864, 0.867 and 0.899 respectively. These values of specific gravity obtained for both biodiesels fall within the limit specified for biodiesel fuels (0.87 – 0.90) by the BIS Standard (Chitra *et al*., 2005; Knothe and Steidly, 2005).

Relative density

The relative densities of diesel, SBO and PKO are shown in Table 2, while similar values for biodiesel of SBO and PKO are presented in Tables 3 and 4 respectively. It can be observed from Table 2 that the relative densities of diesel, SBO and PKO are 0.8442, 0.855 and 0.856 respectively. These values are not significantly different. With the addition of diesel, the relative densities of the oil-diesel blends changed depending on the proportion of diesel in the mixture. As shown in Tables 3 and 4, it can be observed that as the percentage of diesel in the blends increased, the relative densities increased. Methyl esters have been reported to have a specific gravity of approximately 0.88kg/dm^3, while that of ethyl esters is slightly lower (Riva and Sissot, 1999). This finding compares well with those earlier reported by Ajav and Akingbehin (2002), Ali and Hanna (1996), and Peterson et al. (1986). When these results are compared with that of diesel, the difference is not significantly different based on statistical analysis at 5% level of significance.

Viscosity

Viscosity is the measurement of the internal flow resistance of a liquid and of remarkable influence in the mechanism of atomization of the fuel spray. The viscosities of diesel, SBO and PKO at 40°C and 100°C as presented in Table 2 are 5.01, 15.8, 16.6 and 1.52, 9.1, 10.8 respectively. Similar values for the blends of SBO and PKO with diesel at different diesel proportions are presented in Tables 3 and 4 respectively. The viscosities of SBO and PKO biodiesels decreased as the percentage of diesel increased. At 40°C, the viscosities of 70, 75, 80 and 90% blends of SBO and PKO were 10.4, 6.02, 5.66, 5.31 and 10.5, 6.0, 5.34, 5.28 respectively. Similar values at 100°C are 2.85, 2.03, 1.69, 1.6 and 2.93, 2.0, 1.7, 1.6. These observed viscosity values at the two temperature regimes agree closely with a number of earlier works on other oil crops as well as series of Alcohol-Diesel blends. From these results, it can be shown that PKO and SBO biodiesels have higher viscocities than conventional diesel fuel, in agreement with observations of earlier workers (Peterson *et al*., 1995; Graboski and McCormic, 1998; Yuan *et al*., 2004; Knothe and Steidley, 2005; Lebedevas and Vaicekauskas, 2006; Alamu, 2007).

Pour Point

Pour point is the temperature at which wax becomes visible when the fuel is cooled. From the data presented in Tables 3 and 4, it is observed that the pour points obtained for the PKO and SBO biodiesel at different diesel/vegetable oil ratio are higher than that obtained for the conventional petroleum diesel. These results for pour point are consistent with earlier findings on such biodiesel fuel like ethyl and methyl esters of rapeseed, canola, beef tallow, soybean and Midwest biofuels methyl soyate (Peterson *et al*., 1990), ethyl ester of frying oil (Graboski and McCormic, 1998), methyl esters of palm kernel oil and coconut oil (Abigor *et al*., 2000) as well as butyl ester of soybean (Schwab, 1987) amongst others.

Cloud Point

This is the temperature at which solidification of heavier components of the produced biodiesel fuels resulting in a cloud of crystals within the body of the fuels first appeared. The results of cloud points obtained at different diesel/vegetable oil ratios as shown in Tables 3 and 4, are consistent with earlier findings on such biodiesel fuels like methyl soyate (Peterson et al., 1990), ethyl ester of frying oil (Graboski and McCormic, 1998), methyl esters of palm kernel oil and coconut oil (Abigor et al., 2000). However the cloud points obtained for both biodiesel fuels of SBO and PKO at different combinations are lower than 5°C in all cases.

Conclusions

The following conclusions can be drawn from the laboratory scale production of ethyl esters of PKO and SBO.

- The specific gravity values recorded for the PKO and SBO biodiesel are higher than the values obtained for the petroleum diesel. These results agree with earlier reports by several workers on the subject matter
- The relative densities of diesel, SBO and PKO are 0.8442, 0.855 and 0.856 respectively. These values are not significantly different. With the addition of diesel, the relative densities of the oil-diesel blends changed depending on the proportion of diesel in the mixture.
- The viscosities of diesel, SBO and PKO at 40°C and 100°C are 5.01, 15.8, 16.6 and 1.52, 9.1, 10.8 respectively. The viscosities of SBO and PKO biodiesels decreased as the percentage of diesel increased.

- The pour points obtained for the PKO and SBO biodiesel at different diesel/vegetable oil ratio are higher than that obtained for the conventional petroleum diesel. These results are consistent with earlier findings on such biodiesel fuel like ethyl and methyl esters of rapeseed, canola, beef tallow, soybean, Midwest biofuels methyl soyate, frying oil ,and coconut oil .
- The cloud points obtained for biodiesel fuels of SBO and PKO at different combinations are lower than 5°C in all cases.

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Table 1: Fatty acid profile of SBO and PKO

Fatty acid type	Percentage	
	SBO	PKO
Palmitic	5.3	8.4
Stearic	1.5	2.5
Oleic	13.5	15.3
Linoleic	15.6	2.3
Alpha alpha Linolenic	62.2	-
Arachidic	0.1	-
Lauric	-	48.2
Myristic	-	16.2
Capric	-	3.4
Caprylic	-	3.3

Table 2: Properties of diesel fuel, SBO and PKO

Properties	Diesel Fuel	SBO	PKO
Relative Density @15 ^{0}C	0.8442	0.8560	0.855
Viscosity @40 ^{0}C	5.01	16.60	15.80
Viscosity Index	86	97.00	96.0
Flash Point ^{0}C	55	260	250
Pour Point ^{0}C	- 25	- 18	-12
Specific Gravity	0.8616	0.894	0.895
Colour	Translucent brown	Pale yellow	Pale yellow

Table 3: Properties of Blends of Biodiesel of SBO with Diesel Fuel

Parameters	Blends of Biodiesel of SBO with Diesel Fuel					
	[1]SB 0% [2]D 100%	SB 100% D 0%	SB 10% D 90%	SB 20% D 80%	SB 25% D 75%	SB 30% D 70%
Viscosity @40^{0}C (cSt)	5.01	16.6	5.31	5.66	6.02	10.42
Viscosity @100^{0}C (cSt)	1.52	10.8	1.60	1.69	2.03	2.85
Viscosity Index	86	97	87	88.5	90	116
Specific gravity @15^{0}C (kg/dm^3)	0.8616	0.8940	0.8600	0.8640	0.8670	0.8990
Pour Point (^{0}C)	- 25.00	- 18.00	- 24.00	- 23.86	- 22.80	- 21.72
Flash Point (^{0}C)	55	260	67	80	95	118
Relative Density@32^{0}C	0.8442	0.8563	0.8330	0.8289	0.8270	0.8261
Could pount Cloud Point (^{0}C)	5	5 5	5	5 5	5 5	Oooooo5 5

[1]Shea butter oil

[2] Diesel

Table 4 : Properties of Blends of Biodiesel of PKO with Diesel Fuel

Parameters	Blends of Biodiesel of SBO with Diesel Fuel					
	[1]PK 0% [2]D 100%	PK 100% D 0%	PK 10% D 90%	PK 20% D 80%	PK 25% D 75%	PK 30% D 70%
Viscosity @40^{0}C	5.01	15.80	5.28	5.34	6.00	10.51
Viscosity @100^{0}C	1.52	9.10	1.60	1.70	2.00	2.93
Viscosity Index	86	96	85	87	97	106
Specific gravity @15^{0}C	0.8616	0.8950	0.8690	0.8670	0.8680	0.8890
Pour Point ^{0}C	- 25.00	- 12.00	- 24.92	- 23.91	- 22.89	- 21.79
Flash Point ^{0}C	55	250	65	78	91	110
Relative Density@32^{0}C	0.8422	0.8550	0.8340	0.8314	0.8306	0.8286
Could pount Cloud Point ^{0}C	5 5.00 5.00	5 6.00	5.20	5.10	5 5.00	Oooooo5 4.85

[1]Palm Kernel oil

[2] Diesel

Sorghum and sugar cane as additives to guinea grass (*panicum maximum* jacq.) in silage making

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Abstract

An experiment was conducted to assess the contribution of Sorghum and Sugarcane as additives to guinea grass during silage making. A guinea grass pasture was established at the Teaching and Research Farm, Obafemi Awolowo University Ile- Ife, Nigeria. Harvesting of the grass pasture was carried out at six weeks of growth for silage production. Coarsely ground Sorghum grain and chopped Sugarcane (1 – 3 cm) were added as additives to guinea grass in a stack silo in a completely randomized design to formulate four treatments as follows: Treatment A = 30 % w/w Sorghum + Guinea grass, Treatment B = 20 % w/w Sugarcane + Guinea grass, Treatment C = 15 % w/w Sorghum + 10 % w/w Sugarcane + Guinea grass, Treatment D = Guinea grass without any additive (control). The experiment lasted for 16 days, after which samples were taken for pH, proximate and neutral detergent fibre (NDF) analyses. Results obtained from the ensiled grasses recorded a pH range of 3.6 – 4.0. The best ($P < 0.05$) silage production was recorded for treatment B, having the highest crude protein value of 16.17 %, least crude fibre and NDF contents of 9.11 % and 39.55 % respectively. The result indicated that inclusion of sugarcane at the rate of 20 % w/w appears suitable as additive in ensiling guinea grass.

Key words: Guinea grass, Silage, Sorghum, Sugar cane.

Introduction

Several constraints affecting ruminant livestock production in the humid forest zone are as varied as disease, management, climate, genetic potential of the indigenous breeds and feed. Of all these, feed accounts for 60-90% of the cost of production (Food and Agricultural Organization(FAO), 1982), which makes it the most limiting factor (Adebowale, 1985) especially during the dry season when supplies are grossly inadequate to sustain the growth of these livestock. The tropical grasses, which forms the major part of the livestock diet, are early maturing but with a correspondingly sharp decrease in their nutritive value (Akinola, 1974). Livestock loose weight in the dry season due to nutritional imbalance in the available feed (Preston and Leng, 1987) and so, the growth experienced at the onset of raining season by ruminants in the developing countries is not true growth but recuperated growth. Therefore, a means of preserving the excess forage during the period of abundance will ameliorate the problem of feed scarcity during drought and consequently serve as a boost to livestock production.

Silage is a major form of forage conservation which has the advantage of the forage not being exposed to the effect of weather damage, leaf – shattering or bleaching which is a common occurrence during hay making. Various additions to silage have been suggested as methods to improve or alter the fermentation process but the benefits obtained from such additives depend upon their influence on the fermentation process which is usually measured by the reduction in fermentation losses and/or improvement in

silage quality and feeding value (Schroeder 2004). One of the most commonly used additives during ensilage is molasses, a by – product of sugar processing. Use of molasses as additive in silage – making is common in laboratory experiments but it is not readily available to the common subsistence farmers who would adopt silage making process as a means of feed preservation. Hence, other sources of additives apart from molasses will ameliorate the problem of seasonality of livestock feed. Sorghum grain has been reported to aid good silage making (Barney, 2003), but information on the suitability of sugarcane as silage additive is scarce. The objective of this study therefore, was to determine the suitability of sorghum and/ or sugar cane as additives in silage – making.

Materials and Methods

The experiment was conducted on the pasture plot of the Obafemi Awolowo University Teaching and Research Farm, Ile-Ife, between May and October, 2007. A total land area of $162m^2$ was used. Land preparation was manually done after which the plot was divided into nine sub–plots measuring 3m x 6m each. Guinea grass was vegetatively propagated with 4 – 6 tillers per stand at planting distance of 0.5m x 1.0m. Cutting back of the grass pasture was delayed till four weeks of growth to allow for root development and proper consolidation. In the fifth week of establishment, pasture was fertilized with NPK 15:15:15 fertilizer at the rate of 200kgN/ha. The grass pasture was then harvested at six weeks after the first cut-back to determine the forage yield and chemical composition of the grass. The harvested forage was thoroughly mixed and sub–samples were taken for dry matter determination using a Gallenhamp oven at 60°C (for about 96 hours) until a constant weight was obtained. The dry samples were then analyzed for proximate composition using the method of AOAC (1990). Neutral detergent fibre (NDF) was determined according to the procedure of Van Soest *et al.* (1991). The bulk of the harvested forage remaining was air-wilted for 24 hours and then chopped to 5 – 10 cm to allow for easy compaction. Sugarcane was prepared by chopping it to 1 – 3 cm length and sorghum grain was coarsely ground using a locally fabricated Burr/ plate mill machine.

Silage Production

Four treatments were formulated in three replicates for ensiling process as follows:

Treatment A = 30 % w/w Sorghum + Guinea grass

Treatment B = 20 % w/w Sugarcane + Guinea grass

Treatment C = 15 % w/w Sorghum + 10 % w/w Sugarcane + Guinea grass

Treatment D = Guinea grass without any additive (control)

Ensiling was done in a stack silo, using plastic bags for 16 days. The pH of the ensiled forages was recorded on the 17^{th} day, marking the termination of the silage process. Experimental design was completely randomized.

Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA), according to the procedure of SAS (1999) and the treatment means, where significant, were compared using Duncan's Multiple Range Test of the same package.

Results

The forage yield of the guinea grass plot was 5,678 kg DM / ha. The silage pH value obtained ranged from 3.6 – 4.0 with the physical appearance of the silage produced being greenish brown in colour and mild pleasant aroma. The proximate composition of the freshly harvested guinea grass is shown in Table 1. The grass pasture recorded a dry matter content of about 26.0 g/100g and crude protein (CP) value of 16.5 g/100g DM.

Table 2 compares the proximate composition of the ensiled guinea grass and the freshly harvested guinea grass. The freshly harvested grass (Treatment E) recorded the highest ($P < 0.05$) crude protein value of 16.53 g/100g DM while the least crude protein (CP) was obtained for the ensiled guinea grass without any additive (Treatment D) but the difference between the crude protein content of Treatment B and Treatment E was not significant ($P > 0.05$). The ensiled guinea grass in Treatments A and D recorded the highest crude fibre values which were not significantly different ($P > 0.05$), while the least crude fibre value ($P < 0.05$) was obtained for the ensiled guinea grass in Treatment B. The highest ($P < 0.05$) ether extract value of 7.27 % was obtained in Treatment B and the least (2.17 g/100g DM) in Treatment E. Treatment D had the highest ($P < 0.05$) ash content of 10.31 %, followed by Treatments E and D with the least (5.25 g/100g DM) obtained for Treatment B. The highest ($P < 0.05$) NFE value of 53.80 g/100g DM was obtained for Treatment B and least observed for Treatment A (34.98 g/100g DM).

The Neutral detergent fibre (NDF) content of the silage is presented in Table 3. There were significant differences ($P < 0.05$) in all the treatments, with the highest value (92.77 g/100g DM) recorded for Treatment E and the least (39.55 g/100g DM) obtained for Treatment B.

Figure 1 compares the proximate composition of the guinea grass ensiled with sorghum and sugar cane as additives. Treatment B had the highest dry matter, crude protein and NFE contents, as well as recording the least crude fibre content.

Discussion

The 6 – week regrowth harvest used in this study was meant to depict a late season harvest at which time forage conservation would be necessary to mitigate the effect of dry season on the livestock. The observed value compares well with 6,800 kg/ha reported by Omaliko (1980) but was lower than the 16.1 tonnes/ha reported by Oyenuga (1960). The success of an ensiling process is closely associated with the pH of the fermented forage and a pH range of 3.5 to 4.5 was reported to be the ideal pH for storing good silage (Barney, 2003). The silage pH value obtained in this study connotes a good fermentation process and stable silage, where the activity of moulds and bacteria would be almost dormant (Bolsen, 1995). The greenish brownish colour and mild pleasant aroma produced by the silage indicates a good silage colour for grasses and normal lactic acid fermentation (Top fodder silage, 2008).

The 26.0 % dry matter content obtained is close to the value of 30 – 40 % reported by Barney (2003) to produce good silage. The high crude protein (CP) value obtained may be a reflection of the soil nutrient level that has received a boost through the application of the inorganic fertilizer. The loss in the CP content of the silage may be as a result of seepage loss during the ensiling process (Schroeder, 2004), while the inclusion of sugarcane in the silage appears to ameliorate this condition. The high content of water soluble carbohydrates in sugarcane might have played a role in the reduction of the seepage loss and reduced crude fibre content obtained for silage in treatment B. A positive correlation seems to exist between the crude fibre and the ash contents of the silage as they follow similar pattern in their responses to the additives added to the forage. Expectedly, a similar trend was observed for the results of the Crude fibre and NDF of the silage. NDF is a measure of the forage cell wall content and it

is inversely related to the forage intake and digestibility (McDonald et al., 1995; Gillespie, 1998). The sugarcane caused a sharp decline in the cell wall content of the silage. Animals offered sugarcane – based silage (Treatment B) are expected to have a better intake and digestibility than other group, as well as better growth.

Table 1: Proximate composition of the guinea grass forage

Nutrients	Composition (g/100g DM)
Dry matter (DM)	25.80
Crude protein (CP)	16.53
Crude fibre (CF)	25.93
Ether extract (EE)	2.17
Ash	8.32
Nitrogen free extractives (NFE)	40.65

Table 2: Proximate composition (g/100g) of the fresh and ensiled guinea grass on dry matter basis

Treatment	Crude protein	Crude fibre	Ether extract	Ash	NFE
A	13.26^{c}	27.67^{a}	6.00^{c}	8.30^{b}	34.98^{d}
B	16.17^{a}	9.11^{d}	7.27^{a}	5.25^{d}	53.80^{a}
C	14.94^{b}	17.71^{c}	5.22^{d}	5.84^{c}	47.48^{b}
D	7.30^{d}	28.03^{a}	6.61^{e}	10.31^{a}	38.64^{c}
E	16.53^{a}	25.93^{b}	2.17^{e}	8.32^{b}	40.65^{c}
SEM	0.228	0.348	0.066	0.083	0.725

A = 30 % sorghum + guinea grass, B = 20 % sugarcane + guinea grass, C = 15 % sorghum +10 % sugar cane, D = guinea grass without additives, E = Fresh unensiled guinea grass

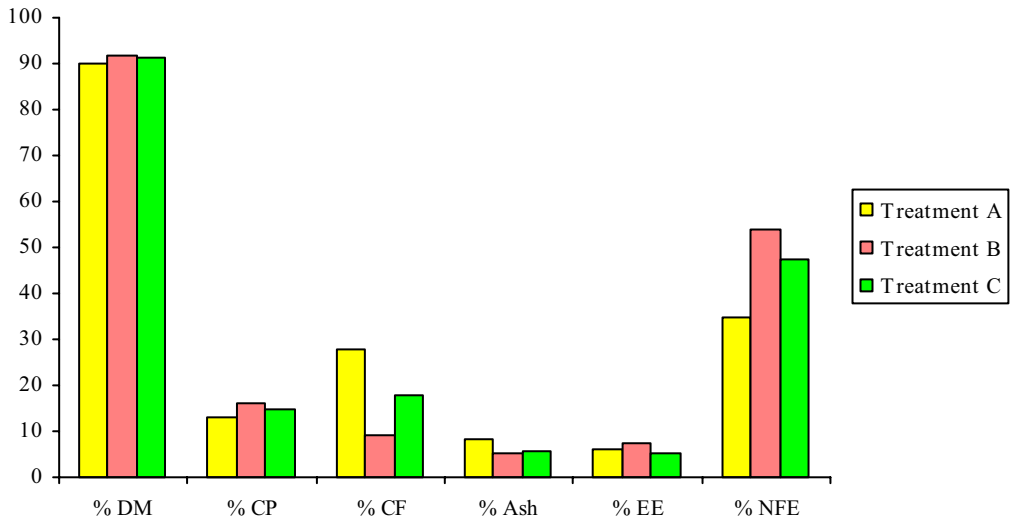
^{a,b,c,d} Means within the column having different superscripts are significantly different ($P < 0.05$).

Table 3: Total cell wall contents of the fresh and ensiled guinea grass

Treatment	NDF (g/100g DM)
A	82.11^{b}
B	39.55^{e}
C	68.69^{d}
D	73.48^{c}
E	92.77^{a}
SEM	0.643

A = 30 % sorghum + guinea grass, B = 20 % sugarcane + guinea grass, C = 15 % sorghum +10 % sugar cane, D = guinea grass without additives, E = Fresh un-ensiled guinea grass

^{a,b,c,d} Means with different superscripts are significantly different ($P < 0.05$).



Treatment A = 30 % sorghum + guinea grass, Treatment B = 20 % sugarcane + guinea grass,
Treatment C = 15 % sorghum +10 % sugar cane
Figure 1: Proximate composition of the ensiled grass forage with sorghum and sugar cane

Conclusion

The crude protein content of the guinea grass silage with sugar cane as additive compares well with the crude protein content of the fresh grass. Also, the inclusion of sugar cane in the ensiled guinea grass reduced the cell wall contents of the forage drastically. Addition of sugar cane to guinea grass at a rate of 20% w/w appears suitable in ensiling stable silage with good keeping quality.

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Decline In Crop Productivity In Nigeria: A Review Of Possible Strategies To Promote Self Reliance, Sustained Production and Environmental Security

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Abstract

Nigeria agriculture is characterized by multiple cropping, small holder scattered over wide expanse of land area, with small holding ranging from 0.05 to 3.0 hectares per farm land, rudimentary cropping systems, low capitalization and low yield per hectare. The sector in Nigeria economy provides primary means of employment for Nigerians and accounts for more than one-third of total Gross Domestic Product (GDP) and labour force. It shared about 90% GDP before independence in 1960, 56% between 1960—1969 and 40% since 1986 (CBN, 2003). Decline in the performance of this sector in both gross domestic product and export earnings is reflected in the slower growth of the sector relative to other sectors of the economy, environmental degradation, rapid climatic changes, mounting food deficits, farmer's inability to replenish nutrients lost in the continuous cultivation, attributed to lack of adoption of modern farming technologies while retail food prices and import bills have been increasing. These effects have further impoverished the smallholder farmers, locking them into a poverty web. National strategic importance of food is evident in its consideration as a key variable in matter relating to national security and in planning against disaster and other emergencies. How- ever, a major indicator of depressed performance of the Nigeria agricultural sector is the food crisis experienced in the country in recent time. The need to establish national agricultural development strategies directed towards self reliance, sustained and improved productivity of smallholder production systems and environmental security

Introduction

Nigeria has an agrarian economy before the boom in the oil market in the late 1970. According to Ogundari and Ojo (2007), Nigerian agriculture is characterized by a multitude of small scale farmers scattered over wide expanse of land area, with small holding ranging from 0.05 to 3.0 hectares per farm land, rudimentary farm systems, low capitalization and low yield per hectare. The roles of agriculture remain significant in the Nigerian economy despite the strategic importance of the oil sector. The agricultural sector provides the primary means of employment for Nigerians accounting for more than one-third of total Gross Domestic Product (GDP) and labour force (FAO, 2003; World Bank, 2003). The agricultural share of the GDP stood at about 90% before independence in 1960, about 56% between 1960—1969 and more than 40% since 1986 (CBN, 2003). Hence agriculture plays basic role in kick-starting economic growth and reducing poverty and hunger in many developing countries (Hazell, 2005) especially in Nigeria before the advent of crude oil.

Decline in Agricultural Productivity in Nigeria: Production is a most obvious output and measure of the activity of a farming system. It can be measured as the biological or economic output from the system, for example as the grain or cash generated. It is implicitly an output from the activity of one or more management units (e.g., families). It is also a measure of the efficiency of the management of the cropping system and can be related to productivity - measured as output per unit of input (land, labour, capital, energy) (FAO 1993).

Food production can rise either through expansion of cropping area (intensification and/or increased mechanization) or through greater cropping intensity (Intensification including use of shorter fallows, perhaps coupled with use of unused poorer land. This is

accompanied by increased complexity of cropping (Okigbo, 1984)). These methods of increasing crop production but have their implications for sustainability.

The decline in the contribution of agriculture to the GDP of developing countries especially Nigeria overtime is due to the slower growth of the sector relative to other sectors of the economy and most especially commercial exploration of petroleum (CBN, 1997). The daunting obstacles to agricultural development causing decline of food production in upland farming systems, especially in Nigeria for example, has often been attributed to poor rural infrastructure, poor market access and transport cost weak institutions to support agriculture (Hazell, 2005). He also emphasized that modern farming technology are either not accessible or simply not economical to adopt. In term of soil improvement, limitation seems to be the farmer's inability to replenish nutrients lost in the continuous cultivation which has replaced the traditional bush fallow system. "Slash and burn" agriculture remains the major food production system in Nigeria.

Cropping Systems:

Major food crops in the southwestern Nigeria include: plantain, banana, maize, rice and root crops (such as cassava, yam, sweet potato and cocoyam) and in the savannah zone; sorghum, maize millet and cowpea (Okigbo, 1980; Mudahar 1986). Traditional cropping systems vary, since they have evolved in response to prevailing soil and climatic conditions and social and ethnological preferences (Ruthenberg, 1976; Okigbo, 1980; Kang, 1986). Traditional farmers often plant more than one crop species in a small patch of cleared and burnt land after several years of bush fallow. Intercropping, the practice of growing two or more crops simultaneously in the same field, is common throughout the country and it is practiced in 80% of the cultivated areas (Osiru, 1982; Steiner, 1984). The multi-story homestead gardens, where more than three annual crop and vegetable species are mixed with tree crops, are also common (Juo, 1989).

Rainfall distribution and solar radiation in the Savanna regions are better suited for a wider range of rainfed agriculture than the forest or semiarid zones. Most of the sorghum, millet, maize, cowpea, groundnuts and yams are produced on high base-status soils. In the forest region of southwestern Nigeria , which is dominated by low-base-status and acid Ultisols and Oxisols (Harpstead, 1973), systems based on trees, shrubs and root crops are more stable than cereal crop systems, as shown by the existence of highly successful tree crop plantations of rubber and oil palm (Kang, 1986; van Wambeke, 1991). Systems based on cassava and plantain are prevalent in the humid region, which is dominated by acid and low-base-status soils. (Juo and Ezumah, 1992). Generally, cropping systems in tropical Nigeria may be grouped into five categories according to Hossner and Juo (1999)

- Cassava-based cropping systems are mainly found in the southwestern forest zone (mainly Ultisols), where other food crops perform less satisfactorily except for coconuts or oil palm. Cassava is mainly intercropped with maize or upland rice. These fast-growing cereals reduce nutrient loss through leaching, runoff and erosion by utilizing a substantial amount of N mineralized (100 to 300 kg N/ha) during the onset of the rainy season (Mueller-Harvey et al. 1985). These systems also recycle nutrients by returning residues to the soil.
- Cropping systems based on plantain or starchy banana are common in forested areas. Intercropped with plantain are cash crops like cacao, kola, coffee, cocoyam, maize and beans, planted so as to maximize light use efficiency.

- Yam-based systems are traditionally intercropped with a number of food crops, including cowpea, maize, cassava, vegetables, plantains, and groundnuts. Under upland conditions, cassava is intercropped with maize or upland rice during the second year as soil nutrient levels become inadequate to support a yam crop.
- Maize-based systems are widely practiced in the humid transitional zone as well as in the subhumid region and tropical highlands. In wetter areas, maize is usually intercropped with cassava, yam or sweet potato. Commercial maize monoculture is hardly found rather intercropping is predominant

Soil Fertility Constraints to Agricultural Production : Hanson (1992) reported that of the three billion hectares of arable land in tropical Africa, only 14.7% is considered to be free of physical or chemical constraints. One third (32.2%) has physical constraints, 13.2% has limited nutrient retention capacity, 16.9% has high soil acidity, and 6.8% has high P fixation. Nitrogen and phosphorus are the most serious limiting factors for cereals and food legumes, respectively (Jones and Wild ,1975; Takow et al., 1991). Deficiencies of potassium in root crops, sulfur and zinc in maize, and boron in cotton and groundnuts have been reported in continuously cultivated fields which have few or no inputs of crop residues or animal manure (Jones and Wild 1975 and Hanson 1992). Furthermore, aluminum toxicity and related calcium, magnesium and phosphorus deficiency also limit the growth and yield of cereals and legumes in acid soils in both humid and semiarid regions (Pieri, 1989; Wilding and Hossner, 1989). Throughout the tropical regions in the world, the slash and burn method has been widely used by small-scale farmers as a means of land preparation and soil fertility maintenance. Practiced in different forms in different regions, slash and burn agriculture involves manually clearing, burning and cropping a relatively small area of land (e.g. 0.5 - 1 ha. IFPRI, 2005)) for one or two years, followed by a long period of natural fallow (e.g. 15-30 years). The land is usually allowed to return to forest or savanna vegetation, in order to restore soil fertility (Nye and Greenland, 1960; Mokwunye and Hammond, 1992).

Where the period of fallow has been shortened and cultivation has been extended for more than two years, crop yields generally decrease rapidly, creating a constant pressure to clear new land (Ayodele, 1986). Burning means that most of the N, S, and C associated with organic matter is lost to the atmosphere. Large-scale clearing accelerates soil erosion, surface sealing and crusting (van de Watt and Valentin, 1992). Subsequent cultivation may result in rapid deterioration of the biological, chemical and physical properties of the soil (Mokwunye and Hammond, 1992).

Continuous cropping of Alfisols, Ultisols and Oxisols in the tropics has resulted in a rapid decline in soil organic matter in the surface soil during the first few years following land clearing (Juo et al., 1995). Continuous cultivation also causes a significant decline in soil pH and exchangeable Ca and Mg levels. This is even more pronounced when acidifying fertilizers are used (Adepetu et al., 1979, Juo and Kang, 1989 and Juo et al. , 1995).

Soil fertility management on small farms in Nigeria has become a major issue, as a result of increasing pressure on land due to increasing population and competing uses for land have shortened fallow period resulting to continued land degradation (FAO, 1981). Major arable soils are often poorly suited to high-input agriculture. Agricultural development efforts, therefore, must be directed towards the improvement of productivity and sustainability of smallholder production systems.

External nutrient inputs are essential to improve and sustain crop production on these soils. Nutrient inputs may either be from organic sources (i.e. crop residues, green manure, and animal manure) or from inorganic sources (i.e. chemical fertilizers and lime). Published results have shown that chemical fertilizers alone cannot sustain crop yields on poorly buffered kaolinitic soils.

The decline of crop yields under continuous cultivation has been attributed to factors such as acidification, soil compaction and loss of soil organic matter (Juo *et al*., 1995). Thus, application of organic materials is needed, not only to replenish soil nutrients but also to improve the physical, chemical, and biological properties of soil. To a large extent, this may be achieved by managing the agroecosystem in such a way that nutrient sources are generated, recycled and maintained. Options for soil fertility improvement could be by incorporating agroforestry into the cropping system and or proper incorporation of leguminous cropping into the

Prospects for Fertilizer Use

The use of inorganic fertilizer in crop production among the subsistence farming communities in southwestern Nigeria have been greatly studied (Adesinmi, 1982; IAR&T, 1991). The scarcity and high cost, most smallholders farmers in Nigeria rarely use inorganic fertilizers on food crops. Moreover, many low-yielding local cultivars are naturally developed to withstand low soil fertility and other environmental stresses, and are therefore less responsive to fertilizer use (McIntire, 1986). Currently, an average of only 5 - 10 kg/ha of nutrients are applied as fertilizer on cropland in sub-Saharan Africa (Bumb and Baanate, 1996). Juo and Lal (1977) indicated that at the current low rate of fertilizer use, the resultant effect is undesirable soil structure and nutrient statue, as they have been for decades. Nutrient inputs from chemical fertilizers are needed to replace nutrients which are exported and lost during cropping, to maintain a positive nutrient balance.

While continuous monocropping of cereals with optimum fertilizer use can sustain crop yields on fertile soils such as Mollisols and Alfisols with high activity clays in the temperate regions, (Jenkinson, 1989), continuous monoculture of cereals, using chemical fertilizers as the main source of nutrients, can lead to a significant decline in yields after only a few years of cropping because of soil acidification and compaction (Kang and Juo, 1986).

Strategies to Promote Self Reliance, Sustained Production and Environmental Security

Food production in Nigeria can rise either through expansion of cropping area and greater cropping intensity or through increases in agricultural productivity. International Food Policy Research Institute (IFPRI) (2002) in its executive summary of reaching sustainable food security for all by 2020 indicated that "*the nature of farming is changing rapidly in many developing countries. Small scale-family farms which is the traditionally backbones of much of developing-country agriculture, is under threat. These rapid emerging factors call for innovative approaches to agricultural policy and rural infrastructural development."*

The primary role of government is to put resources behind their repeated pledges to provide more aid, better focused on contributing to sustainable development and poverty reduction. It bears the primary responsibility of creating an environment within which individuals and communities can effectively participate in production and also make available to small and poor people, a menu of technology options from which they can choose, rather than choosing an option for them. Governments have

also key roles to play in facilitating access to financial services and credit for stakeholders in domestic the agricultural production sector; increase investment in water control technologies; expand the crop areas under irrigation; increase investment in regional research capacity to support the development of new varieties resistant to major pests and diseases and sufficiently robust to withstand drought and climate change-induced shocks; and accelerate the pace of investment in rural infrastructure as road, transport, storage facility and communication infrastructure which would enhance farmers' capacity to response to market signals and improve their access to market. Gbadebo (2005) emphasized that Nigerian efforts in agricultural development over the past three decades have failed to improve the country's economy. A review of the sector depicts a gloomy picture. Performance is reflected in environmental degradation, mounting food deficits, and decline in both gross domestic product and export earnings, while retail food prices and import bills have been increasing. These effects have further impoverished the smallholder farmers, locking them into a poverty web. The Government must seek to establish agricultural strategies which promote political stability, self reliance, public participation, sustained production and environmental security.

Participatory research approach is needed so that the crop production options are relevant and appropriate to the intended beneficiaries. Increase in production activity will depend on farmers' access to appropriate knowledge and technology. Research and development (R&D) is thus essential to achieving sustainable expansion of yield of existing cropping land. Research should focus on sustainable productivity gains and reduced risk on small farms, emphasizing not only staple food crops and livestock but reducing post harvest losses, better use of plant nutrient and producing high-value products.

Integrated nutrient management

Sustainable soil nutrient-enhancing strategies involve the wise use and management of inorganic and organic nutrient sources in ecologically sound production systems (Janssen, 1993). The primary goal of integrated nutrient management (INM) is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way. Integrated nutrient management optimizes all aspects of nutrient cycling. It attempts to achieve tight nutrient cycling with synchrony between nutrient demand by the crop and nutrient release in the soil, while minimizing losses through leaching, runoff, volatilization and immobilization.

The agroecological approach to agricultural research has focused on meeting the needs of small-scale farmers in less favoured areas. The approach is aimed to reduce the amount of external inputs that farmers must use. It relies heavily on available farm labour and organic materials as well as knowledge on improved knowledge and farm management. The use of locally available materials such as crop residues, farm manure, and compost to improve soil fertility is an important part of this approach.

Green Manure Crops and Intercropping

Timely applications of organic materials with a low C/N ratio, such as green manure and compost, could synchronize nutrient release with plant demand and minimize the amount of inorganic fertilizer needed to sustain high crop yields for short-cycle crops such as maize, rice, and soybean, all of which have a high nutrient demand. Fast-growing leguminous species such as mucuna

(Mucuna utilis) and kudzu (Pueroria phseoloides) can be especially useful as cover crops for erosion control, weed suppression and for soil fertility restoration (Wilson *et al.,* 1982). Leguminous green manures and cover crops are able to:

- Enrich the soil with biologically fixed N;
- Conserve and recycle soil mineral nutrients;
- Provide ground cover to minimize soil erosion, *and*
- Require little or no cash input.

However, additional labor is required for timely establishment, maintenance and incorporation of the green manure crop. In the forest zones with bimodal rainfall distribution, it is possible to intercrop a slow-growing legume (e.g. Sesbania) with a food crop (e.g. maize) in the first season, and allow full growth of the legume in the second season to be incorporated as green manure in the first season of the following year (Balasubramanian and Blaise, 1993).

Conclusion

It should be noted that farmers are prospering most in regions where they are best able to compete in the market- regions with good infrastructure and marketing and distribution systems for higher value, perishable foods. There is the need to focus attention on high-value agriculture which should not be left to the market alone. Dr Seck, ***Director General, Africa Rice Center (WARDA)*** said "giving seed, fertilizer to farmers at affordable prices, availability of modern but inexpensive technologies, large tracts of land and mechanization of African agriculture will enhance food production" reported by Neondo, 2008.

According to Neondo (2008), to make agriculture productive and the basis for thriving economies and widespread income generation for more than 70 percent of people in Africa who rely on agriculture for their livelihoods and food security, governments and funding agencies must make consistent and increased investments in agricultural research for development, in effective markets, in value-adding industries, and in decentralized access by farmers to information and new technologies that give high returns without environmental damage.

In the medium- and long-term, Dr Seck said tax on all critical inputs, on-farm cost-saving agricultural machinery and equipments and post-harvest technologies for all players along the rice supply chain need to be reduced.

Agricultural growth and poverty alleviation are likely to benefit the environment. Agricultural development, poverty reduction and environmental sustainability are likely to go hand in hand when agricultural development is broad-based, market-driven, participatory and decentralized and driven by appropriate technology change that enhanced productivity. Agricultural researches must pay greater attention to sustainability, to resource-poor areas, and to the role of property rights and collective action in farmers' adoption of technologies and resource management practices

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Indigenous Practices Of Fruits And Vegetables Preservation: Effect On The Socio-Economic Status Of Women In Oyo State

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Abstract

The study was carried out in Oyo state and was designed to examine the effect of indigenous practices of fruits and vegetables preservation practises on the socio-economic status of women. A structured interview schedule was used to collect data; a hundred and twenty women were interviewed from both Oyo zone and Ibadan/Ibarapa zones of the agricultural development programme. The Study revealed that respondents were generally middle aged (31-50 years) and most of them had at least primary education. They also belong to both Christian and Islamic religions. Results showed that the women produced a wide variety of fruits and vegetables and used various indigenous practices in the preservation of these crops within the duration of 1-4 days after harvest. The use of jute bags was the commonest method used in preserving both fruits and vegetables. Further analysis showed that women who were full time farmers were more involved in the use of indigenous practices than those who were not. The socio economic status indicated that most of the respondents do not belong to any social organisation while the few ones who had organisations they belong to hardly have any leadership role. The socio economic status also indicated that their income level was generally low. The hypotheses revealed that there was a significant ($P < 0.05$) relationship between the use of indigenous knowledge and some socio economic characteristics (e.g. age, education and number of children.). Moreover, the use of indigenous practices had a positive effect on the production level of the women; however the constraints faced by the women (e.g. lack of capital) had a negative impact on their production capacity. It was therefore recommended that women should be empowered both socially and economically so that they can have collective voice in combating some of these constraints. This empowerment will also aid in Post harvest food preservation thereby reducing hunger.

Keywords: women, fruits and vegetables, preservation, socio-economic status, indigenous practices

Introduction

Background to the study

Indigenous knowledge is generated by communities over time to allow them understand and cope with their particular agro-ecological and Socio-economic environment. This knowledge is generated and transformed through a systematic process of observation, experimentation and adaptation. It is the systematic body of knowledge acquired by local people through the accumulation of experience, informal and intimate understanding of the environment in a given culture (World Bank, 2007).

Indigenous knowledge is increasingly gaining popularity among the international community due to two major reasons: realisation of the importance of incorporating it in development effort; and secondly it's potential and values in modern science and technology. Unlike scientific knowledge, which is acquired through a formal process of learning in specially designated institutions, indigenous knowledge is derived from participation with others in everyday activities in a local real life setting . It is not documented any where, but passed over to next generation verbally and through practices (Muyungi and Tillya, 2003).

In recent years development agencies, theorists and academicians have come to realise that development efforts that is based on conceptualisation, methods and values often failed to bring about appropriate and sustainable development in the communities which they target. In analysing these failures it became apparent that the needs of indigenous communities, values, knowledge and capacities form an essential basis for effective development programmes (UNESCO, 2008). They therefore concluded that incorporation of indigenous knowledge in development programmes will empower local communities, increase their self-reliance, confidence and capacity to utilise and manage their resources.

The World Bank (2007) defined indigenous knowledge as the knowledge that is unique to a given culture or society. It is seen to contrast with the knowledge generated within the international system of universities, research institutes and private firms. It is used at the local level by communities as the basis for decision making pertaining to food security, human and animal health, education, natural resources management and other vital activities.

World Bank (2006) reported that in the emerging global knowledge, a country's ability to build and mobilise knowledge is essential for sustainable development. The basic component of any country's knowledge system is its indigenous knowledge. It encompasses the skills, experience and insight of people, applied to maintain or improve their livelihood.

The Green living movement (2007), observed that the last two decades have witnessed growing interest in indigenous knowledge and research has generated data that demonstrated the contribution of indigenous knowledge to sustainable development, this had offered valuable insight into how people suffering from impoverishment and marginalisation used knowledge that they have received from preceding generation in order to manage their natural resources in efficient and sustainable way- ways adapted to their needs and manageable within their limited facilities.

According to World Bank (200**7),** significant contributions to global knowledge have originated from indigenous people, for instance in medicine and veterinary medicine with their intimate understanding of their environments. Indigenous knowledge is developed and adapted continuously to gradually changing environments and passed down from generation to generation and closely interwoven with people's cultural values. Indigenous knowledge is also the social capital of the poor, their main asset to invest in the struggle for survival, to produce food, to provide for shelter or to achieve control of their own lives.

Briggs (2005) also observed that the use of indigenous knowledge has been seen by many as an alternative way of promoting development in poor rural communities in many parts of the world. Indigenous knowledge is part of the lives of the rural poor, their livelihood depend on almost entirely on specific skills and knowledge essential for their survival.

All living creatures including man depend on nature for their food. Most of our foods consist of agricultural products which are usually seasonal and spoil quickly. To make food available throughout the year, rural people have developed methods to prolong the storage life of products- to preserve them. The deterioration process can be delayed through the use of various indigenous practices (James and Bas, 2003).

UNESCO (2008) reported that it is encouraging to observe that over the past ten years, there has been a dramatic increase in interest in the role that indigenous knowledge can play in truly participatory approaches to sustainable development. This interest is reflected in a myriad of activities generated within communities, which are recording their knowledge for use in their school systems and for planning purposes; within national institutions, where indigenous knowledge systems are now being regarded as an invaluable national resource; and within the development community, where indigenous knowledge provides opportunities for designing development projects that emerge from priority problems identified within a community, and which build upon and strengthen community-level knowledge systems and organizations.

It may not be accidental that the growing interest in the potential contribution of indigenous knowledge to development is becoming manifest at a time when current development models have proven not too successful. Today, hundreds of millions of marginalized people all over the world are still being excluded from the mainstream of development. These people have not benefited from development efforts which have mostly been based on a top-down development model, with the maximization of productivity as its major target. The agricultural sector provides a prime example. The objective of the Green Revolution was to maximize yields through the introduction of new crops. These crops depended on the optimal availability of fertilizers and water to achieve high yields. From a production point of view the Green Revolution was a success, but its potential could only be fully realized in areas with good soil and a secure water supply, and by farmers with access to financial inputs. However, for people without good land, no adequate access to irrigation facilities and a lack of financial means, the results have been of little use.

Indigenous knowledge can improve understanding of local conditions and provide a productive context for activities designed to help the communities. In addition, the use of indigenous knowledge 'assures that the end user of specific agricultural development projects are involved in developing technologies appropriate to their needs' (Charyulu 2007). World Bank (2007) further confirmed that some indigenous knowledge practices are the risk of becoming extinct because of rapidly changing environment, fast pacing economic, political and cultural changes. A large section of the household relies on this local knowledge for better crop management, food processing, storage and preservation.

Fruits and vegetables are of great nutritional value. They are important sources of vitamins and minerals, thus, essential components of human diet. Vegetable production forms a substantial percentage (about 25%) of the major food crops cultivated in Nigeria and so it is the source of livelihood for a considerable section of the population mainly women (Ojeniyi, 2002). Fruits, and vegetables play a significant role in human nutrition, especially as sources of vitamins [C (ascorbic acid), A, thiamine (B1), niacin (B3), pyridoxine (B6), folacin (B9), vitamin E], minerals, and dietary fiber. Their contribution is estimated at 91% of vitamin C, 48% of vitamin A, 30% of folacin, 27% of vitamin B6, 17% of thiamine, and 15% of niacin in the diet. Fruits and vegetables also supply 16% of magnesium, 19% of iron, and 9% of the calories (Kader 2002). Legumes, vegetables, potatoes, and tree nut and their proteins are of high quality as to their content of essential amino acids. Nuts are a good source of essential fatty acids, fiber, vitamin E, and minerals. Other important nutrients supplied by fruits and vegetables include riboflavin (B2), zinc, calcium, potassium, and phosphorus (Kader 2002).

Although women have long been the key food producers and managers of their own environment through the use of indigenous knowledge, there has been a neglect of this in our rural areas. The production of fruit and vegetables serve as a good source of income for the women and perishable nature of these crops may lead to huge economic loss for the women if not well preserved hence a negative effect on their socio economic status. Most times women are also at disadvantage in the use of chemical and materials for preserving fruits and vegetables hence this result into the use of indigenous knowledge practices. According to Ojeniyi (2002), fruits and vegetables are regarded as perishables because they get deteriorated easily due to high rate of water loss after harvest. Oftentimes, fruits and vegetables are usually seasonal and their nutritional values are highest when they are fresh. During the harvest season, they are usually available in abundance but at other times they become very scarce.

The general objective of this study is to examine the effect of women indigenous practices of fruits and vegetables preservation on their socio-economic status in Oyo State. The specific objectives are to:

[1] Identify the socio-economic characteristics of women using indigenous practices in the preservation of fruits and vegetables in Oyo state; [2] Determine the various indigenous practices used by women in the study area; [3] Determine the effect of indigenous

practices on the socio-economic status of women in the study area; [4] Identify the constraints faced by women in the use of indigenous practices.

Material and Methods

The study was carried out in Oyo State. Oyo State is situated in the southwestern part the South and in the North and East by Kwara and Osun states respectively. It covers a land area of about 27,000 sq km and it is made up of 33 Local Governments. It is located between latitude $7^{o}3$ and $9^{o}13$ North of the equator and longitude $2^{o}47$ and $4^{o}33$ East of the meridian. Base on the prevailing climatic and soil characteristics, three vegetations are identifiable in the state. These are the forest, savannah and derived savannah. These zones favours the cultivation of wide varieties of tree crops such as cocoa, kola, citrus e.t.c., food crops like maize, yam, cassava e.t.c and also rearing of animals. The population of this study consists of women involved in fruit and vegetables production in Oyo state.

Multistage sampling technique was used to select the sample for the research. Oyo State Agricultural Development Programmes (OYSADEP) is divided into four operational zones these are Ibadan/Ibarapa zone, Saki zone, Oyo zone and Ogbomoso zone. Fifty percent of these zones were purposively selected because of the concentration of fruits and vegetable farmers there. These are Ibadan/Ibarapa zone and Oyo zone.

Oyo block was also purposively selected being the only block while Oluyole block was randomly selected from Ibadan/Iparapa zones making a total number of two blocks. There were 400 registered farmers in Oluyole block in which 20% (80) was chosen while there were 200 registered farmers in Oyo blocks in which 20%(40) was chosen given a total number of 120 farmers in all. The data for this study was collected through the use of structured interview schedule.

Results and Discussion

Table 1 reveals that 69.9% of the women were between the age 31-50years old. This indicates that women involved in the use of indigenous practices were the middle age. This agrees with the work of Kassal (2002), who reported that about 74.5% of women processors were middle age. About, 83.3% of the respondents had between 1-6 children while about 16.3% had more than 6 children. This means that the women have responsibilities in terms of child welfare, education, health e.t.c and also additional labour force on the farm since hired labourers are very expensive. This affirms the work of Oyemade (2003), that; women who were engaged in agro processing had family size range of 4-6. Furthermore 67.5% of the women were married, 13.3% were single showing that the single women were not fully involved in the use of indigenous practices, about 52.5% of the women had primary education, 13.3% had secondary and 3.3% had tertiary education while 34.2% had no formal education. This indicates that there is a progressive decrease in the level of illiteracy among women farmers as against high illiteracy level before. This was also confirmed by Oyemade (2003).

On religion, 44.2% and 48.3% were Christians and Muslims respectively. This means that women involved in the use of indigenous practices were both Muslims and Christians. About 65.8% of the women were full time farmers while 34.2% had other occupation like trading, weaving e.t.c.

Table 1: Socio-Economic Characteristics of Respondents

Variable	Freq	%
Age		
21 – 30	9	7.6
31 – 40	22	18.3
41 – 50	74	61.6
51-60	10	8.3
Above 60	5	4.2
	120	100
Marital status		
Single	16	13.3
Married	81	67.5
Widowed	21	17.5
Divorced	2	1.7
	120	100
Education		
Primary	63	52.5
Secondary	12	10.0
Tertiary	4	3.3
No formal education	41	34.2
	120	100
Religion		
Christianity	53	44.2
Islam	58	48.3
Traditional	9	7.5
	120	100
No of children		
1-3	30	25.0
4-6	70	58.3
More than 6	20	16.7
	120	100
Occupation		
Farming	79	65.8
Others	41	34.2
	120	100

Table 2 reveals the various indigenous practices used by women in the preservation of fruits and vegetables. Covering of vegetables with jute bags was the commonest and most popular method used by the women (97.5%). Keeping of vegetable in dew overnight was another method used by 87.5% of the women, wetting vegetables with water (95.8%), while less than average of the women used other methods like dipping of vegetables in water, immersion of stems in water, covering with perforated nylon e.t.c . Oyemade (2003) also reported that 62% and 53% of women adopted the method of keeping in the dew and wetting with water respectively.

Table 2 further reveals the indigenous practices used by women in fruits preservation. Covering with jute bags was also the most widely used method (96.7%). According to the women, jute bag was being widely used because it does not allow crops to be heated up thereby preserving the moisture content of the crops; also it is available and cheap to buy. Other methods mostly used include Harvesting of unripe fruits (95.8%). The method helps particularly in delaying ripening of fruits and also prevents glut so that women will be able to sell their fruits at better prices. Few of them used other methods like covering with perforated nylon, use of carbide and ash. Other methods discovered on the field were the use of locust beans and "Oro" (African bush mango) to hasten ripening of fruits.

Table 2: Indigenous Practices used in Preservation of Vegetables

Preservation practices	**Yes**	**No**
Keeping in the dew overnight	105 (87.5)*	15(12.5)
Wetting with water	115(95.8)	5(4.2)
Dipping in water	47(39.2)	73(60.8)
Immersion of stem in water	43(35.8)	77(64.2)
Covering with perforated nylon	51(42.5)	69(57.5)
Covering with jute bags	117 (97.5)	3(2.5)
Drying in the sun	50(41.7)	70(58.3)
Keeping in clay pots	24(20.0)	96(80.0)
Fruits		
Harvesting of unripe fruit	115 (95.8)*	5(4.2)
Covering with carbide	8(6.7)	112(93.3)
Covering with ash	49(40.9)	71(59.1)
Covering with jute bags	116(96.7)	4(3.3)
Covering with perforated nylon	56(46.7)	64(53.3)

*Percentages in parenthesis

Table 3. Constraint faced by Women in Indigenous Practices of Fruit and Vegetable

Constraints	Yes		No	
	Freq	%	Freq	%
Lack of material required	72	60.0	48	40.0
Insect and pest infestation hinders preservation	56	46.7	64	53.3
Weather condition has adverse effect on preservation	85	70.8	35	29.2
Produce preserved are liable to theft activities	45	37.5	75	62.5
Labour requirement is high	63	52.5	57	47.5
Lack of capital	67	55.9	53	44.1
Little or no access to land	69	57.5	51	42.5
Poor transportation of produce	58	56.7	52	43.3
Lack of market for produce	93	77.5	27	22.5

Table 3 shows the various constraints faced by women in the use of indigenous practices. Top on the list was lack of adequate market for produce (77.5%); which makes most of the women to reduce the prices of their products so as to dispose them on time considering the perishable nature of fruit and vegetables. Also among the major constraints are weather condition (70.8%), lack of materials (60.0%), little or no access to land (58%) and lack of capital (56%).

Table 4: Socio-Economic Status of the Respondents

Variables	Yes		No	
	Freq	%	Freq	%
Membership of any society	41	32.2	79	65.8
Leadership of any society	24	20.0	96	80.0
Number of children				
1-3	30	25.0	-	-
4-6	70	58.3	-	-
More than 6	20	16.7	-	-
Number of children in secondary school				
1-3	62	51.7	-	-
4-6	39	33.5	-	-
More than 6	19	15.8	-	-
Number of children in higher institution				
1-3	52	43.3	-	-
4-6	44	36.7	-	-
Ownership of Well	58	48.3	62	51.7
Ownership of Generator	24	20.0	96	80.0
Ownership of Pumping	23	19.1	97	80.9
Ownership of Radio	90	75.0	30	25.0
Ownership of Television	66	55.0	54	45.0
Ownership of Cooking stove	75	62.5	45	37.5
Ownership of Electric stove	23	19.2	97	80.8

Ownership of Cooking pots for occasions	58	48.3	62	51.7
Ownership of Coolers	64	53.3	56	46.7
Ownership of Aluminium dishes/cups	81	67.5	39	32.5
Ownership of Glass dishes/cups	86	71.7	34	28.3
Ownership of Refrigerator	50	41.7	70	58.3
Ownership of Decorative wardrobes	61	50.8	59	49.2
Type of house:				
Owned house	56	46.7	64	53.3
Rented apartment	77	64.2	43	35.8

Table 4 reveals the socio-economic status of the respondents. 65.8% of the women do not belong to any organization or society, 80% do not have any leadership role while 20% were leaders of society. 51.7% and 43.3% had between 1 – 3 children in the secondary and tertiary institution. Also as indicated by the table, the economic capacity of the women could not go beyond the acquisition of those items that are not too expensive e.g. cooking stoves, dishes, e.t.c while items like pumping machine, generators, refrigerator e.t.c are expensive and they were unable to acquire them.

It could be concluded that the income level of the women was low probably due to responsibilities due to children welfare and other constraints which may not give room for the possession of all the items they needed.

Hypotheses Testing

Ho 1: There is no significant relationship between women socio-economic characteristics and their use of indigenous practices.

Table 5: Chi-Square Analysis of use of Indigenous Practices of Fruit and Vegetable and socio-economic characteristics of Respondents.

Personal contingency characteristics	Statistical Tool (X)	df	C C	N	P	Remark
Age of fruit producers	24.072	1	0.409	120	0.000	S
Age of vegetables producers	43.200	1	0.514	120	0.000	S
Education of fruit producers	8.279	3	0.254	120	0.041	S
Education of vegetables producers	14.083	3	0.324	120	0.003	S
Religion of fruit producers	4.700	4	0.194	120	0.319	NS

Religion of vegetables producers	9.208	4	0.267	120	0.056	NS
occupation fruit producer	10.228	1	0.280	120	0.002	S
occupation vegetable producer	14.358	1	0.327	120	0.000	S
Production for fruit producer	22.844	1	0.400	120	0.000	S
Production for vegetable producer	15.156	1	0.335	120	0.000	S

Table 4 shows that there is a significant relationship between the age of respondent and their use of indigenous practices. As revealed by Table 1 that most of the women involve in the use of indigenous practices are the middle aged, this means that the younger women were not fully involved in the use of indigenous practices. The use of indigenous practices also requires accumulated experience gathered over the years as it was defined by World Bank (2007). Chi analysis of data revealed that there is a significant relationship between education and the use of indigenous practices. As indicated by Table 1 about 65.8% of the women were literate (i.e. can read and write) therefore the use of indigenous knowledge is better promoted among these sets than their counterparts who were non-literate. The study of Oyemade (2003) confirmed that there was a reduction in the level of illiteracy among women farmers. Also from the table, there is no significant relationship between religion and the use of indigenous practices. This means the religion has no effect or barrier on the use of this knowledge practice irrespective of the women religions. Table 5 showed that there is a significant difference ($P< 0.05$) between occupation and the use of indigenous practices. This implies that women who are full time farmers are more involve in the use of indigenous practices than the women who had other businesses they are doing.

Ho 2: There is no significant relationship ($P > 0.05$) between women socio-economic status and the use of indigenous practices.

Pearson Correlation Coefficient between the use of Indigenous Practices and Women Socio-Economic Status reveals that there is a negative correlation($r=-0.164$; $p> 0.073$) between the socioeconomic status of fruit producers and the use of indigenous practices while there is no significant relationship($r=0.08$; $p>0.341$) between vegetable producer's socio-economic status and the use of indigenous practices. The major reason for this is attributed to the various constraints faced by these women in the production of fruits and vegetables which had a great impact on their income level and their profit margins. Another reason could be as a result of responsibilities like children welfare (Oyemade, 2003).

Ho 4: There is no significant relationship between constraint faced by women and their use of indigenous practices.

Spearman Rho Correlation Coefficient between the use of Indigenous Knowledge and Constraints shows that there is a negative correlation between the use of indigenous knowledge and constraints faced by the women.{fruit producer ($r=--0.35$; $p< 0.000$)}, {vegetable producer ($r=-0.314$; $p< 0.000$)}. This indicates that the higher the constraint faced by the women the lower their production capacity and hence the lower their income and vice versa.

Summary ad Conclusion

The study revealed that:

- Most of the women were between ages (31- 50 years old) and most were married
- Had a family size ranging from 3-6.
- 65.8% were educated while about 65.3% were full time farmers, which constitute both Christian and Islamic religion.
- Among the indigenous methods used by the women are preservation with jute bags, for fruits and vegetables, keeping in due overnight and harvesting of unripe fruit for vegetables and fruits respectively.
- Majority of the women stated that lack of market for produce, weather condition, lack of capital and lack of storage materials are part of the constraints faced.
- Analysis revealed that there were negative correlation between the socioeconomic status and the constraints faced by the women and the use of indigenous practices.
- The use of indigenous knowledge had a positive impact on the production level of the women while the use of jute bags was the commonest practices for the preservation of fruits and vegetables i.e the most economic rewarding method.

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Eye diseases amongst children in rural communities of southwestern Nigeria.

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Abstract

This study was aimed at determining the spectrum of childhood eye diseases in a tertiary hospital serving rural and semi rural communities so as to aid planning and provide baseline data for the development of pediatric ophthalmology subspecialty. Eye diseases in children are potentially blinding and constitute morbidities, which could affect their learning ability, personality and adjustment in school since learning is largely vision dependent. The spectrum of eye diseases varies in different communities. A retrospective review of all patients aged </=15 years cases attended to at the eye clinic of the Wesley Guild Hospital Ilesa, Nigeria between January 2001 and December 2006 was evaluated. Two hundred and eighty six children were seen with male to female ratio of 1:1.1. Children aged 11-15 years made up the largest group (P=0.013). Ocular trauma (21.7%), allergic conjunctivitis (17.8%), infections of the eye and its adnexa (15.4%) and refractive errors (14.3%) were the commonest diseases. Ocular injury was commoner in males (P=0.002), children aged 6-10years (P=0.294) and 87.1% were closed globe injury. No gender difference was observed among children with allergic conjunctivitis. The corneal was most commonly affected location by the infections (40.9%) affecting only children aged 1-5 years. Almost three quarters of the children with refractive error were females (P=0.003). Congenital eye disease represented 13.3% of childhood eye diseases. The common childhood eye diseases recorded can lead to absenteeism from school, are potentially blinding and are largely avoidable. Massive health education aimed at prevention of eye trauma and encouraging early presentation for eye care is needed.

Keywords: children, eye diseases, Nigeria, ocular trauma, refractive errors**.**

Introduction

Eye diseases in children are important reasons for medical consultation [1]. Children ought to receive prompt and proper eye care to avoid vision problems and eye morbidities from which could affect their learning ability, personality and adjustment in school [2,3]. Vision is an important requirement for learning and communication [4]. Childhood blindness is second only to cataract in terms of 'blind years' [5]. Complains necessitating eye care consultation could originate from the child, parents or even teachers [6]. The spectrum of ocular problems varies from country to country and even from region to region in the same country [2]. In the USA, strabismus, amblyopia and optical problems impacting on visual acuity were the most common ocular problems seen amongst school children [7]. Refractive errors (25.7%), vernal conjunctivitis (25.3%), eye injuries (13.3%) and corneal inflammations (12.5%) were the leading causes of childhood eye morbidities reported 12 years ago in Ibadan, Nigeria [8]. Trachoma (33.7%), refractive error (6.3%) and non trachomatous conjunctivitis (5.9%) were the most common childhood eye disorders reported in Ethiopia [9].

Data on the pattern of presentation of childhood eye diseases serve as useful template for planning eye care for children in a given region. Children in rural communities may be involved in agrarian activities which may impact on their health. This study was conducted to determine the frequency and spectrum of childhood eye disorders presenting to the eye clinic of Wesley Guild Hospital, Ilesa. The findings will be useful for pediatric ophthalmic care planning and also serve as baseline for the development of pediatric ophthalmology subspecialty in the tertiary hospital.

Methods

All new patients aged 15 years and below who presented at the eye clinic of the WGH, Ilesa between January 2001 and December 2006 were reviewed. Children who presented for medical check up and had no eye disorder were excluded from the study. The eye clinic of WGH, Ilesa serves as a referral centre for the rural and semi rural communities of Ilesa along with neighboring communities of Osun, Ekiti and Ondo states of southwestern Nigeria. It also provides primary and secondary eye care service to self reporting patients. At first visit, all patients had full ophthalmic evaluation carried out by a consultant ophthalmologist. Investigations were conducted to elicit diagnosis and management commenced as required. Subsequently, patients were seen by resident ophthalmologists under the supervision of the consultant. Consultations to pediatricians and other specialists were made when necessary. Examination under anesthesia was carried out to confirm diagnosis when required.

The age at presentation, sex, clinical diagnosis and age at onset of symptoms were extracted from the records. Clinical diagnosis was grouped as appropriate; diseases which were present at birth but were not due to birth circumstances were considered congenital. Patients were grouped by age into the preschool group (0-5 years), school age (6-10 years) and older children (11-15years).

Data was stored and analyzed using the SPSS. Chi Square statistics was used to relate variables and statistical significance was inferred at $P<0.05$.

Results

Two hundred and eighty six children were seen in the eye clinic during the study period constituting 14.3% of all new patients seen. They were 138 (48.3%) males and 148 (51.7%) of females giving a male to female ratio of 1:1.1. Figure 1 shows the age group and sex distribution of the children seen with a female preponderance in the age group 11-15 years. The highest frequency of consultation was recorded amongst older children constituting 38.5% of the patients ($P=0.013$).

Ocular injuries were the commonest disorders seen (21.7%), followed by allergic conjunctivitis (17.8%), infections of the eye and its adnexa (15.4%) and refractive errors (14.3%). Figure 2 shows the spectrum and frequency of eye morbidities seen. Uveitis was seen in six children and a 15 years old child presented with pterygium.

Table 1 shows the frequency of eye diseases across the three age groups. The difference in presentation by age group was more prominent and statistically significant amongst children with refractive error and infections. Twenty nine (70.7%) of cases of refractive error were seen amongst the older children ($P<0.001$) while infection of the eye adnexa was recorded more (70.5%) amongst preschool children ($P<0.001$).

Forty three of the children with ocular injury (69.4%) with ocular trauma were boys ($P=0.002$). Ocular trauma was recorded more amongst school children, constituting 41.9% of all traumatic eye disorders ($P=0.294$). Eye injury was unilateral in all cases. Table 2 shows the pattern of ocular trauma seen in the 62 children, majority (87.1%) being closed globe injuries[15]. Allergic conjunctivitis incidence was higher in older children with 52% of cases recorded in children aged 11-15 years ($P=0.02$). No gender difference was observed.

Twenty seven (61.4%) of children who presented with infections were females ($P=0.132$). Figure 3 shows the anatomical locations of the infections of the eye and adnexa with cornea infections accounting for 40.9%, out which 33.3% were measles related. All cases of corneal infection were in children aged five years and below. Almost three quarters (73.2%) of the children with refractive error were females ($P=0.003$).

Thirty eight of the 286 (13.3%) children presented with congenital eye diseases of which 76.3% presented as preschool children. Table 3 shows the pattern of congenital eye diseases seen with congenital cataract and strabismus occurring more frequently.

Discussion

Children have unique problems with regards to ocular morbidities; not only because of their inability to articulate their problems but also the potential to develop amblyopia in event of visual impairment [4]. The higher frequency of consultations in older children may due to the fact that they tend to be more articulate about their problems and the chronicity of certain eye disorders would also have been noted with time. This frequency differs from a similar study which reported a higher incidence of consultation in children aged less than 5 years of age, the difference in the spectrum and incidence of childhood eye disorder may account for this [10].

Ocular trauma was the most common morbidity seen in this series. This is different from other reports where pediatric eye injuries featured as the third [8,10,11] or fourth [12] common disorder reported. In India[2] and other regions in Nigeria[10-13]allergic conjunctivitis was the most common childhood eye disease reported while refractive error was reported in Ibadan [8]. The reason for this high frequency of pediatric eye injuries in this environment is not clear. The largely agrarian nature of the communities may predispose the children to injuries from twigs and farming activities. Further study on predisposing factors to eye injuries in children in this region is needed, since the identification of causes of injury helps in determining effective methods for reduction of incidence of injuries [16]. Eye injuries remain a major cause of unilateral visual impairment world wide [17] and a common cause of non congenital unilateral blindness [18]. Children are particularly at risk of ocular injury due to decreased ability to detect and or avoid potential hazards [16,19]. Most childhood eye injuries are sustained during unsupervised play and domestic activities [20-23]. The male preponderance reported is as previously reported [19-23]. The higher incidence of injuries reported amongst school children is similar to other studies [16, 21, 24]. This group represents the independent and adventurous age group thus making them more vulnerable. Closed globe injury type was commoner, as previously reported [2, 16, 23] but different from the Kaduna study where open globe injuries were commoner [21]. The challenge of managing childhood eye injuries in this environment is enormous. Considerations range from late presentation to eye care centers to lack of facilities, low socioeconomic status of children involved, special care required during examination, postoperative management and the risk of amblyopia [10,16,21,23]. Prevention of ocular trauma in children remains a priority to reduce ocular morbidity[16]. This will involve adequate education of children of parents and teachers on adequate supervision at play and avoidance of risky chores.

Previous reports of allergic conjunctivitis as the most common surface disorders in children [1,10-13,25] is corroborated in this study. The largely agrarian occupation in the communities and the dusty environment may be contributory [5,10]. Moreover, rural living is a risk factor for development of chronic allergic conjunctivitis in children [26]. A slight female preponderance was noted in this series and differs from other reports of male preponderance [26,27]. The higher incidence noticed amongst the older children may be related to factors affecting late presentation to eye care facility for a chronic recurrent disease rather than the actual prevalence of the disease. Allergic conjunctivitis is a leading cause of absenteeism from school due to its associated discomfort, chronicity and recurrence[25]. Adequate management will bring symptoms under control, prevent potentially blinding complication, loss of concentration and absenteeism from school [14].

Ocular infections are preventable but challenging causes of blindness particular in children considering the number of blind years involved. Corneal infections constituted more than one third of infections of the eye and adnexa in this series, they are particularly notorious for causing blinding cornea scars. Corneal scarring accounts for 75% 0f childhood blindness in Africa with half of this giving a history of measles shortly before blindness [18, 26]. While more recent reports have credited the Expanded Programme on Immunization for a downward trend noticed n the incidence of measles infection and associated ocular morbidities in Nigeria [1, 10], a total eradication is desired as 33% of childhood keratitis in this study was due to measles. School children were more likely to present with infections of the eye and adnexa in this study; this may not be unrelated to the higher risk of measles infection in the same age group. With cornea opacity of varying causes constituting 3.9% and another 6.3% with keratitis, childhood blinding cornea opacity is a problem. While efforts at establishment of corneal transplant services in Nigeria are ongoing, prevention and prompt treatment of corneal infection is highly essential.

Refractive error affects childhood development as 80% of learning ability in children is sight dependent [28].The higher incidence reported in older children may be due to better articulation and detection of visual problems by older children thus suggesting lack of detection by parents and teachers at younger age. The statistically significant female preponderance is similar to a previous report which suggests that young females tended to report visual problems more than males [17]. School health services for regular eye screening to detect and refer affected children for refractive services will prevent poor performance in school and development of amblyopia [3, 10, 14]. The belief that spectacle use in children further destroys the eye [10] must be changed via health education so as to ensure early presentation and improve uptake of existing refractive services.

Nine (47.4%) of all childhood cataract were congenital. Childhood cataract is not managed just as a smaller version of adult cataract. It poses different challenges from the preoperative assessment, general anesthesia, correction of aphakia, postoperative care and follow up for posterior capsular opacification or glaucoma. Many patients are faced with poor finances and thus cannot afford the available cataract surgical services especially with intraocular lens implantation which is the best option for aphakic correction in most children for reducing the incidence of post operative amblyopia [10, 21].

The most common causes of childhood ocular morbidities were eye injuries, allergic conjunctivitis, infections and refractive error. These disorders require specialist eye care services for proper management since they lead to absenteeism from school and are potentially blinding. Appropriate health education for prevention of childhood eye injuries need to be disseminated as well as early presentation of children to eye care centre for treatment of eye disorders.

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Table 1: Distribution of childhood eye diseases across age groups

Diagnosis	**Age groups (years)**			
	0-5(%)	**6-10(%)**	**11-15(%)**	**Total (%)**
Ocular trauma	16(25.8)	26(41.9)	20(32.3)	62(21.7)
Allergic conjunctivitis	12(24)	12(24)	26(52)	50(17.5)
Infections of eye and adnexa	31(70.5)	5(11.4)	8(18.2)	44(15.4)
Refractive errors	2(4.9)	10(24.4)	29(70.7)	41(14.3)
Cataract	7(36.8)	8(42.1)	4(21.1)	19(6.6)
Corneal opacity	4(33.3)	4(33.3)	4(33.3)	12(33.3)
Tumours	5(45.5)	2(18.2)	4(36.3)	11(3.8)
Strabismus	4(57.1)	1(14.3)	2(28.6)	7(2.4)
Uveitis	1(16.7)	-	5(83.3)	6 (2.1)
Glaucoma	3(75)	-	1(25)	4(1.4)
Others	19(63.3)	4(13.3)	7(23.9)	30(10.5)
Total	**104(36.4)**	**72(25.2)**	**110(38.4)**	**286(100)**

Table 2 : Pattern of ocular trauma in 62 children.

Type of Injury		**Frequency (%)**
Closed globe injury	- contusion	44(71)
	- superficial corneal foreign body	9(14.5)
	-superior tarsal foreign body	1(1.6)
Open globe injury	-penetrating	6(9.7)
Others	-periorbital soft tissue injury	1(1.6)
	-chemical eye injury	1(1.6)
Total		**62(100)**

Table 3: Analysis of 38 congenital eye diseases per age group

Congenital eye disease	**0-5yrs**	**6-10yrs**	**11-15yrs**	**Total (%)**
Cataract	7	2	-	9(23.7)
Strabismus	4	-	2	6(15.9)
Glaucoma	3	-	-	3(7.9)
Ptosis	2	1	-	3(7.9)
Microphthalmia	1	1	1	3(7.9)
Dacryostenosis	2	-	-	2(5.2)
Presumed Leber's amaurosis	2	-	-	2(5.2)
Dermoid cyst	1	-	1	2(5.2)
Eye lid eversion	2	-	-	2(5.2)
*Others	5	-	1	6(15.9)
Total	**29**	**4**	**5**	**38(100)**

* Others are made up of one patient each with macrophthalmia, corneal opacity, persistent hyperplastic primary vitreous, oculocutaneous albinism, ocular albinism and lateral canthal skin tag.

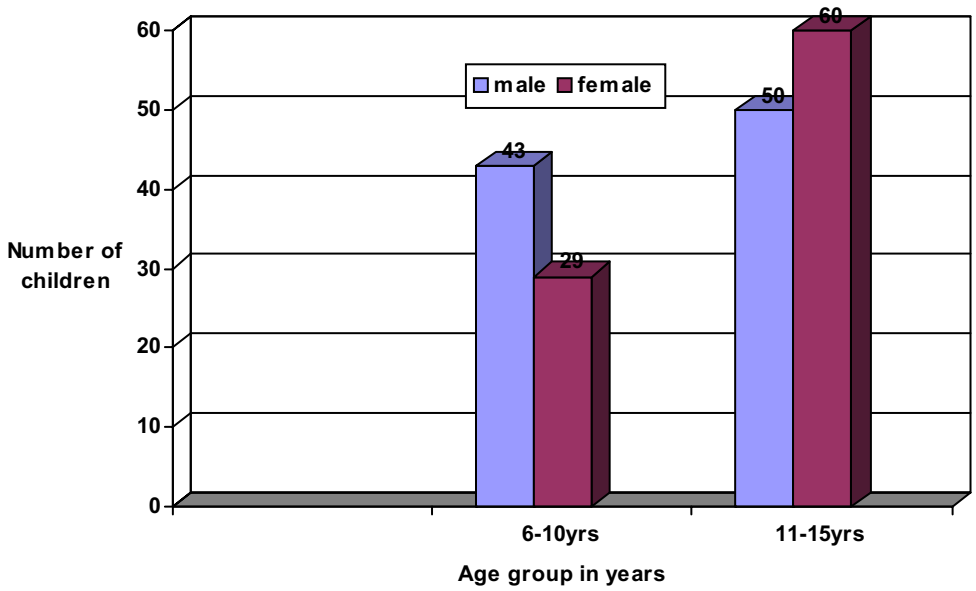


Figure 1: Age group and sex distribution of children

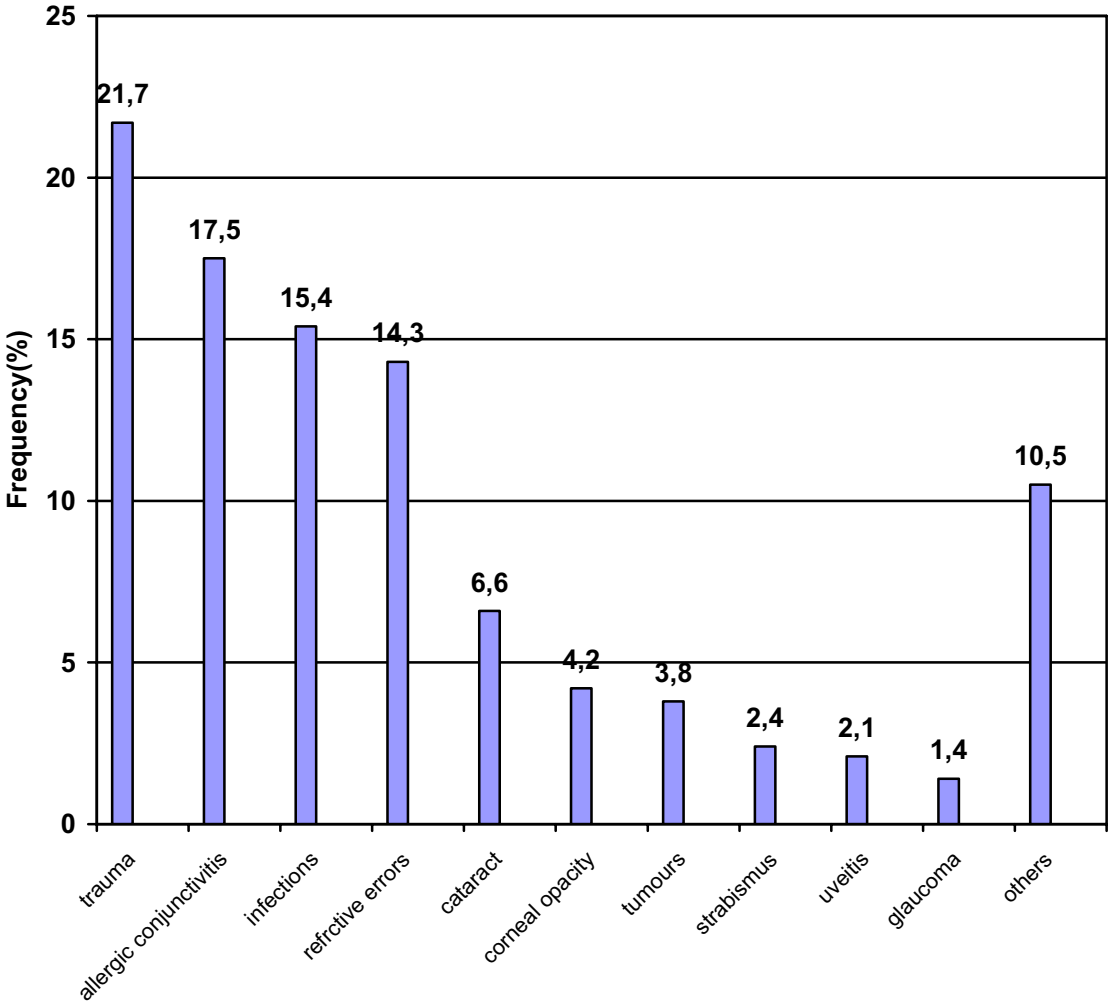
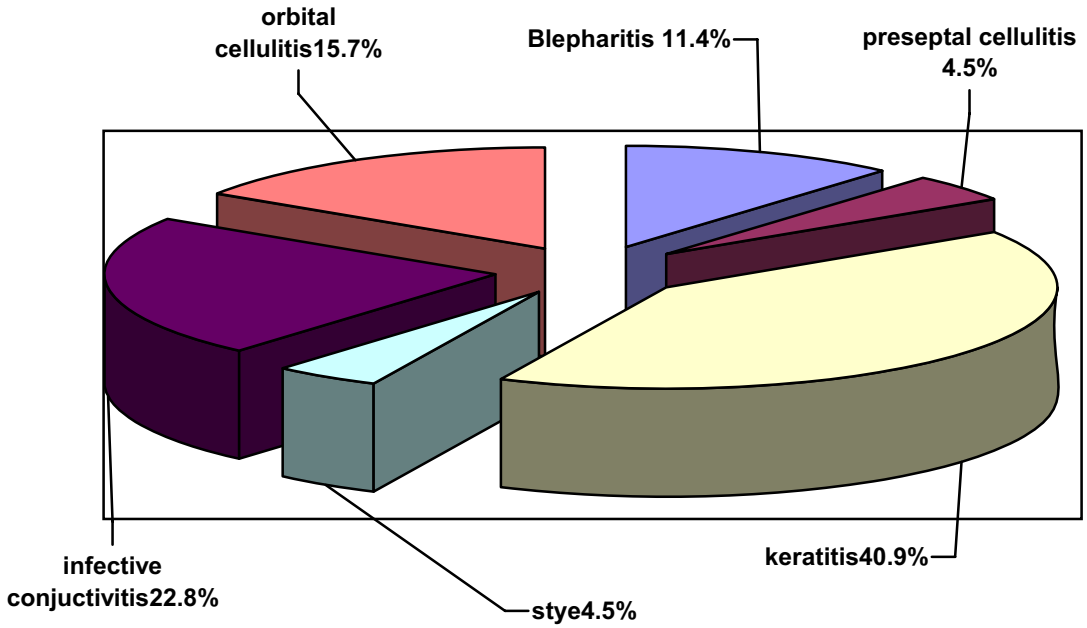


Figure 2: Spectrum of childhood eye disorders.

Figure 3: Childhood infections of the eye and adnexa



Brittle Fracture in Soil Cutting and Tilth Development Processes

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Abstract

Excessive soil compaction and poor soil structure result in progressive decline in land productivity and crop yields. In particular, in developing countries like Nigeria, these challenges pose serious threats to national and household food security. Although tillage is carried out to prevent or ameliorate excessive soil compaction and poor structure, different agro-ecological zones have different tillage requirements for sustainable crop production. The importance of brittle fracture in soil tilth development processes has stimulated considerable research investigations into soil fracture processes. This paper reviews knowledge on microstructural and macrostructural analyses of soil fracture mechanisms. The characterisation of soil fracture behaviour using appropriate soil mechanical properties is discussed. Subsequently, quantitative approaches to soil fracture, namely the statistical, effective stress, strain energy and stress intensity theoretical approaches are discussed. Current limitations and problems associated with the application of these theories to soil brittle fracture are also discussed. Important guidelines are provided for future designs of tines for fracturing brittle agricultural soils, commonly encountered in developing countries in tropical and semi-arid regions.

Introduction

Brittle fracture by the propagation of tensile cracks accounts for soil failure during natural (frost heaving, drying, root penetration) and artificial (mechanical cultivation) tilth forming processes (Koolen, 1973; Miller, 1978; Towner, 1987; Snyder and Miller, 1989; Aluko and Seig, 2000). Furthermore, the cracks produced in brittle fracture serve as preferential transmission routes and habitat for soil organisms (Hallett *et al*., 1995). The importance of brittle fracture in different soil processes that are vital to agricultural production, has prompted considerable research into soil fracture behaviour in brittle agricultural soils (Briones and Uehara, 1977; Braunack *et al*., 1979; Utomo and Dexter, 1981; Chandler, 1984; Chandler and Stafford, 1987; Snyder and Miller, 1989; Okunlola and Payne, 1991; Berntsen and Berre, 1993; Watts and Dexter, 1998; Aluko and Chandler, 2004). The objective of this paper is to review recent developments and advances in the characterization and quantitative analysis of soil fracture behaviour in tilth development processes.

Mechanical Properties and Behaviour of Soil

Soil reaction, or mechanical behaviour, will depend on the type of loading imposed on it. As such, the same soil may exhibit different mechanical behaviour in different operations. This is further complicated by the transient nature of the mechanical properties of agricultural soils and indeed, the frequent divergence in practical requirements even within the same field of application. For example, a soil subjected to wetting and subsequent drying out can go from a weak mud to a hard brittle soil. Such soils are commonly encountered in tropical and semi-arid regions.

The mechanical properties of soil, particularly its strength properties, are used in quantifying its mechanical behaviour or response to the application of external loads. As pointed out above, the mechanical behaviour of soil will vary with both soil and loading conditions. In particular, in soil cutting operations, different types of soil failure have been reported. In this regard, the choice of appropriate soil properties for process characterization is very important. The mechanical properties of soil that have been more widely applied and form the basis of most existing soil cutting theories are its cohesion c and angle of internal shearing resistance ϕ. The soil is assumed to behave as a rigid-plastic Mohr-Coulomb material. The Mohr-Coulomb criterion postulates that shear

failure will take place on a plane when the applied shear stress is sufficient to overcome simultaneously, the bonding between soil particles (cohesion) and the frictional resistance to shear movement between the two surfaces at the plane of failure. The Mohr-Coulomb criterion is commonly expressed by the following equations:

$$\tau = c + \sigma_n \tan \phi \quad (1)$$

and

$$\sigma_1 = \sigma_3 \tan^2 (45 + \phi/2) + 2c \tan (45 + \phi/2) \quad (2)$$

where σ_n is the normal (compressive) stress, τ is the shear stress at failure, σ_1 is the major principal stress and σ_3 is the minor principal stress. The Mohr-Coulomb model ignores strain and deformation prior to failure as well as the intermediate principal stress σ_2.

Another parameter often used to quantify soil strength is the cone index, CI. It is a measure of the penetration force of a cone at a certain speed and soil depth. The force is divided by the projected cone base area to give the cone index, CI. CI has been used in compaction studies (Gill, 1968) and in analytical studies of the draft of cutting blades (Wismer and Luth, 1972). However, only empirical relationships for a given situation are forthcoming from the use of CI. Siemens (1963) pointed out that an understanding of the fundamental aspects of the mechanism of soil cutting was not possible using the cone penetrometer approach as a basis for study.

Another soil strength property which has been investigated by some research workers is the tensile strength of soil. Owing to the difficulties of direct measurement (Vutukuri *et al*., 1974), the tensile strength of soils is often determined from indirect tests such as the brasilian test (Kirkham *et al*., 1959) or flexural tests (Farrell *et al*., 1967) carried out on specimens of the soil. The tensile strength thus determined is sometimes termed the modulus of rupture. Tensile strength (modulus of rupture) has been used as an index of the crusting of soils (Richards, 1953) and in the study of the resistance to seedling emergence in a crusted soil (Arndt, 1965). Tensile strength is used in the quantification of soil friability *F*, which reflects a soil's amenability to crumbling under applied stress (Utomo and Dexter, 1981; Watts & Dexter, 1998). Tensile strength has, however, not been used in quantifying soil cutting forces though its ratio to soil shear strength has been suggested as a possible criterion for predicting the type of failure to be expected in soil cutting (Elijah and Weber, 1968). Farrell *et al*. (1967) have also suggested that the tensile strain energy might prove useful in estimating the degree of soil breakup by tillage implements.

Young's modulus *E* and Poisson's ratio *v* have also been used in elasticity theories for soil compaction (Sohne, 1956; Seig, 1985) and in numerical analyses (finite element method) of some soil cutting problems (Yong & Hanna, 1977; Chi and Kushwaha, 1987, 1989; Fielke, 1999). The latter have, however, been based on the assumption of shear failure. Chandler (1984) showed that soil strength could be quantified in terms of the fracture properties of soils. Using a method of producing controlled fracture in laboratory prepared soil specimens, he studied the soil's resistance to crack growth. The intrinsic crack growth resistance of the soils tested was observed to increase as the cracks grew. In this regard, he concluded that the tested soils showed similar behaviour to that of tough metals.

Effect of physical properties on soil strength

The physical properties of soil, particularly its moisture content, micro-structural state and textural composition, have a significant influence on its mechanical strength properties. Two broad micro-structural states, commonly encountered in agricultural soils, have been identified (Hettiaratchi and O'Callaghan, 1985). These are the remoulded state and the cemented state. Cementation in soils can be due to wetting and drying cycles (Koolen and Kuipers, 1983) or the presence of clay particles or ions which produce strong internal bonds within the soil aggregates. Hardsetting soils commonly encountered in tropical and semi-arid regions such as Africa and Australia (Willcocks, 1982; Mullins *et al*., 1990), and crusted soils are examples of "cemented" soils. Several investigations (Farrell *et al*., 1967; Spoor & Godwin, 1979; Hettiaratchi and allaghan, 1980; Towner, 1987; Hatibu, 1987) on the influence of the physical properties of soil on its mechanical strength properties and behaviour, have shown that decreasing moisture content, increasing clay content and increasing cementation lead to an increase in soil strength and brittleness.

Soil fracture and ductility

Agricultural soils can be regarded as having a crumb structure (Russell, 1973). The crumbs are bonded together in a bulk soil by cohesion due to moisture or organic secretions. The different ways in which the soil crumbs are packed together and the fact that they can be deformed accounts for changes in soil structure (Chandler, 1985). The crumb structure approach is particularly useful in understanding fracture processes in soil. The basic fracture process involves the breaking of bonds between the soil crumbs. When the crumbs are hard and the bonding between crumbs is weak, the soil cracks in a brittle manner. On the other hand, when the bonding between the crumbs is strong compared with its internal strength, it may become distorted without breaking (*i.e*., it is ductile). Chandler (1985) considered the action of a mouldboard plough working in different soils. In a hard brittle soil, the plough produces cracks ahead of the share, and large clods are separated which are too strong to be broken up as they move across the mouldboard. In contrast, in a soft, ductile soil little cracking occurs and a ribbon of soil is produced. The occurrence of brittle fracture is particularly common in hardsetting soils, especially during rapid and intense drying of these soils in hot dry regions (Mullins *et al*., 1990).

Stress-strain characteristics of soil

The mechanical behaviour of a soil is often assessed on the basis of its stress-strain characteristics in laboratory testing. *Figure 1a* shows typical stress-strain curves for loose, dense and brittle soil. It can be seen that brittle behaviour is characterised by an essentially linear stress-strain curve up to the point of failure. Yield and failure occur almost at the same time and post-failure behaviour is marked by a significant drop in the stress level to a very low residual value. The initial linear portion of the curve corresponds to elastic behaviour where the strains (deformations) are recoverable upon unloading. Brittle behaviour of soil in this manner has often been reported (Gill and VandenBerg, 1968; Hettiaratchi and O'Callaghan, 1980; Hatibu, 1987). The stress-strain curve for a loose soil is essentially non-linear and exhibits significant plastic (irrecoverable) deformation. The residual stress is seen to be significantly higher than the yield stress. This behaviour is commonly termed strain hardening. The stress-strain curve of a dense soil will, in general, lie between these two curves exhibiting plastic deformation preceeded by an initial approximately elastic portion (*Fig. 1a*).

The effect of some physical properties of soil, such as pore pressures, on its mechanical behaviour introduces enormous complications which make it difficult, if not impossible, to specify the actual stress-strain relationships within the soil during soil

cutting operations. Research workers investigating the mechanics of soil cutting have therefore employed simplified models of soil behaviour in order to obtain reasonable solutions to real problems. The Mohr-Coulomb model is the most widely used simplified model of soil behaviour. The idealized stress-strain behaviour assumed by this model is depicted schematically in *Fig. 1b* and forms the basis for existing two- and three-dimensional soil cutting models, which have evolved from passive earth pressure theory (Reece, 1965; Hettiaratchi *et al*., 1966; Hettiaratchi and Reece, 1974; Godwin and Spoor, 1977; McKyes and Ali, 1977). As pointed out above, soil failure by shear is assumed in these models. *Figure 1c* shows the idealized stress-strain behaviour for an elastic-brittle material. This stress-strain behaviour is commonly characterised by Young's modulus E and Poisson's ratio v. In his investigation of crack growth resistance in soils, Chandler (1984) subjected specimens having a preformed crack to tensile loading in a flexural test. By monitoring crack extension as a function of the applied load, he obtained force-displacement curves similar to that of *Fig. 1c*. Such specimens showed elastic-brittle behaviour. Linear elastic fracture mechanics methods, which utilise the elastic-brittle model of *Fig. 1c*, have been applied to the study of brittle fracture in soil cutting (Aluko and Chandler, 2004).

Analytical Studies of Soil Fracture

Braunack *et al*. (1979) reported a statistical theory for finding the mean distribution of the weakest flaws within soil aggregates. The flaws could be microscopic pores or cracks, material packing inhomogeneities or inclusions of foreign bodies. The fracture strength of soil was considered to be limited by these weakest flaws and crack propagation was considered to occur when a flaw was activated by a critical tensile stress. The statistical theory of soil brittle fracture forms the basis for the quantification of soil friability, which itself has been defined as the tendency of a mass of unconfined soil to disintegrate and crumble under applied stress into a particular size range of smaller fragments (Utomo and Dexter, 1981). Considering its sensitivity to sample size and the occurrence of microcracks (and/or other flaws) in the soil, Watts and Dexter (1998) posited that the quantification of soil friability relies on the study of soil tensile strength. Soil friability was therefore re-defined as the coefficient of variation of soil tensile strength.

Other quantitative approaches that have been used to analyse soil fracture in tilth development processes, are based on Griffith's theory of crack propagation. These may be termed the effective stress, strain energy (or energy balance) and stress intensity factor approaches.

Griffith's theory of crack propagation

Griffith (1920, 1924) considered the distribution of stresses around cracks in elastic materials. For an infinite plate of unit thickness, containing an elliptical crack and subjected to a remotely applied uniform tensile stress σ normal to the plane of the crack (*Fig. 2*), Griffith found that the maximum tensile stress σ_m occurred at the sharpest edges (tips) of the crack. The value of σ_m was found to be many times greater than σ. Griffith postulated that tensile failure (brittle fracture) initiates at these points of stress concentration once σ_m attains a certain critical value which is a material constant. The ratio σ_m/σ is a function of crack geometry and is independent of both crack length and material elastic constants. Griffith (1924) further showed that shear-stress components parallel to the plane of a crack also contribute to the tensile stress concentration at crack tips. The Griffith criterion can be expressed, in terms of principal stress relationships and the uniaxial tensile strength, by the following pair of conditions (Paul, 1968):

$$\sigma_1 + 3\sigma_3 < 0 : \sigma_3 + \sigma_t = 0 \quad (3a)$$

and

$$\sigma_1 + \sigma_3 < 0 : (\sigma_1 - \sigma_3)^2 + 8\sigma_t(\sigma_1 + \sigma_3) = 0 \quad (3b)$$

where σ_t is the uniaxial tensile strength of the material. For uniaxial compression, σ_3 is equal to zero and Eqn. (3) implies that fracture will initiate once $\sigma_1 = 8\sigma_t$ (Ingles & Frydman, 1963; Snyder and Miller, 1989).

The effective stress approach

Soil tensile strength has been estimated using an effective stress approach (Mullins and Panayiotopoulos, 1984; Snyder and Miller, 1985, 1989; Young and Mullins, 1991; Panayiotopoulos, 1996). This approach assumes that the soil particle system is held together primarily by surface tension and the negative hydrostatic pressure u_w of the pore water. It is also assumed that the soil-water matric potential and pore water pressure of unsaturated soils are equivalent. According to the effective stress approach, soil tensile strength is given by

$$\sigma_t = c_t + \chi\psi \quad (4)$$

where c_t represents the cohesion component of tensile strength, χ is a function of the degree of saturation ranging from 0 in a dry soil to 1 in a saturated soil and ψ is the matric potential. Snyder and Miller (1989) proposed a modified effective stress relationship which takes into consideration the Griffith theory of stress concentration at crack edges. Assuming that the stress concentration σ_m/σ at crack edges could be represented as a function of the degree of pore saturation S of the soil, a parameter $f(S)$ (where $f(S) = \sigma_m/\sigma$) was introduced which is a function that is dependent on the shape of pores and cracks (*i.e.*, unsaturated flaws) within the soil. Using the theory proposed by Snyder and Miller (1985, 1989), Eqn. (4) becomes (Panayiotopoulos, 1996)

$$\sigma_t = c_t + \chi\psi/f(S) \quad (5)$$

The energy balance approach

As pointed out earlier, Griffith's model, later modified by Irwin (1948), applies to materials that exhibit essentially elastic behaviour, non-elastic deformation being limited to regions near the crack tip whose linear dimensions are small compared with the crack length. Such materials can be considered to contain several microscopic cracks. As the material is loaded, elastic strain energy is stored reversibly within it. When the applied load is sufficient, a crack begins to propagate and energy is absorbed by the deformation in the region of the crack tip. The energy required to let a microcrack grow a unit of length as well as the energy absorbed by the deformation in the vicinity of the crack tip are supplied by the release of the stored elastic energy. Hence, the Griffith model is termed the energy balance approach in fracture mechanics (Ewalds & Wanhill, 1986). The Griffith criterion is usually expressed as:

$$G \geq R \quad (6)$$

where G is the elastic energy release rate and R is the crack resistance or fracture energy.

For the case of the infinite plate of unit thickness, containing an elliptical crack and subjected to a remotely applied uniform tensile stress σ as shown in *Fig. 2*, Griffith showed that

$$G = \frac{\pi\sigma^2 a}{E} \qquad (7)$$

and

$$R = 2\,\gamma_e \qquad (8)$$

where a is half the crack length and γ_e is the elastic surface energy of the material. With Irwin's modification, Eqn (8) becomes

$$R = 2(\gamma_e + \gamma_p) \qquad (9)$$

where γ_p is the energy absorbed in plastic deformation. Studies on soil fracture that have used the energy balance approach include Farrell *et al*. (1967), Briones and Uehara (1977), Hadas (1987) and Okunlola and Payne (1991).

The stress intensity approach

Owing to the limitations of the energy balance approach in dealing with a wide range of practical problems, Irwin (1957) later developed the stress intensity approach. The stress intensity approach postulates that fracture occurs when a critical stress at a fixed distance ahead of the crack tip is reached. From linear elastic theory, Irwin showed that the stresses in the vicinity of a crack tip are given by:

$$\sigma_{ij} = \frac{K}{\sqrt{2\pi r}}\, f_{ij}(\theta) + \ldots\ldots\ldots, \qquad i, j = 1, 2, \qquad (10)$$

where r and θ are the cylindrical polar coordinates of a point with respect to the crack tip (*Fig. 3*), $f_{ij}(\theta)$ is the deformation function describing the geometry of growth at the crack tip with respect to angle θ and K is the stress intensity factor in MN $m^{-3/2}$. The factor K is a constant and it gives the magnitude of the elastic stress field. In the application of the stress intensity approach three modes of loading are recognised (Ewalds & Wanhill, 1986). These are the opening mode, sliding mode and tearing mode. They are usually denoted by mode I, mode II and mode III, respectively and the corresponding stress intensity factors by K_I, K_{II} and K_{III}. Only modes I and II are relevant to two-dimensional fracture analyses.

The stress intensity factor K for an infinite plate containing a slit crack of length $2a$ (*Fig. 2*) is given by:

$$K = \sigma\sqrt{\pi a} = \sqrt{G\,E} \qquad (11)$$

and the failure criterion governing crack propagation is:

$$\sigma\sqrt{\pi a} \geq \sigma_c\sqrt{\pi a} = K_c \qquad (12)$$

where σ_c is the critical tensile stress and K_c is the critical stress intensity factor in plane stress. For plane strain, K_c is replaced by K_{Ic} in Eqn (12). The factor K_{Ic} is a material property and is usually determined experimentally by measuring the fracture stress for a material having a crack of known length. The stress intensity approach has been used widely to solve a variety of crack problems and forms the basis of linear elastic fracture mechanics (LEFM) theory.

Development of Brittle Fracture Soil Cutting Theory

Previous methods of analysis of soil cutting may be classified as empirical methods employing dimensional analysis (Luth and Wismer, 1971; Wismer and Luth, 1972), rigid body static solution techniques (Sohne, 1956; Rowe and Barnes, 1961) and techniques deriving from passive earth pressure theory (Reece, 1965; Hettiaratchi *et al*., 1966; Hettiaratchi and Reece, 1974; Godwin and Spoor, 1977; McKyes and Ali, 1977). It has, however, been shown (Elijah and Weber, 1968; Utomo and Dexter, 1981; Berntsen and Berre, 1993; Aluko and Seig, 2000) that these techniques are inadequate (and/or incompatible) for the analysis of brittle fracture and soil fragmentation processes, respectively, during soil cutting tillage operations. This is partly because a fundamental assumption of these theories is that soil fails in shear. Since the mechanism of crack propagation differs completely from that of shear failure (Aluko and Seig, 2000), it follows that the Mohr-Coulomb criterion and the shear parameters c and ϕ cannot be used to characterise the failure process. Indeed Elijah and Weber (1968) recognised this limitation of c and ϕ when they reported that a new parameter was needed to characterise tensile failure (brittle fracture) in soil cutting. Furthermore, whilst empirical methods employing dimensional analysis are limited (in application) to specific soil and tool conditions, the rigid body static solution techniques and the techniques deriving from passive earth pressure theory rely on the equilibrium of forces acting on a rupture block of assumed geometry. In brittle fracture, however, the process of cracking can be very irregular and it is not possible to associate a particular shape or size of clods with certain soil and blade conditions (Aluko and Seig, 2000).

Deformation and force characteristics of brittle fracture

Detailed experimental investigations of soil cutting, carried out by Aluko and Seig (2000), have shown that the deformation characteristics of brittle fracture are significantly different from those of shear failure. Whilst shear failure is characterised by extensive shear distortion, compaction and the regular formation of distinct slip planes, brittle fracture is characterised by crack propagation and negligible deformation within separated soil clods. This shows that brittle fracture in soil cutting is principally an elastic problem and can be modelled using methods of fracture mechanics for elastic-brittle materials.

An important assumption leading to the development of the brittle fracture soil cutting theory is that the cutting force is essentially from the region of the blade tip (*i.e*., the leading edge of the cutting blade). This assumption was based on the observation (Aluko and Seig, 2000) that for slight penetrations of the blade tip, crack propagation (leading to clod separation) occurred at a much faster rate than tool speed. Similar observations have been reported in the literature (Koolen, 1972, 1973).

The foregoing deformation and force characteristics are important in the development of an analytical model for the mechanism of brittle fracture in soil cutting.

Characterisation and modelling of the mechanism of brittle fracture

Using the experimental observations reported by Aluko and Seig (2000) in conjunction with similar reports in the literature (Selig and Nelson, 1964; Elijah and Weber, 1968; Koolen, 1972, 1973), Aluko and Chandler (2004) identified the following key process stages in the mechanism of brittle fracture in soil cutting:

(a) splitting and crack initiation;
(b) influence of bending moment and subsequent breaking off of a soil clod; and

(c) initiation of a new crack with further blade movement and simultaneous movement of previous soil clod over the blade surface.

Aluko and Chandler (2004) further noted that the nature of force application and crack propagation during soil cutting was similar to that of fracture mechanics edge notch crack problems such as flaking, flint knapping and indentation fracture.

Based on the key process stages identified above, Aluko and Chandler (2004) developed a theory for crack propagation and subsequent clod formation during two-dimensional soil cutting operations in brittle agricultural soils. The theory assumes that the material property governing failure is the critical stress intensity factor K_{Ic} of the soil and the failure criterion is $K_I > K_{Ic}$ where K_I is the applied stress intensity factor. Using fracture mechanics methods for some edge notch crack problems, Aluko and Chandler (2004) showed that for an ideally horizontally propagating crack in a brittle agricultural soil (*Fig. 4*), the fracture process leading to clod formation comprises two regimes of crack growth/development termed the *short* and *long* crack regimes. During the initial stages of crack growth in the short crack regime ($a << h$), the relationship between the developing crack and the applied cutting force is given by (Aluko & Chandler, 2004):

$$\frac{K_I}{H}\left[\frac{a\left(\pi^2-4\right)}{4\pi}\right]^{1/2} = \frac{V}{H}-\frac{2}{\pi} \qquad (13)$$

where V and H are the vertical and horizontal components, respectively, of the cutting force P exerted on the soil by the blade (*Fig. 4*) and a is the crack length. With further development, crack behaviour changes from short to long. The model for long crack ($a/h > 2$) behaviour (Aluko & Chandler, 2004) is

$$\frac{K_I h^{1/2}}{H} = -0.541 + 1.68\left(\frac{V}{H}\right) + 1.92\left(\frac{V}{H}\right)\left(\frac{a}{h}\right) \qquad (14)$$

where h is the height of the encastré soil beam above the developing crack. Aluko and Chandler (2004) showed that the force exerted by the blade on the soil beam above the developing crack creates a bending moment, which causes additional tensile stresses at the crack tip. Increase in the bending moment as the crack length increases causes the direction of cracking to turn off upwards when the crack length attains a critical value a_c. The critical crack length a_c is given by (Aluko & Chandler, 2004)

$$a_c = \frac{2Hh}{3V} \qquad (15)$$

Aluko and Chandler (2006) subsequently developed a method and apparatus for the determination of a soil critical stress intensity factor K_{Ics}, which characterises the fracture strength of brittle agricultural soils and replaces K_{Ic} in the brittle fracture soil cutting theory. The procedure consists of subjecting single edge notch bend (SENB) specimens, each having a pre-formed crack of known depth, to a simple flexural test during which the applied load and deflection are monitored to failure. The introduction of K_{Ics} changes the failure criterion for brittle fracture from $K_I > K_{Ic}$ to $K_I > K_{Ics}$. The soil critical stress intensity factor K_{Ics} is given by (Aluko & Chandler, 2006)

$$K_{Ics} = \frac{FS}{BW^{3/2}} f(a/W) \quad (16)$$

and

$$F = F_a + W_s/2 \quad (17)$$

where F is the failure load in soil fracture strength testing, F_a is the vertical applied load in soil fracture strength testing, W_s is the self-weight of the soil SENB specimen, a is the specimen preformed crack depth, S is the distance between soil specimen supports, B is the thickness of the soil specimen, W is the width of the soil specimen and $f(a/W)$ is a dimensionless geometric function of the ratio of preformed crack depth to width of the fracture test (SENB) specimen.

Discussion

The importance of tensile strength in the study of soil fracture is well attested to in the literature. Tensile strength in particular is sensitive to soil structure because it is controlled by the microcracks or other flaws in the soil (Watts and Dexter, 1998). Tensile strength is especially sensitive to microstructure because of the intensification of stresses which occurs at tips of cracks (Hallett *et al*., 1995). This leads to failure at smaller applied stresses than is the case if cracks are not present. This sensitivity of tensile strength to structure does not manifest itself with compressive modes of soil failure where the cracks become closed and inactivated, and do not influence values of mean failure stress (Watts and Dexter, 1998).

Using previously published experimentally determined values of tensile strength, soil water pressure (or soil-water matric potential) and degree of pore saturation, Snyder and Miller (1985) found excellent agreement between experimental tensile strength data on sands and silts and corresponding values predicted from a modified effective stress theory similar to Eqn. (5). Based on the conditions expressed in Eqn. (3), some studies have considered the applicability of Griffith's criterion to soils by examining the relationship between experimentally determined values of indirect tensile strength and unconfined compressive strength (Young and Mullins, 1991; Panayiotopoulos, 1996). As pointed out earlier, according to the Griffith crack theory, the ratio R of compressive to tensile strength should be 8.0 for unconfined samples (Ingles and Frydman, 1963). Young and Mullins (1991) and Panayiotopoulos (1996) found this ratio to be 6.3 for soils with low structural stability and 3.8 for soils with high structural stability, respectively. Rather than the constant value of 8.0 suggested by Griffith's theory, these studies suggest that R varies between and within soils as well as with matric suction. For a loam soil, however, Farrell *et al*. (1967) found R to be close to the predicted value of 8.0 for low water contents up to 10%.

In general, applications of the statistical, effective stress and strain energy theories have focused on the study of soil tensile strength (or tensile strain energy) with efforts being made to correlate experimentally measured tensile strength (usually indirect tensile strength measurements) with corresponding values predicted from Griffith's theory. Each of these approaches has its advantages and drawbacks and can be considered as complementary to each other (Snyder and Miller, 1989). Although these studies provide some insight into the microstructural analysis of soil fracture, these approaches are inadequate for the macrostructural analysis of crack propagation and clod formation during the cutting and tillage of brittle agricultural soils.

Prior to the initiation of fracture in highly ductile materials, considerable plastic deformation occurs in the region around the crack tip (Rice, 1968; Raju, 1979). This tends to blunt the crack tip, reduce the stress concentration effect in the plastic zone and could

ultimately lead to the arrest of crack growth unless the applied stress is increased. The application of LEFM to soil fracture has been questioned on grounds of a possible oversimplification of the actual influence of plasticity on crack growth in soils. Hallett *et al*., (1995) have argued that the application of fracture mechanics to soil fracture requires the use of an "effective" crack length which comprises the actual crack length and an additional increment, Δc. The crack length increment, Δc, was introduced to account for energy dissipated on aspects of the fracture process other than the formation of new surfaces. Snyder and Miller (1989) recognised the need for a better understanding of the effects of plasticity on soil fracture. Non-linear fracture mechanics, though used by Chandler (1984) to study the fracture toughness of some soils, is cumbersome and difficult to apply (Hallett *et al*., 1995). Aluko and Seig (2000), however, found that when fracture occurs during soil cutting, the behaviour of brittle agricultural soils can be macroscopically considered to be elastic.

The brittle fracture soil cutting theory (Eqns. (13) – (15)), which is based on the stress intensity approach, has been applied to the study of clod sizes produced in soil cutting. Although it was not possible to associate a particular shape or size of clods produced during brittle fracture with certain soil and blade conditions (Aluko & Seig, 2000), Aluko and Chandler (2004) found that in cases where brittle fracture occurred, clod size estimates based on critical crack lengths predicted using Eqn (15) were in closer agreement with measured experimental rupture distances than rupture distances predicted using shear failure theory.

Brittle fracture force-displacement curves (Aluko & Chandler, 2004) corroborate the prior assumption and show that there are important differences between the nature of the cutting force in brittle fracture and that known to be characteristic of shear failure. Whereas the cutting force in shear failure results from the continuous development of passive pressures on the surface of the cutting blade, in brittle fracture, the cutting force is cyclic in nature and is essentially concentrated in the region of the blade tip.

Cutting force estimation using the brittle fracture theory (Eqns. (13) and (14)) requires prior knowledge of the soil critical stress intensity factor K_{Ics} and the angle of inclination of the cutting force P relative to the horizontal (*i.e*., the ratio V/H of the vertical to the horizontal components, respectively, of the cutting force P). Aluko and Chandler (2006) carried out fracture tests on specially prepared soil SENB specimens and reported K_{Ics} values for a sandy loam, a clay loam and a cemented sand soil. For a given soil type, K_{Ics} was found to increase with increasing soil dry density. For particular soil and loading conditions, however, the determination of V/H is not so straight forward. It has been shown (Aluko and Seig, 2000) that transitions between the brittle fracture and shear modes of failure are influenced, not only by soil strength and blade geometry (*i.e.*, rake angle), but also by soil-blade interface condition. Thus, consideration of blade geometry alone may lead to the inaccurate estimation of V/H.

Another limitation of the brittle fracture soil cutting theory arises from the inability to deduce short crack behaviour under non-symmetrical mixed mode loading. Aluko and Chandler (2004) analysed Eqns. (13) and (14) and showed that the applied cutting force attains a maximum during the transition from short to long crack behaviour. However, further extraction of the maximum cutting force was precluded because the derivation of Eqn. (13) was based on conditions of symmetrical single mode crack loading rather than non-symmetrical mixed mode crack loading.

An important requirement in soil cutting and tillage practice is the reliable prediction of expected soil failure mechanism(s) and the associated soil crumbling and aggregate size reduction patterns for specific soil and implement conditions. Analysis of Eqn. (13) (Aluko and Chandler, 2004) has shown that there is a limiting value of V/H below which crack growth is annulled and brittle

fracture will not occur in soil cutting. Furthermore, when cutting is performed on wet, relatively weak soil, shear failure rather than brittle fracture will occur irrespective of the rake angle of the cutting blade and hence, *V/H*. From consideration of the ratio W_s/F of the specimen self weight to the failure load during fracture testing of soil SENB specimens, Aluko and Chandler (2006) proposed a simple criterion which provides an indication of the type of failure mechanism to be expected during two-dimensional soil cutting with simple plane blades. By comparing fracture test results with previously reported results of soil cutting experiments on the same soils (Aluko & Seig, 2000), Aluko and Chandler (2006) showed that a maximum value *m* of the ratio W_s/F exists, such that if $W_s > mF$, shear failure rather than brittle fracture will occur at all rake angles. For the sandy loam and clay loam soils tested, *m* was found to be 0.26 and 0.29, respectively.

Summary and Recommendations for Further Research

Agricultural soil constitutive relations are not yet fully understood. Consequently, the development of reasonable solutions to practical problems involves the use of simplified models of soil behaviour and some assumptions. This is especially true in the quantitative analyses of soil cutting and tilth forming processes.

Brittle fracture is an important aspect of soil mechanical behaviour in natural and artificial tilth development processes. The quantitative study of brittle fracture is essential for the optimum design of tines for fracturing brittle agricultural soils. Current knowledge on soil fracture mechanisms is derived from a number of theoretical approaches. These are the statistical, effective stress, strain energy and stress intensity approaches. The first three approaches provide information on microstructural aspects of soil fracture. Macrostructural aspects of brittle fracture during soil cutting and tillage operations are addressed using the fourth approach.

Further research is needed to deduce short crack behaviour under non-symmetrical mixed mode loading. This will enhance the estimation of maximum cutting forces using the brittle fracture soil cutting theory. Considering the nature and origin of the brittle fracture cutting force, the influence of the cutting edge interface condition on the ratio *V/H* requires further study. The influence of pore water pressure (or matric suction) and degree of pore saturation on the soil critical stress intensity factor also requires further study.

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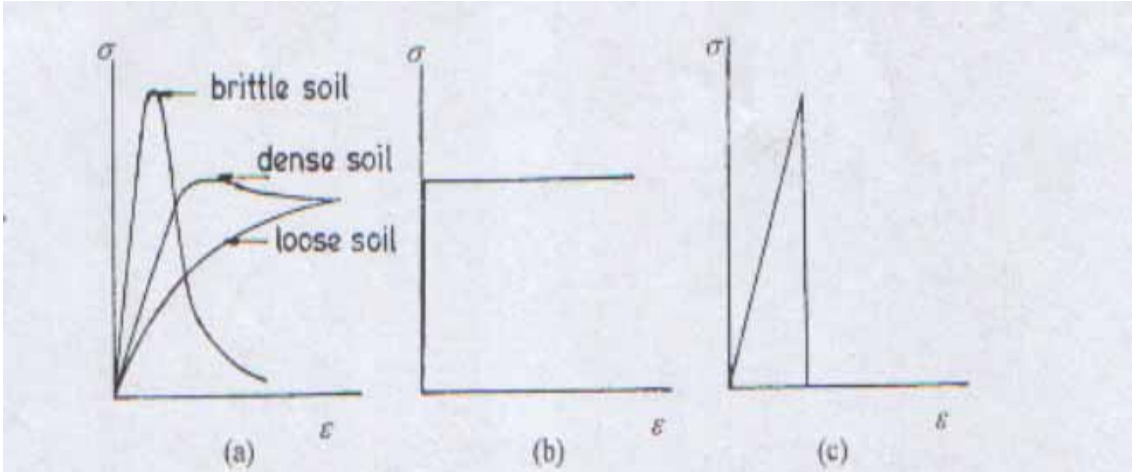

Fig. 1. Stress-strain relationships. (a), dense, loose and brittle soils; (b), rigid-plastic model; (c), elastic-brittle fracture model.

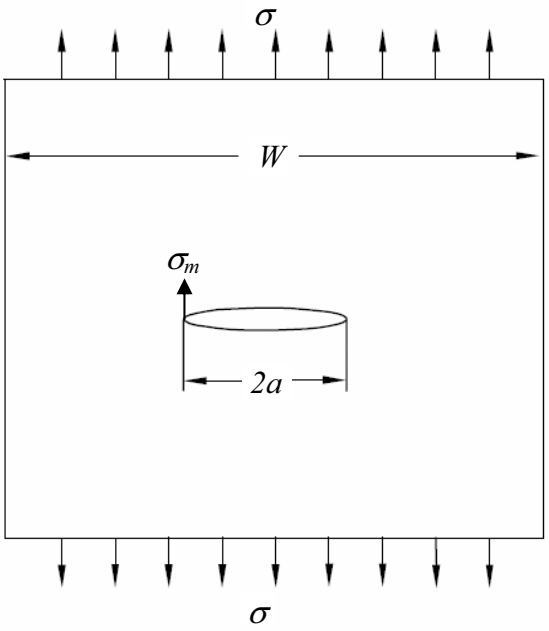

Fig. 2. Infinite plate of unit thickness containing a through crack of length 2a; σ, remotely applied uniform tensile stress; W, plate width; σ_m, maximum tensile stress at crack edges

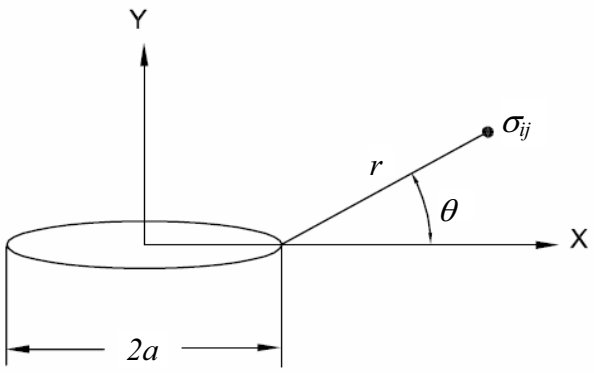

Fig. 3. Stresses σ_{ij} at a point ahead of a crack tip; a, half crack length; r, θ, cylindrical polar coordinates of a point with respect to the crack tip

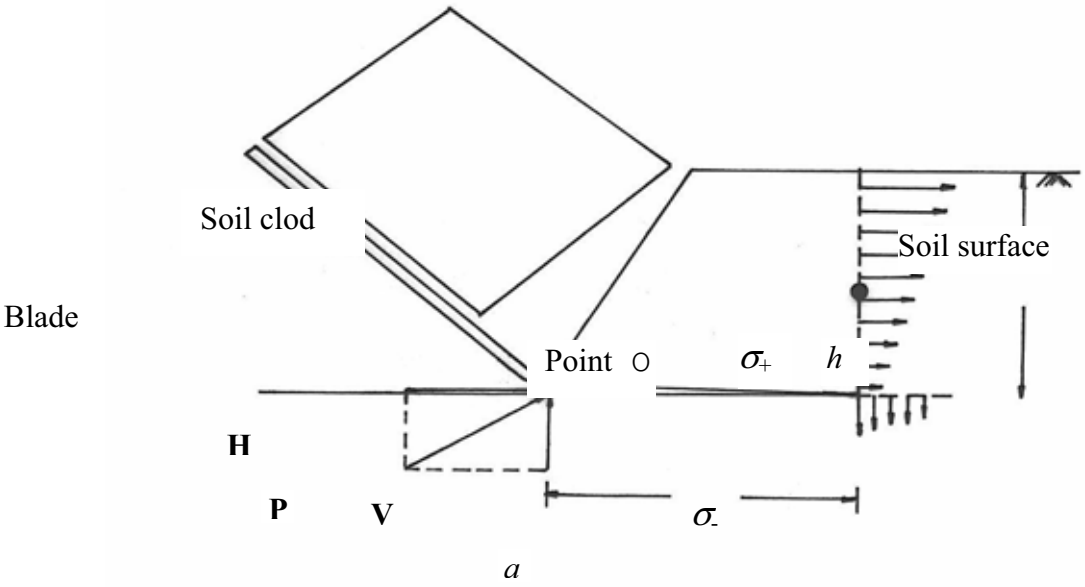

Fig. 4. Schematic illustration of the brittle fracture model for two-dimensional soil cutting; P, cutting force exerted by the blade; H, horizontal component of force P; V, vertical component of force P; a, crack length; h, height of encastré soil beam above developing crack; σ_+, compressive stress; σ_-, tensile stress

EDXRF Elemental Assay of Airborne Particulates:
A Case Study of an Iron and Steel Smelting Industry, Lagos, Nigeria.

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Abstract

The unregulated activities of a scrap iron and steel smelting industry in Lagos, Nigeria necessitated the sampling of PM_{10} and $PM_{2.5}$ particles from various sections of the industry. The samples were analyzed using polarized energy dispersive x-ray fluorescence (EDXRF) technique which allowed the simultaneous detection of over 25 elements in each of the samples. The mass concentration levels ranged from 86 μg/m^3 to 8765 μg/m^3 for PM_{10} and 10 μg/m^3 to 462 μg/m^3 for $PM_{2.5}$. The highest concentrations of 8765 μg/m^3 and 462 μg/m^3 for PM_{10} and $PM_{2.5}$, respectively, were observed at one of the electric arc-furnaces (EAF-2). This was attributed to the scrap smelting and additives used. The observed higher concentrations of PM_{10} Pb at various sites, when compared with exposure limit of between 1.0 and 5.0μg/m^3 set by Occupational safety and Health Administration (OSHA) and United State Environmental Protection Agency (US EPA) is emphasized. For Zn, the measured levels exceeded the OSHA workplace occupational exposure limit set at 1 mg/m^3 for an 8-hour workday over a 40-hour work week and that set by the National Institute for Occupational Safety and Health (NIOSH) for up to a 10-hour workday over 40-hour workweek. These results suggest the need for immediate repair or replacement of the emission control devices.

Key Words: [PM_{10}, $PM_{2.5}$, Polarized EDXRF, Toxicity Potential, Electric arc-furnace, Turboquant]

Introduction

Industries, through their various processes generate toxic pollutants. Some of these pollutants are in particulate form, while others are in particulate form. In developed countries, environmental protection agencies ensure that industries install and maintain pollution abatement technologies, so as to reduce concentrations of the pollutants to conform to set-down guidelines. However, in developing countries, environmental protection agencies are hardly effective, in that very little efforts are geared towards pollution control devices, if they exist at all. The consequence of the ineffectiveness is that industries emit these pollutants into the workplace and neighbourhood environments. Unfortunately in these countries, industries are sometimes located in residential and commercial areas partly due to lack of proper enforcement of urban planning bye-laws. Both the populace in the vicinity of such industries and the workers in the industries get exposed to the pollutants as they spend large fraction of their lives within the polluted environment (Akeredolu, 1989). Various studies evaluating the mass concentrations as well as the elemental composition of airborne particulate matter in workplace environments have been reported (Akeredolu *et al*., 1994, Obiajunwa *et al*., 2002 and Cambra *et al*., 1999).

In Nigeria, there has been a remarkable advancement in industrial progress within the last two decades. This rapid rate of industrialization has not been matched with proper planning for environmental pollution problems that are usually associated with such development (Adejumo *et al*., 1994). The activities of the scrap iron and steel smelting industry has been on the high side due to increasing importation of used vehicles into the country. This has contributed to high and unregulated degradation of ambient air quality. Several studies evaluating the mass and composition of PM_{10} and total suspended particles (TSP) in the ambient air of urban environments have been described (Olise *et al*., 2007). Most of these studies were carried out in vehicular traffic prone areas, and the rest were in cement industries. Lagos, Nigeria is a rapidly growing city, with a population of about nine million people, according to the Nigerian population census of 2007. The city also has a rapidly growing number of both large and small scale industrial establishments. The industries form major contributors to the environmental pollution problem in the city. The national and state environmental protection agencies are struggling to set up guidelines to limit emissions from the industries.

The production of steel in an electric-arc furnace (EAF) is a batch process, and the input material is typically 100 percent scrap. Scrap, alloying agents and fluxing materials are loaded into the cylindrical, refractory-lined EAF. The current through the graphite electrodes generates heat which subsequently melts the scraps. The emitted dust is principally iron, and silica oxides and lime. The concentrations of the trace metals such as chromium, copper, manganese, nickel, lead, zinc, etc are significant (US EPA, 1995). Several works by different authors in this area have linked several health problems to exposure to some of these pollutants. These include increased allergy, asthma, cardio-vascular and cardio-pulmonary diseases. If exposure is prolonged, cases of different forms of cancer have been reported (Erhabor *et al.*, 1992 and Odu *et al.*, 1993). Some heavy metal pollutants have also been implicated in certain disorders of the nervous system (Kagawa, 1984). Though standards and guidelines on allowable concentrations of these pollutants have been set by environmental protection agencies, there is no consensus on whether there is any threshold concentration below which a pollutant has no detrimental effect on human health. It is therefore very important to monitor the level of pollutants from industries, especially in the work-place environment.

This work monitors airborne particulate matter in working area of an iron and steel smelting industry in Lagos, Nigeria. Samples were collected and analyzed for 25 major, minor and trace elements with a view to assessing the impact of the factory operations on the factory workers as well as the factory's immediate environment.

Experimental

Sampling:

The airborne particulate matter samples were collected at five major production sections of the iron and steel smelting industry [two electric arc-furnaces (EAF-1 & 2), continuous casting (Cont. Cast.), rolling mill, and quality control laboratory (Qual. Control)]. The sampling locations were selected to reflect locations where workers spend most of their working hours, and the samples were collected at a height of about 1.6m above the floor.

Measurements of PM_{10} and $PM_{2.5}$ fractions of particulate matter were carried out using a low-volume Metris Gent Stacked Filter Unit (Model M250) PM_{10} sampler. The stacked filter unit contains two filters, a fine filter (for particles with aerodynamic diameter $d_{ae} \leq 2.5\mu m$) and a coarse filter (for particles with aerodynamic diameter $2.5\mu m \leq d_{ae} \leq 10\mu m$). The sampler operated at a flow rate of between 16-17 litres per minute. The sampling times were between four and twenty-four hours depending on the activities in each of the production sections. The variations in the sampling time depended on the particulate load in the production sections at the time of sampling. After sampling, the exposed filters were unloaded from the filter unit and pre-

conditioned for 24 hours before reweighing to determine the particulate matter weight deposited on the filter. In all, 220 samples of both fractions were collected during the campaign over a period of one year covering both the wet and dry seasons. All the samples were collected during the working days, at least once a month from each production section and offices. The sampling was done for each location at the same fixed point throughout the sampling periods.

Analytical techniques:

The mass concentrations of the PM_{10} and $PM_{2.5}$ fractions of the particulate matter were determined by gravimetric analysis. Concentration of each fraction of the suspended particulate matter in the ambient air was determined by dividing the difference between the filter weight after and before sampling, W_A and W_B respectively, by the total volume of air sampled, V.

$$C_{SPM} = \frac{\Delta W}{V} = \frac{W_A - W_B}{V} \qquad 1$$

Toxicity potentials (TP) were calculated for each site (Table I & 3) for both PM_{10} and $PM_{2.5}$ fractions of the suspended particulate matter.

$$TP_I = \frac{C_I}{TLV_I} \qquad 2$$

where TP_I is the toxicity potential, C_I the concentration (μg/m^3), and TLV_I is the threshold limit value for the size fraction *I*. TLV_I was set equal to the US EPA standard.

The elemental concentrations of the samples were determined using the polarized EDXRF (SPECTRO LAB2000) spectrometer. The analysis time per sample was 25 minutes for the determination of trace elements, which allowed the simultaneous detection of analytes from Na to U in all the samples. The detection limit for each element is of the order of a few ng/cm^2. Micromatter standard reference samples (Micromatter, US) were used for the system calibration. A check on the calibration was done by analyzing the standard CRM128 (Fly ash on artificial filter) of the Bureau of Community Reference (BCR). The samples were quantified using TURBOQUANT, a brand name for a SPECTRO method.

Results and Discussion

PM_{10} and $PM_{2.5}$ mass concentrations:

The mass concentration levels ranged from 86 μg/m^3 to 8765 μg/m^3 for PM_{10} and 10 μg/m^3 to 462 μg/m^3 for $PM_{2.5}$ respectively as shown in figures 1 and 2. The lowest concentration levels of 86 μg/m^3 and 10 μg/m^3 for PM_{10} and $PM_{2.5}$ respectively were observed at the Quality Control Laboratory while the highest concentrations of 8255 μg/m^3 and 462 μg/m^3 for PM_{10} and $PM_{2.5}$ respectively were observed at the EAF-2. It was observed that the $PM_{2.5}$ fraction sampled at EAF-1 and EAF-2 is lowest in July, 2003 for EAF-1 and in June, 2003 for EAF-2. The same fraction was highest in January, 2004 and October, 2003 for EAF-1 and EAF-2 respectively. This might be as a result of particle sizes emitted when the furnaces are in the charging stage. Sampling did not take place in October 2003 at EAF-1 and in March 2004 at EAF-2 and this explains their non-inclusion in figures 1 & 2. The dust loadings at the other sampling sites within the same industry were also high. This was found to be due mostly to electric arc furnace emissions (Michand, 1993). The emission control device in this industry was not functioning at the time of the sampling. We observed that the effect of seasonal variation was not significant because high mass concentration recorded between

May, 2003 to August, 2003, which was the wet season in Nigeria, was not as a result of seasonal change but due to the nature, quantity of scrap and the additives used during the process of production. Mass concentrations were unexpectedly observed to be very high at the continuous casting section. This can be attributed to the downwind location of this section to the EAF-1 & 2 where most of the particles are emitted. Also, it was observed that the measurements in EAF-1 & 2 especially for $PM_{2.5}$ exceeded the US EPA 24-h average standard of 65μg/m^3 with average annual mass concentrations exceeding annual standard of 15μg/m^3 in all the sites (World Bank, 1992 and ECEE, 2001). The suspended particulate matter (SPM) at every sampling site was also higher than the ambient air quality standard of 250 μg/m^3 set by the Nigerian Federal Environmental Protection Agency.

Elemental Concentrations of PM_{10} and $PM_{2.5}$ fractions:

Table 2 shows average elemental concentrations for PM_{10} and $PM_{2.5}$ fraction in all the samples and also the detection limit for each element. The EDXRF technique allowed the simultaneous detection of Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Se, Rb, Br, Sr, Cd, Sn, Sb, Cs, Ba, Pb, and Bi in all the samples. Of particular interest are the concentrations of PM_{10} and $PM_{2.5}$ Pb at various sites. The concentration of PM_{10} Pb ranged from 0.4 to 160.2 μg/m^3 with the highest and lowest values respectively observed at EAF-2 and quality control lab. Also the concentration of $PM_{2.5}$ Pb ranged from 0.1 to 9.7 μg/m^3 with the lowest value at the quality control lab and the highest value at the continuos casting section. Four elements: Mg, Mn, Fe and Zn have relatively higher concentrations in all the sections and show same trend of higher values in the PM_{10} compared with the $PM_{2.5}$ particle fractions. However, Al was observed to have lower concentration in the PM_{10} fraction compared with the $PM_{2.5}$ fraction at the continuos casting section only while the Cs concentration values were consistently lower in the PM_{10} fractions compared with the $PM_{2.5}$ fraction. Vanadium and Ni were observed to be consistently low for the mass fractions for all the sections.

The two particulate fractions are inhalable and the $PM_{2.5}$ fractions are particularly respirable, and are therefore likely to get into the respiratory system and get absorbed into the blood. Some of the heavy metals especially Pb from workplace air have occupational exposure limit of between 1.0 to 5.0μg/m^3 set by Occupational safety and Health Administration (OSHA) while United State Environmental Protection Agency (US EPA) set occupational limit at 1.5μg/m^3, 8-hour working day and 40-hour work week (US EPA, 1995). For Zn, the OSHA workplace occupational exposure limit was set at 1 mg/m^3 for an 8-hour workday over a 40-hour work week and National Institute for Occupational Safety and Health (NIOSH) has set the same standards for up to a 10-hour workday over 40-hour workweek. A worker at EAF-1 section, working 12-hour per day, was exposed to average $PM_{2.5}$ and PM_{10} of about 15.6 and 178 μg/m^3 for Pb respectively and to 87 μg/m^3 and 6.4 mg /m^3 for Zn respectively. Likewise, for a worker at EAF-2 with the same 12 hours per day was exposed to 17.7 μg/m^3 $PM_{2.5}$ Pb and 480 μg/m^3 PM_{10} Pb and 62.8 μg/m^3 $PM_{2.5}$ Zn and 8.5 mg/m^3 PM_{10} Zn. All these exceeded the limit when compared with the above set standards.

Toxicity potential (TP) calculated for average PM_{10} and $PM_{2.5}$ mass concentrations at these sites were much higher than 1, except for $PM_{2.5}$ of the quality control laboratory (Table 1). This was also reflected in PM_{10} and $PM_{2.5}$ Pb toxicity potential for each of the site except at quality control laboratory (Table 3).The implication of this is that workers were being exposed to excessive level of this toxic pollutant. Table 4 shows the comparison between this work $PM_{2.5}$ elemental concentration in the EAF sections with that of US (AISI, 2000). The concentrations of elements: Fe, Zn, Mn and Pb were observed to be higher than those of AISI, 2000 except for Fe in EAF-2. The EAF-2 was about ten years old while EAF-1 was about thirty years. Other elements: Cr, Cu and Ni were observed to be relatively low, and this may be attributed to the nature of scraps. The scraps used by the smelting industry are majorly iron and steel.

Conclusion:

This study has shown the extent of air particulate pollution in the workplace of a scrap iron and steel smelting industry in Lagos, Nigeria. It was observed that there were high mass concentrations in some of the production sections especially in the electric arc-furnaces. The elements Cr, Mn, Fe, Cu, Zn, and Pb measured in PM_{10} and $PM_{2.5}$ fractions of the particulates were found to be high in the electric-arc furnace section as a result of the scrap and additives used in the process and the rate of emission are relatively high when compared with other production sections within the industry. This has led to the observed high elemental concentrations of some of the elements which have been implicated as having serious health impacts on human life. It was also observed that emitted pollutants from the furnaces are blown in the direction of continuous casting section because of its downwind location, which makes the measured elemental concentrations at that section higher than expected.

It can be inferred from this work that if the emission of the pollutants are left unabated, the workers' health are likely to be at risk. The high levels of PM_{10} and $PM_{2.5}$ particulate fractions with the concomitant high level of heavy metals are likely to lead to impairment of the workers' lung functions, (Kelsall *et al*., 1997 and Pagano *et al*.; 1998). Thus it is recommended that the emission control devices should be repaired to control the emissions from the production processes. Also, regular air quality monitoring should be carried out both by the industry and the government agents who are responsible for ambient air quality standards.

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Table 1: Average PM_{10} and $PM_{2.5}$ mass concentrations and the sampling sites toxicity potentials.

	PM2.5		PM10	
Site	Conc. (µg/m^3)	TP	Conc. (µg/m^3)	TP
EAF-1	171.4	2.6	2244	34.4
EAF-2	156.0	2.4	4975	76.5
Continuous Casting	147.7	2.3	3314	51.0
Rolling Mill	92.8	1.4	687	10.6
Quality Control Lab	31.9	0.5	127	2.0

Table 2: Average elemental concentrations (µg/m^3) of PM_{10} and $PM_{2.5}$

Element	DL (ng/cm^2)	EAF-1		EAF-2		Cont. Cast		Rolling Mill		Qual. Control	
		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Na	50	13.6	1.8	34.6	2.0	26.5	3.33	4.7	0.9	0.3	0.1
Mg	9	472.7	393.9	125.1	4.4	1120.5	1117.8	378.6	1.0	82.1	1.1
Al	5.4	42.9	34.3	20.0	0.6	71.2	124.5	2.8	0.5	10.3	0.4
Cl	0.9	31.7	9.1	49.6	8.0	36.4	6.6	7.1	1.0	0.7	0.1
K	28.2	34.7	4.9	83.7	5.4	60.3	10.5	9.0	2.8	1.6	0.7
Ca	5.2	7.4	0.5	32.3	1.3	12.7	7.6	2.9	2.8	1.1	0.2
Ti	1.6	0.4	0.0	1.8	0.0	1.0	0.4	0.1	0.0	0.0	0.0
V	3.1	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Cr	4.4	3.6	0.3	6.4	0.1	5.9	0.9	1.1	0.1	0.3	0.0
Mn	9.6	53.4	4.5	132.8	3.0	95.3	11.2	13.0	0.6	2.0	0.1
Fe	12.3	527.4	38.2	1592.1	23.8	913.5	106.5	198	14.1	43.0	8.0
Ni	1.9	0.6	0.0	1.8	0.0	1.3	0.7	0.2	0.0	0.2	0.1
Cu	4.7	4.8	0.5	12.7	0.3	9.8	3.8	1.8	0.2	2.4	0.9
Zn	6.3	311.8	29.0	2817.5	20.9	481.5	39.8	39.0	3.7	1.6	0.5
Br	1.8	2.0	0.3	8.5	0.3	3.6	0.3	0.4	0.1	0.0	0.0
Rb	3.2	0.3	0.1	0.7	0.1	0.4	0.1	0.1	0.0	0.0	0.0
Sr	2.7	0.1	0.0	0.3	0.1	0.2	0.3	0.0	0.0	0.0	0.0
Cd	26	0.9	0.1	2.3	0.2	1.9	0.4	0.2	0.1	0.0	0.1
Sn	25	1.7	0.6	3.9	0.2	2.4	1.3	1.6	0.3	0.5	0.2
Sb	17	0.6	0.4	2.6	0.0	0.9	1.0	0.1	0.0	0.1	0.0
Cs	2.1	0.9	1.4	0.5	0.9	1.3	3.8	0.2	0.5	0.3	0.2
Ba	23	3.5	3.0	4.0	1.1	5.0	4.0	1.4	0.8	0.8	0.3
Pb	5.1	59.2	5.2	160.2	5.9	103.6	9.7	11.9	1.4	0.4	0.1
Bi	3.5	0.4	0.1	1.2	0.1	1.0	0.3	0.1	0.1	0.0	0.0

Table 3: PM_{10} and $PM_{2.5}$ Pb toxicity potential for each site

	$PM_{2.5}$ Pb	TP	PM_{10} Pb	TP
EAF-1	5.2	3.47	59.2	39.47
EAF-2	5.9	3.93	160.2	106.8
Continuous Casting	9.7	6.47	103.6	69.07
Rolling Mill	1.4	0.93	11.9	7.93
Quality Control Lab	0.1	0.07	0.4	0.27

Table 4: Comparison of this work $PM_{2.5}$ average elemental concentration in EAF (µg/m^3) with literature

	EAF		
Element	AISI, 2000	EAF-1 (TW)	EAF-2 (TW)
Fe	29	38	24
Zn	16	29	21
Mn	4	5	3
Pb	2	5	6
Cr	1.3	0.3	0.1
Cu	2.7	0.5	0.3
Ni	0.3	0	0

TW: This work

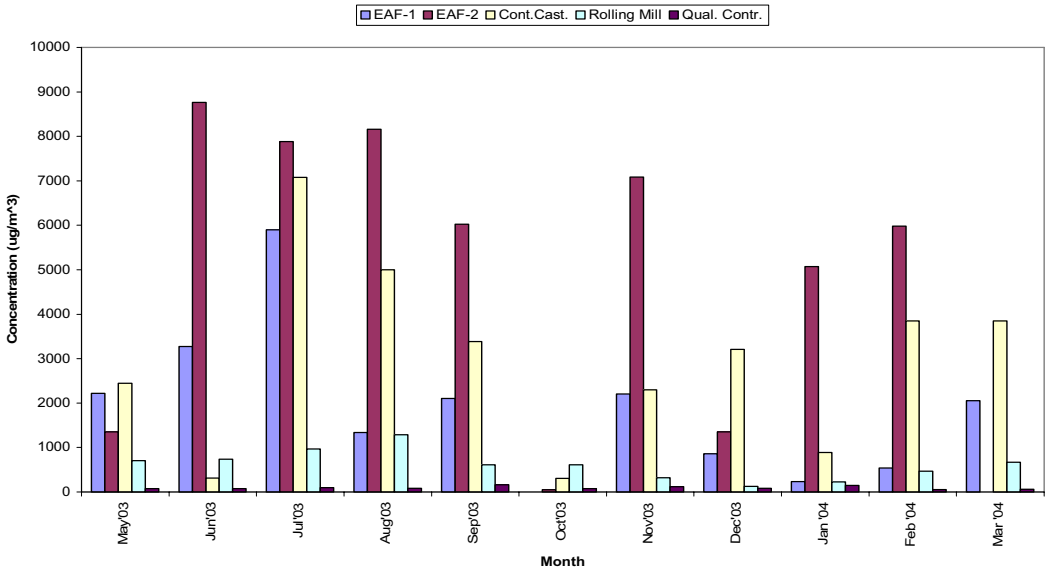

Fig. 1: Average mass concentration of PM_{10} particles in the five production sections of the scrap Iron and Steel Smelter.

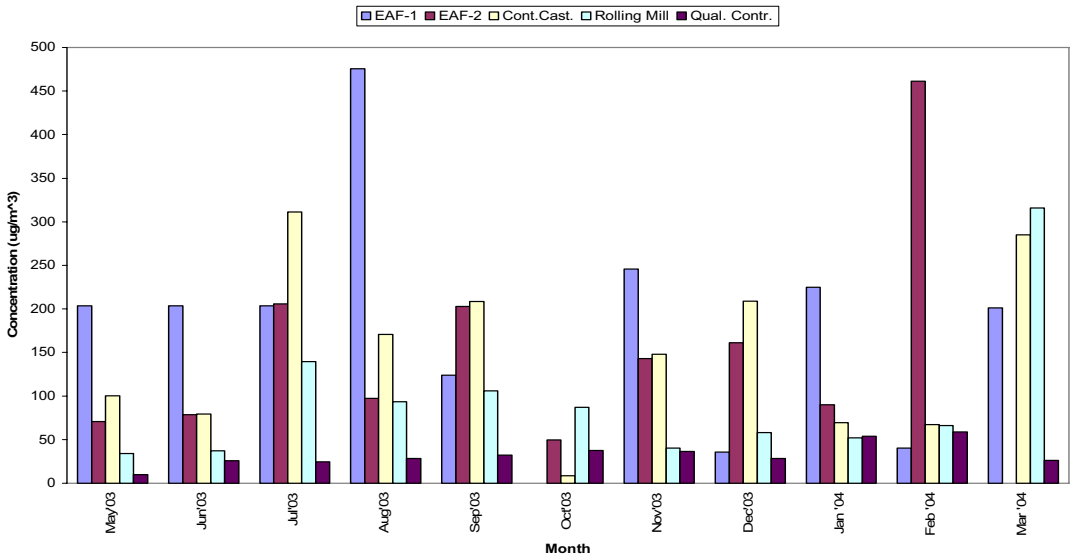

Fig. 2: Average mass concentration of $PM_{2.5}$ particles in the five production sections of the scrap Iron and Steel Smelter.

Growth performance and grain yield of a quality protein maize (*Zea mays* l.) hybrid alley-cropped with two woody legumes at Ile-Ife, southwestern Nigeria.

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Abstract

Field studies were conducted at Ile-Ife, Southwestern Nigeria between 2000 and 2005 to examine the growth performance, biomass production and grain yield of a quality protein maize hybrid cv 'Dababa' planted in alleys of pruned *Leucaena leucocephala* (Lam) de Wit and *Gliricidia sepium* (Jacq) Walp spaced 4 m apart. The mainplots were control (no tree), alley cropping with leucaena and alley cropping with gliricidia, while subplot treatments were with or without addition of the tree prunings. There was no significant difference ($P>0.05$) in maize seedling emergence and number of ear per plant among the treatments. In the two cropping seasons, maize planted in alley plots with addition of prunings had significantly ($P<0.05$) higher growth and grain yield than maize plants in plots without prunings in both tree species and the control (no tree). Between the tree species, in the first season, maize planted in leucaena –with-prunings plot recorded significantly ($P<0.05$) higher net assimilation rate (NAR), leaf area, dry weight between 4 and 8 weeks after planting (WAP) than maize planted in gliricidia-with-prunings plot. However, maize planted in gliricidia –with-prunings plot had higher NAR (185 g/m^2-week) and dry matter (2.6 kg/plant) at 12 WAP and grain yield (289 kg/ha) than maize in leucaena-with-prunings plot. In the second season, maize planted in gliricidia-with –prunings plot had significantly ($P<0.05$) higher NAR (av.187 g/m^2-week), leaf area (av.52 cm^2), dry matter (av.3.4 kg/plant) between 8 and 12 WAP and grain yield (280 kg/ha) than maize grown in leucaena –with-prunings plot. The results of the studies suggested that quality protein maize cv 'Dababa' performed better in gliricidia alleys with addition of prunings than leucaena alleys with addition of prunings, leucaena or gliricidia alleys without addition of pruning and no tree control plot.

Keywords: Growth, grain yield, *G. sepium*, *L. leucocephala,* maize

Introduction

Leucaena leucocephala (Lam) de Wit and *Gliricidia sepium* (Jacq) Walp are recommended woody leguminous trees for alley cropping in the rainforest belt of southwestern Nigeria (Kadiata *et al*., 1997b; Oikeh, 1999; Okogun *et al*., 2000). Annual nitrogen yield of the woody legumes varies with spacing, pruning regime, and soil type. In southwestern Nigeria, a wide range of N yields of about 150-560 kg N/ha/yr was reported for alley-cropped leucaena and gliricidia (Okogun *et al*., 2000). Most of the benefits of the alley cropping system come from its contribution to soil conservation and to the maintenance of soil fertility (Hauser *et al*., 2000). When hedgerow species are established on sloping land, they can form a solid barrier that helps soil and water conservation, thus, alley cropping can reduce runoff and erosion and permit greater crop yields than conventional tillage or no-tillage. Furthermore, continuous supply of prunings from hedgerow species provides sufficient surface soil cover (organic mulch) which, under conditions of erosive rains, can effectively reduce runoff and soil erosion. Organic mulching

also lowers soil temperature and reduces temperature fluctuation, and increases moisture infiltration and retention (Oikeh, 1999).

Results of long-term studies indicate that the addition of prunings from hedgerows of *L.leucocehala* and *G.sepium* maintained higher soil organic matter and nutrient status, particularly of N, K, Ca and Mg, than the control treatments (Kadiata *et al*.1996; Kadiata *et al*., 1997a; Oikeh, 1999). When legumes are used as hedgerow species in alley cropping, they have significant potential for reducing the nitrogen requirement of companion crops. They can fix between 134 and 274 kg N/ha/yr under field conditions, representing an average of 45% of the total N contribution. The increase in soil organic matter level under alley cropping, resulting from addition of prunings, litter fall, and crop residues, has been shown to enhance soil biotic activities, particularly the production of earthworm casts (Mulongoy *et al*., 1990; Oikeh, 1999).

In western Nigeria on an Alfisol, the nitrogen uptake of maize was assessed in a sole crop and in an alley cropping system with *L. leucocephala* by Mulongoy *et al*., 1998). Main plot treatments were maize alley cropped with leucaena and maize only, and the subplots contained leuceana prunings. The nitrogen contributed to the maize by the pruning was low, ranging between 4.4 and 23.8 kg/ha, equivalent to 3.2% and 9.4% of the nitrogen released during the decomposition of the prunings. Application of prunings increased the grain yield of the sole crop maize by 38% and the maize yield in the alley-cropped plots by 104%. Results indicate that part of the nitrogen from the prunings was retained in the soil organic-nitrogen pool (Mulongoy *et al*., 1998). Similarly, the nitrogen contribution from the shoot and root system of symbiotically grown leucaena was evaluated in a field experiment on an Alfisol at IITA in southern Nigeria by Sanginga *et al*., (1998). Maize grown in plots that received prunings from inoculated leucaena contained more nitrogen, and grain yield was increased by 1.9 Mg/ha. Leucaena prunings contained large quantities of nitrogen (300 kg N/ha in six months), but the efficiency of utilization of this nitrogen by the maize crop was lower than that from 80 kg N/ha inorganic fertilizer. The nitrogen fixed symbiotically when leucaena was inoculated with Rhzobium strain IRc 1045 was equivalent to 25 kg/ha inorganic fertilizer. Results showed that application of prunings from inoculated leucaena gave higher soil organic C, total N, pH and available nitrate than pruning from uninoculated leucaena (Sanginga *et al*., 1998)

According to Hauser and Kang (1993) results of a leucaena alley cropping trial conducted on an Alfisol at Ibadan in southwestern Nigeria showed that maize grain yield was generally higher in the alley cropped plots than in the plots without hedgerows (control) partly due to nutrients being readily available from the first pruning. The average yield advantage in five years of alley cropping was 25.8% compared to the control. The amount of N and K applied with the first pruning were significantly correlated with maize grain and dry-matter yield, grain-N and-K contents, and the K content in the dry matter. Over 90% of the K applied with the first pruning was released by the second pruning, but N release was slower. After six years of continuous cropping a surface (0-15 cm) soil organic carbon level of 0.94% was maintained in the alley cropped plots compared to the control plots with 0.59%, while higher levels (1.23%) were maintained under the hedgerows. More earthworm casting was observed under the hedgerows than in the alley or the control resulting in greater nutrient and C recycling and retention under the hedgerows.

Studies on the performance of maize grown in alleys of *L. leucocephala* and *G. sepium* involved several conventional maize varieties such as TZPB, TZSR-W, FARZ 7, CMS 8704, Ekona 83 TZSR-Y, TZESRW, 8321-18 (hybrid). There is no information on the performance of quality protein maize (QPM) in alley cropping with these two woody legumes. This information is essential because QPM contains nearly twice as much usable protein as other maize (or corn) grown in the tropics and yields 10% more grain than traditional varieties of maize (Katak *et al*., 2003). Conventional maize is a poor-quality food staple because of one significant flaw; it lacks the full range of amino acids, namely lysine and tryptophan, needed to produce proteins. Unless consumed as part of a varied diet – which is beyond the means of most people in the developing world –conventional maize typically causes malnutrition. Babies weaned on it are frequently underweight, prone to disease, and at high risk for starvation. QPM produces 70-100% more of lysine and tryptophan than the most modern varieties of tropical maize. These two amino acids allow the body to manufacture complete proteins, thereby eliminating wet-malnutrition (Cordova *et al*., 2003). Besides protein quality, another important factor is 'biological value', which refers to the amount of absorbed nitrogen needed to provide the necessary amino acids for different metabolic functions. The biological value of normal maize protein is 45%, while that of QPM is 80% (Katak *et al*., 2003). The other nutritional benefits of QPM include higher niacin availability due to a higher tryptophan and lower leucine content, higher calcium and carbohydrate73, and carotene utilization74. Further, high quality protein maize can be transformed into edible products without deterioration of its quality or acceptability, and can be used in conventional and new food products for their energy and protein intake, and for other nutrients, are indeed quite significant. The nutritional and biological superiority of QPM has also been amply demonstrated in model systems such as rats, pigs, infants and small children as well as adults (CIMMYT, 2003; Srinivasan *et al*., 2003). The objective of this study was to evaluate the growth performance and grain yield of a quality protein maize hybrid planted in alleys of *L. leucocephala* and *G.sepium* at Ile-Ife, Nigeria.

Materials and Methods

The study was conducted at the Teaching and Research Farm of the Obafemi Awolowo University, Ile-Ife ($07^{o}28'$N, $04^{o}33'$E), Nigeria between 2000 and 2004. Ile-Ife, 224 m above sea level, has a bimodial rainfall pattern with peaks in June and September and a short break in August. Ile-Ife has a mean annual rainfall of 939.90 mm^2 and an average daily maximum temperature of 33.5^{0}C.

Soil sampling

Soil samplings were carried out twice: before maize planting in 2003 and 2004. At each sampling, thirty cores of soil samples were randomly collected per plot at 0-15 cm with a soil auger of 6.0 cm diameter under the different woody trees for chemical and physical analyses. Soil samples from different woody trees plot were analyzed separately and soil characteristics summary presented.

Woody trees seed preparation and planting

The seeds of *L.leucocephala* were scarified with sulphuric acid (Opabode *et al*., 2007) before sowing. The seed of *G.sepium* were not scarified. They were sown two per hill at 50 cm within row and 500 cm between rows. At four weeks after planting (WAP) the seedlings were thinned to one plant per hill. The trees were allowed to grow freely

for three years. The plot size was 12 m x 15 m. Within the plot, there were two alleys separated by three rows of woody trees. Each alley was 4 m wide.

Field preparation

After the establishment of the woody trees, weed control was achieved by slashing manually at a regular interval of three months. Before maize planting each year, the trees were pruned at 45 cm above the ground (Kadiata *et al*., 1997a). The pruning were weighed fresh (woody twig not included) and evenly spread on the sub-plots. Two other prunings were done when maize was growing and were taking out of the plot. Disc ploughing was done immediately after pruning application.

Experimental design

The experiment was a randomized complete block design replicated three times. The main treatments were *L. leucocephala*, *G.sepium* and control (no tree) while the sub-treatments were with or without addition of prunings. The control plots neither had woody trees established in them from the time the woody trees were established in the trial field, nor received any prunings. The distance between each plot was 2.5 m while the distance between the control plots and the woody trees plots was 3.5 m. There was no barrier set up between the control and the woody trees plots. About 175 kg of fresh prunings of each woody legume was applied per plot two weeks before ploughing. Two seeds of quality protein maize cv *Dadaba* were planted per hill at 75 cm between rows and 25 cm within rows leaving a 50 cm space to either side of the woody trees. There were four rows of maize per alley. The maize was thinned to one plant per hill at 2 WAP.

Sampling and harvesting

(i) Maize seedling emergence: At 8 days after planting maize seeds, numbers of emerged seedlings were recorded per plot.

(ii) shoot height: At 2, 4, 6, 8, 10, 12 WAP, shoot height were determined on 10 maize plants per plot using a graduated field ruler from the above ground to the base of the youngest leaf on the plant.

(iii) Leaf area: Total leaf area per plant was determined on four maize plants per plot with the aid of a LiCor-3100 area meter at 2, 4, 6, 8, 10, 12 WAP.

(iv) Net assimilation rate (NAR): At 4, 8, 12 WAP, NAR was determined on four plant per plot using Radford (1967) formula for growth estimate: $NAR= (InL_2-InL_1/t_2-t_1)(W_2-W_1)/L_2-L_1)$ where In =natural logarithm, W_2 and W_1 =dry weight (g) on two successive occasion t_2 and t_1, L_2 and L_1 =total leaf area (m^2) of the plant on two successive occasions t_2 and t_1

(v) Biomass determination: Four maize plants per plot were randomly sampled in the first and second year at 4,8 and 12 WAP in each plot for above ground (cutting maize plant at soil level with a sharp machete) and the below ground (digging with garden fork to remove roots) dry matter yield. They were dried to a constant weight at 80 ^{0}C for 72 hours in a Gallenkamp oven.

(vi) Grain yield determination: Maize grain yield at the end of each season was determined by harvesting the maize cobs in the four rows of each plot excluding the first two maize plants at each border. The maize grain was dried for 72 hours at 70^{0}C for the dry weight after initial air drying for 10 days.

Data analysis and presentation

Shoot height, leaf area and grain yield data were presented graphically with their standard error of mean using Microsoft Excel software. Analysis of variance was performed on biomass and net assimilation rate data and their means separated using Duncan's Multiple Range Test at 5% level of probability.

Results and Discussion

Soil properties

The textural class of the soil was sandy loam. The soil was slightly acidic (pH 6.4). In 2003 before first planting, the total soil nitrogen (%) in leucaena, gliricidia and control plots were 0.14, 0.14 and 0.10 respectively, while in 2004 before second planting, the total soil nitrogen (%) in leucaena, gliricidia and control plots were 0.09, 0.08 and 0.08 respectively. Similarly, the soil organic carbon (%) in leucaena, gliricidia and control plots in 2003 was 0.62, 0.75 and 1.48 respectively, while soil organic carbon (%) in leucaena, gliricidia and control plot was 0.98, 1.01 and 0.93 respectively, in 2004.

Shoot height

Shoot height of maize planted in 2003 and 2004 seasons under different treatments had similar trend and there values were not markedly different; therefore mean shoot height for both season is presented (Fig.1). Between 4 and 8 WAP, shoot height of maize planted in leucaena-with- prunings plot was the highest while maize in control plot had the lowest shoot height. Within the period, shoot heights of maize were in this order leucaena-with-pruning > gliricidia-with-pruning > leucaena-without pruning > gliricidia-without-pruning>control. Thereafter, between 8 and 12 WAP, maize in gliricidia with pruning plot recorded the highest shoot height while those in the control plot had the lowest shoot height. The combine influence of soil nutrient status particularly nitrogen and decomposing prunings had impact on the growth of maize. The fast early growth rate of maize in leucaena-with-pruning plot could be attributed to the fact that available nitrogen was not tied down in decomposing prunings as in gliricidia. Gliricidia prunings were reported to release its nutrient at slower rate than leucaena prunings (Oikeh, 1999). High organic matter and positive effect of addition of prunings combined to give maize planted in gliricidia-with-prunings alleys high rate of growth as shown by shoot and leaf area.

Leaf area

The values and trend of leaf area of maize in both seasons were different (Fig.2 and Fig.3). In 2003, the leaf area of maize planted in leucaena-with-pruning plot was higher than other treatments between 3 and 10 WAP (Fig.2). Between this period, leaf area of maize were in this order leucaena-with-pruning>gliricidia-with-pruning>leucaena-without-pruning>gliricidia-without-pruning>control However, in 2004 maize in gliricidia with pruning recorded the largest leaf area between 6 and 10 WAP (Fig.4). Investment in shoot height and leaf area development observed in maize planted in leucena-with-prunings alleys in the first planting was outmatched by maize in gliricidia-with-prunings plot in the second planting. Decline in soil nutrient status might explain this result as total nitrogen and organic carbon of the soil had declined slightly between 2003 and 2004. Leaf area of crops represent photosynthetic area of crop which mainly influence assimilate production and distribution.

Net assimilate rate

Result of net assimilate rate supported the trend observed in shoot height (Table 1). Maize planted in leucaena-with-pruning plot recorded the highest NAR while maize in control plot had the lowest in 2003. In 2004, net assimilate rate of maize were leucaena-with-pruning > gliricidia-with-pruning > leucaena-without-pruning > gliricidia-without-pruning>control. NAR, which measures the rate of increase in dry matter per unit leaf area, showed that maize in gliricidia-with-pruning plot had capacity to increase their dry weight in terms of assimilatory surface, indicating they are more photo synthetically efficient than maize planted in other treatments. This is not real photosynthesis according to Opabode *et al*. (2007), but it represents the net result of photosynthetic gain over respiratory loss and may therefore vary according to the magnitude of respiration.

Biomass production

At 4, 8 and 12 WAP in 2003, the dry weights of maize planted in leucaena-with- pruning plot were significantly ($P<0.05$) higher than in other treatments. However in 2004, dry weight of maize in gliricida with pruning plot were significantly ($P<0.05$) higher than in other treatments at 4, 8 and 12 WAP. The first early shoot height development, larger leaf area and higher NAR observed in maize planted in leucaena with pruning plots compare with other plots combined to produce higher dry weight in 2003. The trend could not be sustained in the second planting (2004), as maize planted in gliricidia-with-prunings plots produced greater shoot height, leaf area, NAR and dry weight than other treatments. Weather conditions were similar in both years of the study suggesting release of nutrient (particularly N) from prunings and soil nutrients status as factors that could be attributed to the result. Leucaena prunings had been reported to have faster rate of decomposition and N release than gliricidia prunings (Hauser *et al*., 2000; Okogun *et al*., 2000). And nutrients status and particularly nitrogen level on leucaena plot do not take long to be drawned down by associated food crops (Kadiata *et al*.,1996; Oikeh, 1999).

Grain yield

In both 2003 and 2004 seasons, grain yields of maize in gliricidia-with-pruning plots were higher than that of other treatments. Grain yield of the treatments were in this order gliricidia-with-prunings>leucaena-with-prunings>gliricidia-without prunings > leucaena-with-prunings > control. Between the 2003 and 2004, there was no marked difference in grain yield across treatments. The fast rate of growth and large biomass production displayed by maize in gliricidia-with-pruning plot cumulated in higher grain yield of maize than in other treatments. Grain yield of maize planted in alleys with addition of prunings had been reported to be greater than alleys receiving no prunings and control (no tree) plots (Mulongoy *et al*., 1998; Sanginga *et al*., 1998). Leucaena was reported to support short term crop production as crop yield decline due to low nutrient status after second planting while gliricidia support long term production as it has slow rate of releasing of pruning nutrient and high organic matter than leucaena pruning (Akinnifesi *et al*.1997; Oikeh, 1999).

Conclusion

Quality protein maize planted in alleys of woody legumes had higher growth and grain yield than ones planted in control (no trees) plots. In addition, quality protein maize planted in alleys that received prunings perform better

than ones that did not receive prunings. Quality protein maize had greater grain yield when alley-cropped with *G. sepium* than *L. leucocephala*.

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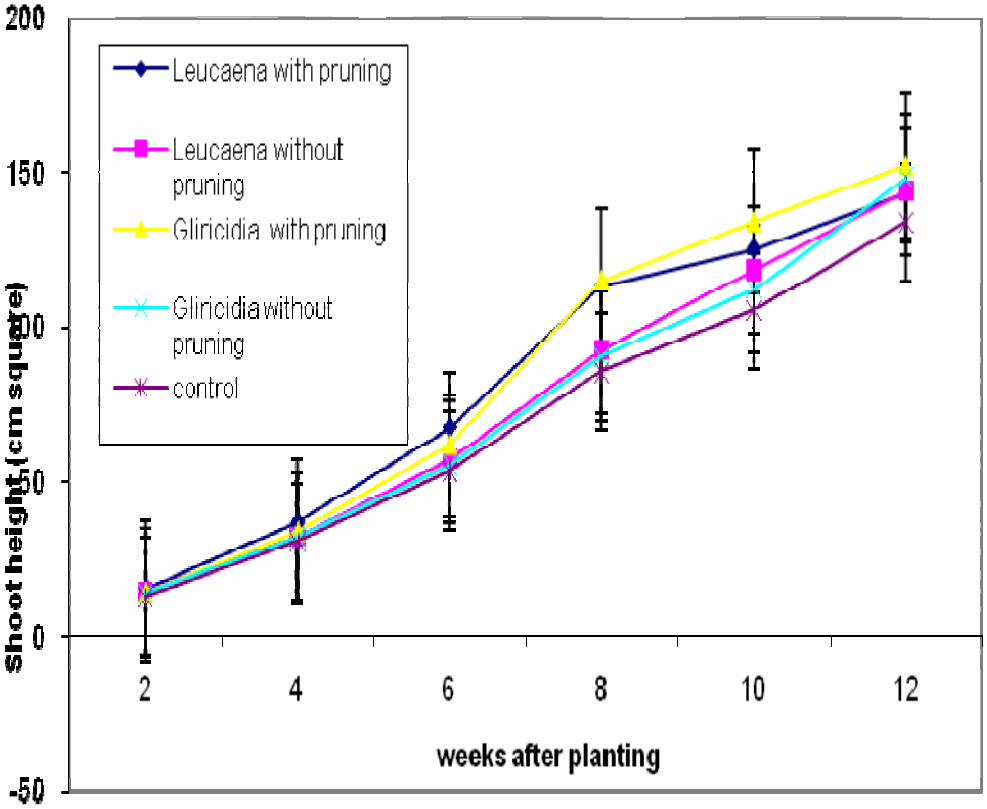

Fig.1: Mean shoot height of maize at 2,4,6,8,10 and 12 weeks after planting in 2003 and 2004 seasons. Bars represent standard error of the means.

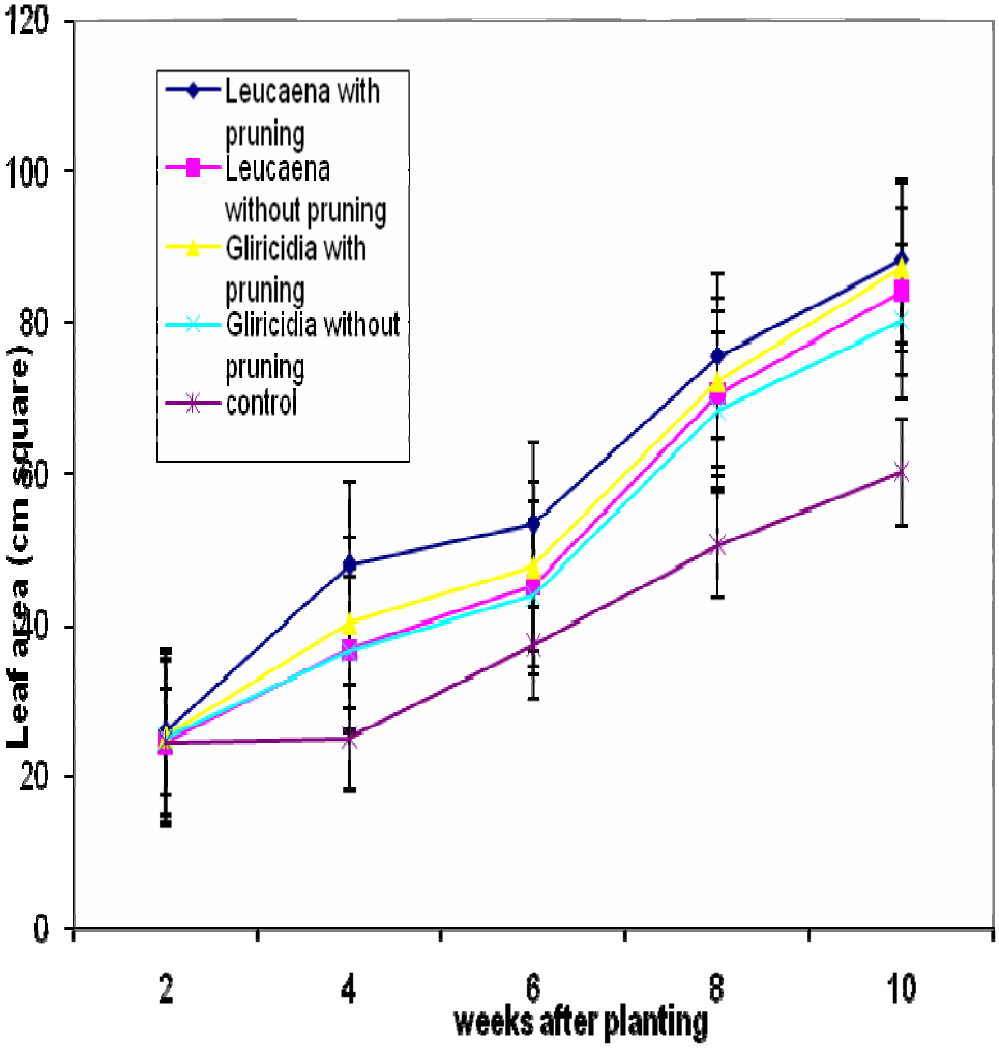

Fig 2:Leaf area of maize at 2,4, 8 and 10 weeks after planting In 2003 season.Bars represent standard error of the means

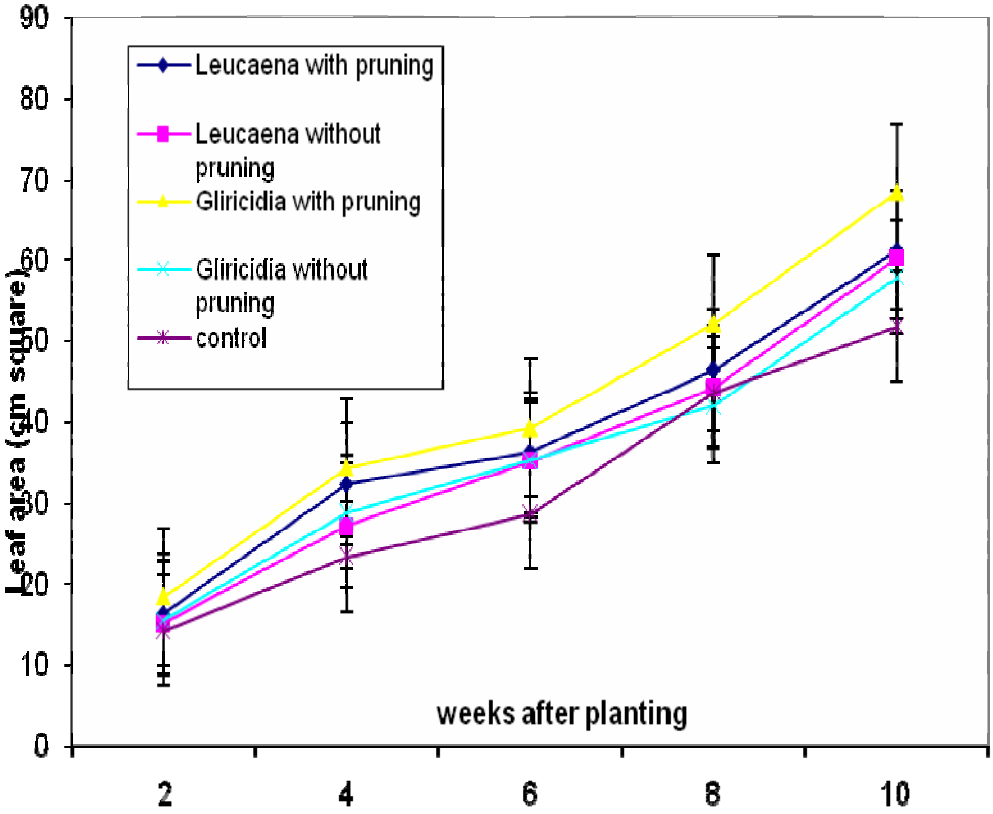

Fig. 3: Leaf area of maize at 2,4,6,8 and 10 weeks after planting In 2004 season.Bars represent standard error of the means

Table 1: Net assimilate rate (g/m^2-week) of maize at 4, 8 and 12 weeks after planting (WAP) in 2003 and 2004 seasons.

Treatments	2003			2004		
	4 WAP	8 WAP	12 WAP	4 WAP	8WAP	12WAP
Leucaena with prunings	152c	178d	82d	149c	182c	76b
Leucaena without prunings	143a	164b	70b	146b	172 b	72b
Gliricidia with prunings	148 b	173c	76c	153d	187d	83c
Gliricidia without prunings	144a	162b	72b	145b	175b	73b
Control	142a	156a	60a	140a	158a	64a

Means in a column followed by the same letters are not significantly different at P=0.05 according to Duncan's Multiple Range Test.

Table 2: Dry weight (kg/plant) of maize at 4, 8 and 12 weeks after planting (WAP) in 2003 and 2004 seasons.

Treatments	2003			2004		
	4 WAP	8 WAP	12 WAP	4 WAP	8WAP	12 WAP
Leucaena with prunings	2.1c	2.5 b	2.8c	2.0 b	3.0c	4.1c
Leucaena without prunings	1.4 a	2.2b	2.4a	1.7 a	2.8b	3.7b
Gliricidia with prunings	1.6 b	2.4b	2.6 b	2.3b	3.4d	4.3c
Gliricidia without prunings	1.4a	2.2 b	2.3a	1.8a	2.8 b	3.6b
Control	1.3 a	1.8a	2.2a	1.5 a	2.2a	3.2a

Means in a column followed by the same letters are not significantly different at P=0.05 according to Duncan's Multiple Range Test.

Complementation between protein of *Acacia colei* seeds and some carbohydrate sources in West Africa.

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Abstract

Acacia colei is one of the well known drought resistant trees, which thrives very well and bear heavy seed in dry zones of Africa where other food crops have failed. This plant has been proposed as a windbreak, source of firewood and a possible solution to the incessant famine occurring in the Sahelian and other drought prone areas of the world. *Acacia colei* seed flour has been identified as a potential supplement for other staple cereals often in short supply. In Nigeria where desertification moves southwards at a rate of 0.6 km per year, and the northernmost part have become an arid zone, *A. colei* could then be the answer to both environmental and dietary issues confronting the region. It is however, important to investigate whether the acacia protein, lipid and dietary fibre components would complement those of the traditional sources of energy in Africa, hence this investigation. The crude protein content of millet and sorghum was lower than that of *A. colei* but expectedly higher than that of *acha* and cassava. Potassium was the predominant mineral element. Ash content was low in *acha* and moderate in millet, sorghum and cassava. Dietary fibre was high in millet and sorghum and moderate in cassava whereas *A. colei* recorded the highest value. Tannin was highest in *A. colei*, followed by red sorghum and lowest in white sorghum whereas all the samples contained low levels of phytate. A 28 - day bioassay using laboratory rats was carried out to evaluate the complementarity of the carbohydrate sources with seed flour of *Acacia colei*. The acacia provided 67 % of the crude protein in all diets except for the cassava-acacia diet (91 %) and the starch-acacia control (100 %). Weight gain and protein efficiency ratio (PER) were highest in animals fed *acha* - acacia based diets. Those fed sorghum-acacia performed better than those fed millet-acacia, whereas cassava-acacia and cornstarch-acacia control diets resulted in morbidity and mortality, indicating that the cassava-acacia food combination would be unsuitable as a major component of human diets and acacia is unsuitable as the sole protein source.

Key words: *Acacia colei*, complementation, *Digitaria exilis*, sorghum, nutrition

Introduction

Flour made from the seeds of *Acacia colei* Maslin & Thomson, a species from Australia's tropical dry zone widely planted in the Africa Sahel, has potential as a human food for semi-arid regions of Africa and Asia (Harwood, 1994). Seeds of this species formed part of the traditional diet of the Australian Aborigines. Chemical analysis (Adewusi *et al.* 2003) showed that the seed flour had a crude protein content of 21.4 %. Amino acid analysis and protein digestibility-corrected amino acid scores (FAO / WHO, 1991) indicated that the seed protein is first limiting in tryptophan and secondly in the sulfur amino acids while the lipid content (10.9 %) of the seed had linoleic acid as the predominant fatty acid Adewusi *et al.* 2003). Preliminary rat bioassay in our laboratory to test acacia seed flour in corn

starch-based diets indicated that the protein quality of the seed is only fair and that methionine supplementation greatly improved the nutritional value.

Acacia colei tree is now planted widely in Maradi district, in the southern part of Niger Republic and yields substantial quantities of seed. Millet and sorghum are the staple foods of the people of this region (Adewusi *et al.*, 2006a). These cereals are known to be deficient in lysine (FAO, 1970). Prior to 1975, cassava had been planted in the Maradi district as a staple food crop until it was wiped out by pests and diseases (T. Rinaudo, pers comm. 1995). Improved disease-resistant varieties of cassava are now being re-introduced into southern Niger including Maradi district, to take advantage of the drought-hardiness of cassava and its ability to produce under adverse conditions. Cassava contains two cyanogenic glucosides, linamarin and lotaustralin, which on hydrolysis yield cyanide, detoxified in vivo by rhodanese in the presence of labile sulphur supplied by methionine (Oke, 1980). Acha and fonio (cereals reputed to be rich in sulphur amino acids [de Lumen *et al.* 1993]) are cultivated in both the Northern part of Nigeria as well as the southern part of Niger Republic.

The diets of rural people in the Maradi district combine cereals and legumes with very small quantities of meat and other animal products when available (Adewusi *et al.*, 2006). Given the availability of *A. colei* seed and cassava in this region, the question arises as to the best way to combine these two hardy potential food sources with other staple foods in nutritious and safe diets. This study evaluates, by chemical analysis and bioassay, the complementation between the protein content of *A. colei* seed and those of some common carbohydrate sources in West Africa, with a view to providing recommendations for balanced diets incorporating *A. colei* seed flour.

Materials and Methods

Foodstuffs tested

Acacia colei seeds were harvested from several trees in Maradi district, milled in Ile-Ife, Nigeria and sieved (0.6 mm aperture size sieve) to remove the coarser fragments of the seed coat. The sieved seed flour was used in the experiments. Red and white sorghum and millet were purchased at the market in Maradi. Two types of acha (*Digitaria exilis*) with varying shades of white colour, were purchased in Jos, Nigeria. Brown coloured *Digitaria fonio* was also purchased in Jos. Cassava was harvested from a farm in Ile-Ife, peeled and dried.

Chemical analysis

Ether extract was determined on triplicate samples with petroleum spirit b.p. 60 - 80 ^{o}C in a soxhlet extractor (AOAC 1984). Dietary fibre was determined by the gravimetric method of Lee *et al.* (1992) using a combination of three enzymes (heat-stable α-amylase, protease solution, and amyloglucosidase) for the digestion. Soluble sugar was extracted three times from 2 g samples with 80 % ethanol, filtered and the residue washed with the same solvent to give a total volume of 50 ml. Total sugar was then estimated spectrophotometrically by the modified anthrone method according to Cerning-Beroard (1975) using glucose as a standard.

For determination of total mineral content, a 1.0 g sample was digested twice to dryness with 20 ml aqua regia (1 part HNO_3 + 3 parts HCl) and twice with $HClO_4$ and the residue made up to 20 ml with 1.0 M HCl. Minerals in the digestate were determined by Inductively Coupled Plasma - Optical emission spectrometry (ICP-OES**)** with a laboratory coefficient of variation of 3 %. Tannin was extracted from a 0.5 g sample with 1 % HCl in methanol for one hour and

analysed by the vanillin-HCl method of Price and Butler (1977). Determination of phytate from a 2.0 g sample was by the anion-exchange method (Harland and Oberleas, 1986). *In vitro* protein digestibility was measured on one or two gram samples by the method of Saunders *et al.* (1973) using the pepsin-pancreatin enzyme system. Nitrogen was determined in the residue after the digestion by the Kjeldahl method.

Bioassay

The bioassay tested seven diets, all incorporating *A. colei* seed flour, which was heated at 70 - 80^{o} C for one hour to destroy the protease inhibitors (Harwood 1994) before incorporation into the diet. All diets contained 10 % crude protein. The carbohydrate sources tested were white acha, brown fonio, millet, red sorghum and cassava. In the first four of these diets the carbohydrate source provided 33 % of the total crude protein content whereas cassava, which was low in protein, only provided 9 % of total crude protein with *A. colei* seed flour contributing the balance of the protein content of each diet. Two control diets tested *A. colei* with cornstarch as the carbohydrate source. One of these two controls incorporated casein at a level that provided 33 % of the protein, whereas the other control used *A. colei* as the sole protein source. Non nutritive cellulose was incorporated as the dietary fibre (DF) in quantities to balance the content at 9.5 % and vegetable oil was added to make the lipid content of all the diets equal at 8 % (AOAC 1984) as shown in Table 1. The diets were moistened, extruded into pellets and baked at 52^{o} C in an air oven to avoid the possibility of dust irritating the animals**.** For each of the seven diets, six weanling rats of the Wistar strain were housed individually, conditioned to their environment for three days, given the basal diet for 48 h and the test diets and water *ad libitum* for 28 days. Nutrition parameters - Protein Efficiency Ratio (PER), Net Protein Utilization (NPU), and True Digestibility (TD) - were determined as described by FAO / WHO (1991). The other bioassay and analytical procedures were as outlined earlier (Adewusi and Ilori 1994).

Results

Chemical composition of common carbohydrate sources:

Millet and white sorghum had the highest crude protein content of 9.5 % while cassava had the lowest protein content of 1.8 %. Ash content was very low (0.3 - 0.4 %) in all the *Digitaria* samples and moderate (1.7 - 2.4 %) in millet, sorghum and cassava. Crude and dietary fibres were highest in millet and red and white sorghum, moderate in cassava and low in acha. Lipid content was highest in millet (4.9 %) and lowest in cassava (1.8 %). Total extractable sugar was highest in cassava (355 mg / g) and lowest in acha (58 mg / g). Tannin was highest in red sorghum (15.4 mg / g) and lowest in white sorghum (1.2 mg / g). Phytate was highest in millet and red sorghum and lowest in cassava. In vitro protein digestibility was highest in millet (73 %) and lowest in white acha sample 2 (58 %). Sieved *A. colei* seed flour had much higher crude protein (21 %), lipid content (12 %), dietary fibre (29 %) and ash (3.5 %) than the carbohydrate sources (Table 2). The mineral composition of the carbohydrate sources is presented in Table 3. Potassium was in the highest concentration in all the sources except the acha samples. Total Fe, Mg, Ca and Zn content were high and the content of heavy metals (Pb, Cd, Sr) low.

Morbidity and Physiological parameters:

The morbidity and physiological parameters of the rats on the different diets are summarised in Table 4. All the animals on white acha - acacia based diet looked healthy with no sign of eye infection and survived the bioassay period. One rat however lost some hair, noticeable from the 21st day of experiment. All the animals fed brown fonio - acacia based diet survived but one had a serious eye infection while two others lost about 50 % of their hair in the dorsal region.

Five of the rats on the millet-acacia based feed survived whereas the sixth became dull on the 24th day of the experiment and died 24 hours later. One rat in this treatment lost hair on its thigh, which became noticeable on the 15th day of the experiment. In sorghum-acacia based diet, one of the 6 rats had a serious eye infection around day 21 of the experiment and died three days later. Another one lost hair from the thigh to the back. This rat, and the four others, survived the bioassay period.

Nutritional and Toxicological Variables:

A summary of the nutritional parameters is given in Table 5. Feed intake was highest in animals fed brown fonio - acacia diet closely followed by white acha - acacia while the least was consumed by rats on the corn starch - acacia diet. Weight gain and protein efficiency ratio (PER) were highest in animals fed the acha and fonio based diets (high in methionine) and negative in animals fed both corn starch - acacia and cassava - acacia diets (low methionine diets). A surprising result was the high protein efficiency ratio (PER) of animals fed red sorghum - acacia diet, which also had the highest net protein retention (NPR). This seems to indicate a better complementation for sorghum - acacia than for millet – acacia diets. NPR value, of 2.1 for animals fed the cassava - acacia diet and 2.7 for corn starch - acacia diet, indicated that the acacia protein might be marginally sufficient for body maintenance in these diets. True digestibility was low (52 - 76 %) in all the treatments. The proportional weight of the kidney was smaller in rats fed acacia -cereal based diets especially millet, red sorghum and brown fonio than in the corn starch control and the cassava-acacia diet (Table 6). Liver weight was proportionally smallest in the rats fed the millet - acacia based diet and highest in the animals fed corn starch - acacia which also had the highest kidney weights. Brain and heart weights did not differ significantly among the treatments.

Urinary protein level is an indication of the nutritional value of ingested protein in the diet. The result of the urinary chemistry presented in Figure 1 showed that protein content was very low in the urine of rats fed corn starch – acacia - casein and corn starch-acacia diets and highest in those fed sorghum - acacia at the middle of the experiment but towards the end the reverse seemed to hold.

Acid phosphatase level was very low in the rats fed starch-acacia and cassava-acacia based rations but moderate in all the other treatments at the mid-point of the study (Figure 2). Acid phosphatase concentration decreased significantly in the urine of rats fed white acha, brown *fonio* and millet but increased in those on sorghum based ration towards the end of the experiment. Alkaline phosphatase was highest in the urine of rats fed sorghum-acacia at the middle of the experiment (Figure 3) but not by the end of the experimental period. Inorganic sulphate was highest in the urine of rats fed sorghum - acacia but with little difference with time (Figure 4). Plasma protein levels measured on day 28 differed little between treatments, the lowest level being 44.1 mg / ml for rats on casein-acacia and the highest 51.0 for rats on cassava-acacia.

The casein-acacia and cassava-acacia diets produced mean levels of lactate dehydrogenase activity in the plasma at least 3-4 times those of the other treatments (Figure 5).

Discussion

Though both white and red sorghum varieties are consumed around Maradi, white sorghum has been shown to be inferior to the red in bioassay experiments (Adewusi *et al*. 1991). The proximate composition of the grain seeds (millet and sorghum) was within 10 % of the values reported by FAO (1970). The low protein content of cassava confirms findings of earlier workers (Adewusi *et al*. 1991, Bradbury and Holloway 1988). Jideani and Akingbala (1993) reported 6.2 % crude protein, 1.3 % fat, 0.1 % ash and 0.41 % crude fibre for acha which accorded well with the results presented here.

The low true digestibility was probably due to the high levels of dietary fibre, which has been reported to reduce protein digestion (Adewusi and Ilori 1994). In addition, tannin, when present at concentration above 2 mg / g, reduces protein digestion and hence the food values of such foods (Osuntogun *et al*., 1989). Low true protein digestibility values of 63-65 % have been reported in experiments with children fed millet and ragi-based diets in India (FAO/WHO 1991). Adewusi *et al*. (1991) reported a tannin content of 15.7 mg / g catechin equivalent for a red sorghum sample similar to the value of 15.4 mg / g reported here, while Osuntogun *et al*. (1989) reported a 29.2 mg/g value for the red sorghum - SRN 484. Phytate binds divalent cations and forms stable complexes resulting in poor mineral bioavailability (Sandberg *et al*. 1989, Sandberg and Svanberg 1991). All the samples investigated in the current study contained low levels of phytate when compared to lima bean (Ologbobo and Fetuga 1982), winged bean (Kantha *et al*., 1986) some Nigerian legume seeds (Adewusi and Osuntogun 1991, Adewusi and Falade 1996) and peanut flour (Harland and Oberleas 1986).

Eye infection in one or more rats was observed in all the treatments in this bioassay, except white acha-acacia and millet - acacia based feeds. The eye infection could not due to the physical nature of the diets, since the feeds used in this experiment were baked. The level of survival of experimental rats during 28-day bioassays in our laboratory is typically close to 100 % except when toxic components are tested. Indeed, this is the first experiment in which morbidity such as eye infection and mortality on this scale has been observed. It may or may not have been directly induced by the diets, although animals on the corn starch - acacia and cassava based diets proved more vulnerable to infection. In other trials (Adewusi *et al.* 2006b) acacia seed flour had been incorporated into the diet at 40 % (w / w) to breed three generations of rats without mortality or morbidity other than the loss of hair.

The higher mortality rate in animals fed the cassava-based diet may be attributable to the presence of the cyanogenic glucosides, linamarin and lotaustralin in the cassava root. Though these cyanogenic glucosides when intact are relatively non-toxic, they break down during processing (when the roots are crushed) to give the cyanohydrin which also breaks down enzymatically or automatically to give the free cyanide and a ketone. The major bulk of the cyanogenic glucoside potential therefore exists as the cyanohydrin and / or free cyanide form in the processed cassava products which could reach levels of up to 8 mg / 100 g (Adewusi and Akindahunsi 1994). Free cyanide is lethal with an average dose of 50 mg capable of killing a 70 kg man (Conn 1973) but sublethal quantities are detoxified in the presence of labile sulfur provided by methionine (Oke 1980) to yield the less toxic thiocyanate (SCN) which is then excreted in

the urine. In the presence of iodine deficiency, and/or protein malnutrition, SCN competes with iodine uptake resulting in goitre and other hypothyroidism syndromes (Adewusi *et al*. 1993). In the preliminary investigation, we had earlier observed that methionine supplementation was beneficial to rats fed corn starch-acacia based diets although the protein digestibility-corrected amino acid score (Adewusi *et al.* 2003) indicated the first limiting amino acid in *Acacia colei* seed flour was tryptophan. The susceptibility of rats fed cassava-acacia based diet to infection, morbidity and mortality might therefore be explained purely on nutritional factors, principally amino acid imbalance. This would also account for the loss of hair. The principal amino acid in hair is cysteine (Radcliffe *et al.,* 1985) and if this and methionine, which can be metabolised to cysteine, is in short supply, then hair loss would be inevitable.

The morbidity and mortality of rats on corn starch-acacia and corn starch-casein acacia diets can be attributed to (a) malnutrition as a result of very low feed intake and (b) amino acid imbalance because of the deficiency of some of the essential amino acids in acacia, and casein being also first limiting in methionine.

The amino acid composition of each diet was computed (FAO / WHO 1991) and the protein digestibility-corrected amino acid score calculated in an attempt to explain the differences in the bioassay results. These calculations, not presented here, indicated that tryptophan was the first limiting amino acid in the casein-acacia, corn starch-acacia, cassava-acacia and acha-acacia based diets, with lysine second. In the millet-acacia and sorghum-acacia diets, lysine was first limiting and tryptophan second. The sulfur amino acids were generally third or fourth limiting. It is difficult to explain the large difference especially in the PER values of animals fed millet and sorghum based rations. The first four limiting amino acids in both rations were the same and millet was marginally better in the most important limiting amino acids - lysine, the sulfur amino acids, tryptophan and threonine. The better PER values observed in rats fed the sorghum-acacia based diet might be explained by postulating that red sorghum is one of the cereals that could encourage microbial growth in the large intestine (FAO / WHO 1991). These microorganisms could synthesize some of the essential amino acids, which would then be reincorporated by the host animal. In this case, the high tannin content of red sorghum may confer on it an advantage through inhibition of protein digestion; the undigested portion can then be metabolized by the microorganisms to produce proteins and amino acids including the essential ones which could then be absorbed by the host.

The level of urinary acid and alkaline phosphatases and lactate dehydrogenase is an indicator of nephrotoxicity (Ngaha 1974). However, none of the levels recorded are indicative of serious toxicity problems. Inorganic sulfate in the urine, the major end product of sulphur metabolism in animals, is used to predict the dietary status of the sulphur amino acids (Lundquist *et al.* 1980, Adewusi *et al.* 1993). Judging by the high levels of this metabolite in the urine of rats fed the nutritionally inferior diets (corn starch-acacia alone and cassava-acacia based rations), one would be tempted to infer an adequate dietary supply of the sulphur amino acids. This would however be inconsistent with hair loss and the beneficial effects of methionine supplementation (Adewusi *et al.* 2006b). An alternative source of the sulphur in the urine of the rats on these diets is the deamination of S-carboxyethyl cysteine, one of three principal non-protein amino acids in *A. colei* seed (Harwood 1994), followed by excretion of inorganic sulfate.

Conclusion

The analytical studies and bioassay reported here show that there is substantial variation in the nutritional value of different staple carbohydrate sources when combined in diets with *A. colei* seed flour. Red sorghum, brown *fonio* and white acha provide the best complementation in terms of weight gain, protein efficiency ratio and animal health, while millet complimented acacia seed moderately. The cassava-acacia diet resulted in substantial morbidity and mortality of experimental animals, indicating that this food combination would be unsuitable as a major component of human diets.

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Table 1. Diets for rats fed *Acacia colei* seed flour and different carbohydrate sources

Diet Components (% by weight)	Diets: Protein Free diet	Casein + acacia	Acacia alone	Cassava + acacia	White acha[1] + acacia	Brown *fonio* + acacia	Millet + acacia	Red sorghum + acacia
Corn starch	66.2	43.96	38.0	-	16.35	11.66	20.56	17.17
Sucrose	10.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Casein	-	5.1	-	-	-	-	-	-
Acacia	-	24.0	40.0	36.92	24.0	24.0	24.0	24.0
Cassava	-	-	-	41.1	-	-	-	-
Brown *fonio*	-	-	-	-	-	38.3	-	-
Millet	-	-	-	-	-	-	30.2	-
Red sorghum	-	-	-	-	-	-	-	33.5
Dietary fibre	10.0	2.54	-	0.30	2.45	2.46	2.32	2.17
Oil	8.8	4.40	2.0	1.70	3.90	3.58	2.92	3.16
Mineral mix	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Vitamin mix	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

[1]Acha: *Digitaria exilis*

Table 2. Chemical composition of carbohydrate sources used in the study and *Acacia colei* seed flour

Foodstuff	Crude protein %	Ash %	Crude lipid%	Crude fibre %	Dietary fibre %	Total sugar mg/g	*In vitro* % protein digestibility	Phytate mg/g	Tannin mg/g
White acha 1	8.0	0.3	1.5	0.3	1.7	65	69	0.7	3.8
White acha 2	9.0	0.3	1.1	0.2	0.6	58	58	0.3	3.3
Brown *fonio*	7.0	0.4	2.1	0.2	0.5	92	62	0.7	5.0
Millet	9.5	2.4	4.9	0.7	9.5	183	73	1.3	5.8
Red sorghum	8.7	1.9	3.7	1.1	9.6	138	64	1.3	15.4
White sorghum	9.5	1.7	3.4	1.1	9.8	125	67	1.1	1.2
Cassava	1.8	2.0	1.8	0.5	5.1	355	62	0.2	1.3
Acacia colei flour (sieved)	21.4	3.5	12.1	-	29.1	137	-	0.09	86.7
Maximum Standard errors	0.5	0.2	0.2	0.1		18	3.8	0.1	1.2

Table 3. Mineral element contents (mg/100g) of carbohydrate sources and *Acacia colei* flour

	Cassava flour	Millet	Brown *fonio*	White acha I	White acha 2	Red sorghum	White sorghum	*A. colei* sieved flour
Mg	6.1	17.6	7.4	5.3	9.2	16.4	16.5	290
Fe	54.5	69.4	175.4	71.4	383.7	111.0	49.5	31
Mo	842.1	1175.7	662.0	583.9	340.0	1435.1	1298.7	-
Al	10.7	23.2	35.9	16.6	16.7	32.8	15.7	6.0
Ca	817.9	197.2	300.2	239.7	248.9	95.7	150.6	274
Na	98.0	22.8	60.1	45.8	49.2	36.0	24.5	7.0
mK	5987	3838	521	439	271	2950	3180	934
Zn	6.5	33.0	19.4	19.2	22.6	22.2	26.0	3.0
Pb	0.4	0.3	0.3	0.6	0.6	0.3	0.2	0.1
Cd	0.06	0.1	0.04	0.04	0.04	0.04	0.04	Nd
Ni	3.4	1.3	9.2	1.0	26.5	1.4	1.3	-
Cu	4.5	4.1	4.8	3.5	4.4	3.2	2.9	0.6
Sr	4.5	1.2	1.9	1.6	1.7	0.7	1.0	-
B	4.2	2.2	2.2	1.8	2.1	3.3	2.3	-
Co	0.4	1.2	4.3	1.5	1.5	1.3	1.9	-
Ba	4.0	2.4	12.8	1.7	1.9	1.5	1.8	

Table 4. Morbidity and Physiological parameters

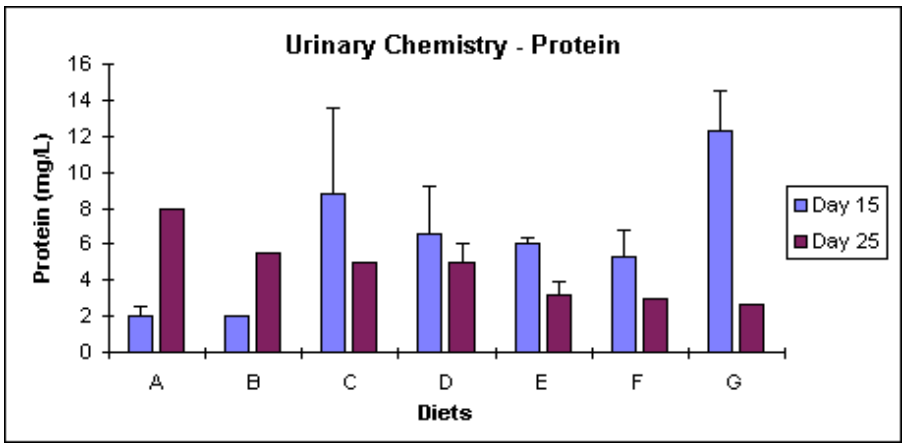
Diet	Sluggish movement	Eye infection	Hair loss	No of death
Protein free diet	2	2	2	2
Starch/casein/acacia	2	2	1	2
Starch/acacia	2	5	-	3
Cassava/acacia	4	2	-	4
White acha/acacia	-	-	1	-
Brown *fonio* /acacia	-	1	2	-
Millet/acacia	1	-	1	1
Red Sorghum/acacia	1	1	1	1

Table 5. Feed intake, weight gain, protein efficiency ration (PER), net protein retention (NPR), true digestibility (TD) over 28 days, and number of rats surviving (out of 6) for the different bioassay diets. Standard errors are shown.

Diet	Feed intake (g)	Weight gain / loss (g)	PER	NPR	TD	Number surviving
Protein free diet	118.5±1.9	-28.3±1.0	-	-	-	2
Starch/casein/acacia	124±19.4	8.1±3.2	0.6±0.2	2.9±0.4	56.8±5.2	4
Starch/acacia	95±14.6	-2.5±3.8	-0.3±0.3	2.7±0.4	55.1±6.8	3
Cassava/acacia	122±22.0	-2.5±2.5	-0.4±0.1	2.1±0.4	76.0±6.4	2
White acha/acacia	196±33.7	25.4±4.2	1.3±0.2	3.0±0.4	55.1±2.1	6
Brown *fonio* /acacia	204±35.3	28.7±4.3	1.4±0.2	3.0±0.3	56.7±2.7	6
Millet/acacia	131±15.8	6.6±1.0	0.5±0.1	3.0±0.2	51.7±1.0	5
Red Sorghum/acacia	166±1.1	18.0±1.9	1.1±0.1	3.1±0.3	52.8±1.5	5

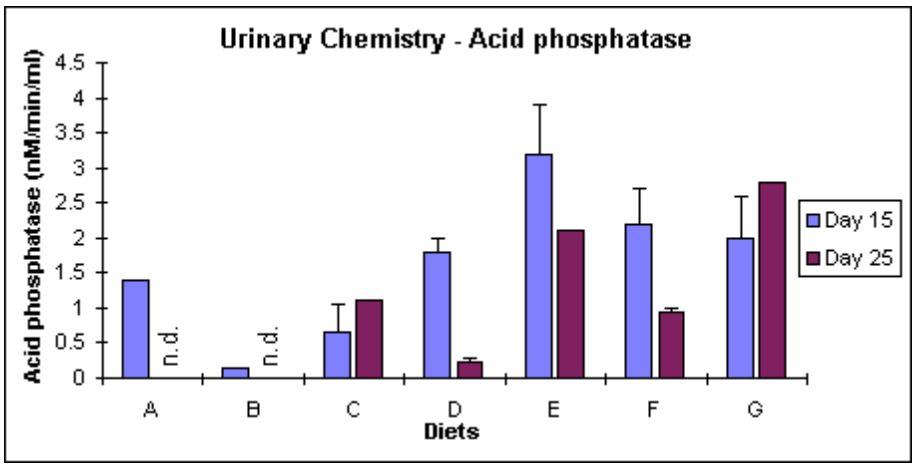
Table 6. Weight of organs (g/100g body weight ± standard error) of rats fed *Acacia colei* flour and different carbohydrate sources

Diet	Heart	Kidney	Brain	Liver	Spleen
Protein free diet	0.50±0.01	1.5±0.02	2.4±0.1	5.2±0.2	0.36±0.01
Casein + Acacia	0.54±0.03	1.6±0.05	2.6±0.2	5.7±0.1	0.45±0.05
Acacia alone	0.49±0.03	1.7±0.2	2.9±0.2	6.4±0.4	0.38±0.06
Cassava + Acacia	0.53±0.04	1.6±0.06	3.2±0.2	5.3±0.3	0.37±0.06
White Acha + Acacia	0.47±0.02	1.3±0.03	2.4±0.2	5.3±0.3	0.40±0.03
Brown *fonio* + Acacia	0.45±0.02	1.2±0.04	2.4±0.2	5.3±0.3	0.27±0.02
Millet + Acacia	0.47±0.02	1.1±0.04	2.7±0.3	4.6±0.4	0.34±0.04
Red Sorghum + Acacia	0.47±0.02	1.2±0.02	2.3±0.2	5.4±0.4	0.25±0.02



Starch/casein/acacia, Starch/acacia, Cassava/acacia, White acha/acacia, Brown *fonio* /acacia, Millet/acacia, and Red Sorghum/acacia diets are coded A, B, C, D, E, F and G, respectively.

Fig 1: Urinary Protein of rats fed *Acacia colei* seed flour and different carbohydrate sources, on days 15 and 25 of bioassay.



Starch/casein/acacia, Starch/acacia, Cassava/acacia, White acha/acacia, Brown *fonio* /acacia, Millet/acacia, and Red Sorghum/acacia diets are coded A, B, C, D, E, F and G, respectively.

Fig 2: Acid phosphatase activities in urine of rats fed *Acacia colei* seed flour and different carbohydrate sources, on days 15 and 25 of bioassay.

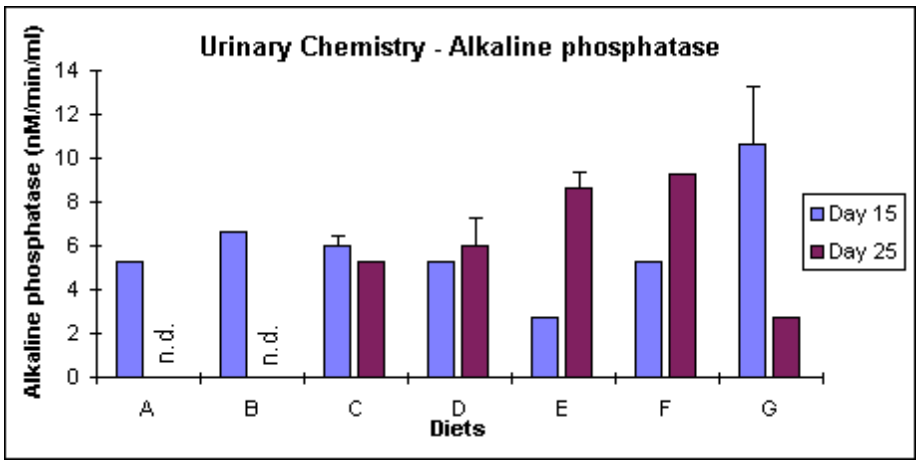


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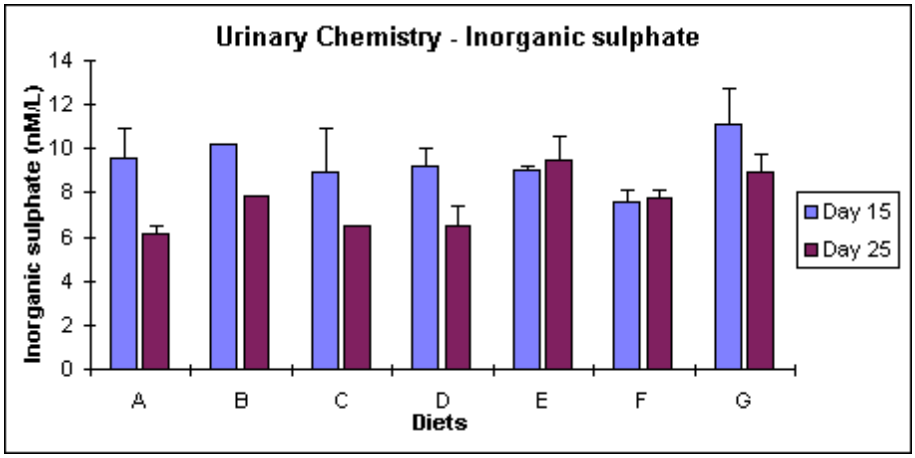
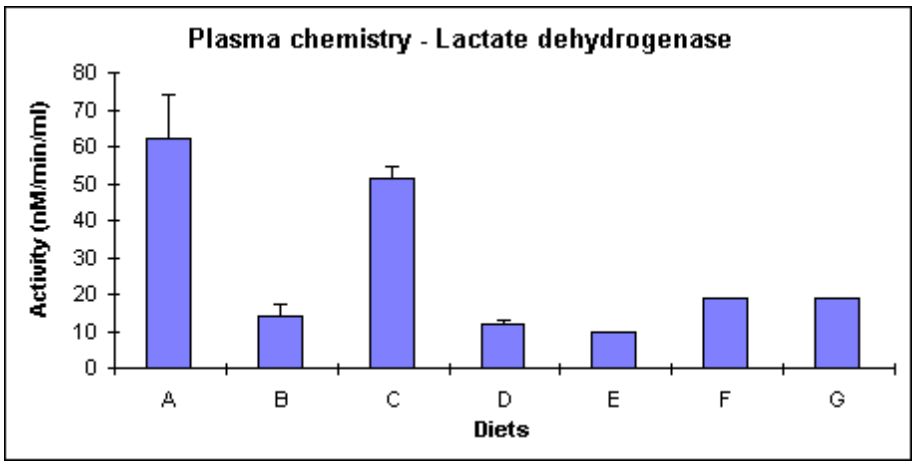
Fig 3: Alkaline phosphatase activities and inorganic sulphate in urine of rats fed *Acacia colei* seed flour and different carbohydrate sources, on days 15 and 25 of bioassay.



Starch/casein/acacia, Starch/acacia, Cassava/acacia, White acha/acacia, Brown *fonio* /acacia, Millet/acacia, and Red Sorghum/acacia diets are coded A, B, C, D, E, F and G, respectively.

Fig 4: Inorganic sulphate in urine of rats fed *Acacia colei* seed flour and different carbohydrate sources, on days 15 and 25 of bioassay.



Starch/casein/acacia, Starch/acacia, Cassava/acacia, White acha/acacia, Brown *fonio* /acacia, Millet/acacia, and Red Sorghum/acacia diets are coded A, B, C, D, E, F and G respectively.

Fig 5: Lactate dehydrogenase activity of rats fed *Acacia colei* seed flour and different carbohydrate sources, on day 28 of bioassay.

Food Choice and Meal Consumption Pattern among Undergraduate Students in Obafemi Awolowo University, Ile – Ife, Nigeria*

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Abstract

The food choice and meal pattern of undergraduate students from Obafemi Awolowo University, Ile-Ife (n = 202; 98 male and 104 female), with a mean age of 23 years; were studied and compared to the recommended dietary allowance (RDA) for energy and nutrients. Structured questionnaire was used to elicit information on socio-demographic characteristics, food intake and meal consumption pattern. Anthropometric indices were used to assess the subjects' nutrient status. The consumption pattern indicated that subjects who chose and consumed at the recommended minimum number of servings, were 58 % male and 62 % female (cereal and grain group); 32 % male and 42 % female (meat and meat substitutes group); 20 % male and 40 % female (fruit and vegetables group); 50 % male and 35 % female (roots, starchy fruits and tubers group); 10 % male and 25 % female (milk and milk substitute group). Greater percentage of the students ate twice skipping either breakfast or lunch or both taking snacks instead. Intake of nutrients indicate that 48 % female and 28 % male exceeded their requirement for energy to which 60 % was contributed by carbohydrate while 60 %, 85 % and 40 % did not meet the RDA for protein, calcium and iron respectively BMI classification shows that 31 % female and 27 % male are overweight, 8 % and 5 % of female and male are obese while 13 % male are underweight. Nutrient intake indicated energy consumption was around 9.8 MJ with carbohydrate 14 % protein and 26 % fat. About 33 % of the subjects consumed more than 100 % energy requirement but most students did not meet the requirement for protein, calcium and iron. There was no significant difference in food choice and intake among gender as well as among those on campus or off campus. The study revealed the Obafemi Awolowo University undergraduate students in Nigeria are poorly financed reflecting in their unhealthy eating habit.

Keywords: Food choice, meal consumption pattern, food groups, Recommended Dietary Allowance (RDA).

Introduction

Dietary intake and eating patterns of young adults are of special interest because young adulthood is a critical age of childbearing and sets the stage for lifestyles that influence later health (Croft *et al*., 1986). Koszewski and Kuo (1996) had also asserted that unhealthy eating behaviour remains predominant among

this age group. After leaving secondary school, young adults change lifestyles rather drastically. Independence brings responsibility and social pressure and the family no longer dictates dietary habits. The pressure of being independent, living a hurried lifestyle and providing support for a new family (in a few cases) affect eating habits and consequently nutrient consumption. Adolescent is the period of the growth spurt with its attendant increase in the requirement for energy, macro and micronutrients. During this period inadequate stores or intake of nutrient can have adverse effect on the physical growth and cognitive development (Corish and Kennedy, 2003). Unfortunately, Skipping breakfast is a habit that seems to begin in adolescence and increases with age while relying on "convenience foods" and eating snacks that are low in nutrients contribute to the nutritional vulnerability of these young adults. This vulnerability to aberrant eating patterns makes them at risk of nutrient inadequacies (Nicklas *et al*., 1998).

The idea for this study was conceived with certain propelling indicators. Some twenty years ago, the Federal Government of Nigeria as owners and operators of all the universities in Nigeria ceased to operate the cafeteria system where subsidized food was sold to students following a set time table and food combination that provided adequate nutrients to the adolescent. From that period, public universities in Nigeria have not been involved in how and when the students eat their meals. Medical statistics in Obafemi Awolowo University had indicated lower anthropometric parameters such as lower weight to height ratio for the students especially at the end of the semester as well as increased attendance at the university health centre probably due to examination stress and inadequate or unbalanced food intake. The second indicator is the overall state of the household in Nigeria with regards to food security and the limitations to meeting the dietary needs of the individuals. The specific objectives of the study were to identify the food consumption pattern of university students in Nigeria and to examine this in relation to intake of energy and nutrients as well as anthropometric data and then to compare with the Recommended Dietary Allowance (RDA) of nutrients.

Methodology

The subjects were undergraduate students (n = 202) of the Obafemi Awolowo University, Ile-Ife, (OAU) located in the Southwestern part of Nigeria. The institution is owned by Federal government. The study population drawn through random sampling included 98 male and 104 female students who either lived on or off campus.

Anthropometric Measurements; The subjects were asked to remove their shoe, socks and clothes that could add significantly to their weight. The weight was measured to the nearest 0.1 kg using a standardized digital scale. Standing height was measured to the nearest 1 mm using a portable Stadiometer. From these measurements, Body Mass Index (BMI - weight divided by the square of the height (kg / m^2) was then computed. The information obtained from BMI was used to grade the subjects into normal weight, overweight, obese or underweight (World Health Organization Obesity Task Force, 1998) categories.

Biceps muscle (BM) and triceps skin fold thickness (TST) were measured using standard calipers while mid-arm circumference (MAC) was taken at the left hand side of the body of all subjects. Also waist and

hip were measured with tape to the nearest mm; all measurements were carried out according to standard techniques (WHO, 1995).

Socio-demographic Characteristics: Information on socio-demographic characteristics of the subjects such as age, sex, and department, level of study and average pocket money per month, where consumption of snacks is higher either at home or school and the factors of motivation for snacks consumption and choice of foods, were obtained through a structured questionnaire

Food Intake: Information on food intake was obtained through a food frequency questionnaire (FFQ). The composite meals prepared were displayed for the subject to see, they were to pick out the size of the food they usually consume out of the different sizes on display. The standard amount consumed for each item was stated e.g. a plate of rice, a bottle of soft drinks etc and was later converted to weight (gram) or volume (litre) during analysis. Frequency of consumption considered the following categories; number of times the subject eats per day, food taken as breakfast, lunch, dinner, or as snacks. The foods consumed were grouped in sections according to nutrient affinity and the food quantities was converted into nutrient by applying standard food composition tables (Eyeson and Ankram, 1975; Udoh, 1988; United States Department of Agriculture, 1963) and then compared with the Recommended Dietary Allowance.

Data analysis: Analysis was both quantitative and qualitative. Microsoft Excel package and Pearson correlation was used in the analysis to assess the personal characteristic variables as well as the nutrient consumption of the respondents. Gender specific RDA (Whitney *et al*., 1991) was also used to assess the nutrient quality of the diets of the population.

Results and Discussion

Healthy eating and adequate dietary intake influences normal growth and development while unhealthy eating and poor food choices have been implicated for progression of obesity and many diet induced disorders (Kant, 2000). The ability to measure the nutrient intake vis-à-vis the dietary habit of the university undergraduates is of great importance because life long nutritional habit may be established during this period of life. The fact that they assumed primary responsibility for their own food intake makes this a very important issue for examination.

The results of socio-demographic and food frequency analysis are presented on Table 1. The age ranged from 15 to 35 years and the subjects were randomly selected from all the departments and levels of study in the institution. The monthly stipend received by students from all sources indicated that 7 % male and 16 % female received below ₦2,000, 41 % male and 26 % female between ₦ 2,000 to ₦ 5,000, 22 % male and 15 % female earned between ₦ 5,000 to ₦ 8,000 while14 % male and 19 % female earned above ₦ 10,000 The result revealed that the students irrespective of the gender are poorly financed; receiving on the average, a stipend of about a dollar a day. The poor stipend observed in this study, which was barely above the poorest standard of living all over the world, would definitely affect the choice of food negatively as many of the students would not be able to afford the cost of nutrient dense meals that could supply nutrients needed for growth and developmental demand of the age.

The eating habit of undergraduate students in OAU revealed that 5 % of both gender ate only once a day while 10 % of the students ate more than three times a day; indeed any time they felt like eating. 40 % male and 27 % female ate twice, 45 % male and 58 % female ate thrice. About 80 % indicated that their eating habit changed while in school compared with their homes, 51 % and 20 % would eat thrice and at any time respectively when at home. There was no significant difference in eating habit of the students whether living on campus or off campus, this may be due to the fact the students were not living with their parents, they are the one to manage their own affairs. About 67 % male and 78 % female students indicated that they consumed more snack in school than at home, the reason adduced to snacking in school was convenience (65 %) and availability (35 %), response to time of snacks consumption, 7 % male and 13 % female ate snack as breakfast, 23 % ate snacks as lunch while 67 % male and 56 % female students consumed snacks as refreshment and in between meals. The meals mostly affected by snacking are breakfast and lunch, most of the students irrespective of their abode (on or off campus) reportedly skip breakfast and lunch for snacks, due to the hectic nature of academic work that would not allow them to go for normal meals. On factors of motivation for the choice of meal, convenience (39 % male; 35 % female) and availability (25 % male; 33 % female) were rated high as the major determinants of food eaten by both genders, 17 % of the subjects were motivated by nutrition awareness, 12 % would consider the price of food as basis for choice while about 3 % gave family tradition as reason for food choice. Thus, convenience and availability formed the criteria for food choice for about two-thirds of the students of both gender sampled and not the nutritional benefits.

Fig. 1 indicated the consumption pattern of food according to nutrient affinity and the percentage of subjects who consumed within the recommended daily allowance minimum serving. The percentage of subjects who consumed cereal and grain group was 58 for the male students and 62 for the female while less than half of the subject population consumed the minimum RDA in the root tuber and starchy fruit, fruit and vegetable, meat and meat substitutes categories while only 10 % of the male and 25 % of the female respondents consumed the minimum RDA in the milk and milk substitute group (Figure 1). Analysis of dietary recall and meal composites also confirmed that starchy root and tuber, and cereal grain group are the major food groups from which respondents chose their meals, thus the quality of meals in terms of essential nutrients is considered poor as can be seen from the result that the meals were energy dense and nutrient poor. Milk and meat groups, which are regarded as veritable sources of proteins, available iron and micronutrients, recorded less consumption especially among the male subjects. This could be due to the high cost of these milk, milk products and meat groups whereas starchy roots and cereals are cheaper and remain the major staple food in Nigeria (Anazonwu-Bello, 1981).

The consumption pattern of meals and snacks is presented in Fig 2. Among male students 61 % ate thrice out of which 31 % combined their meals with snacks and fruits, 14 % added snacks alone, 4 %, fruits only while 21 % ate meals only. 44 % ate twice, 9 % of these subjects added both snacks and fruits, 20 % snacks only, 15 % ate meals only without snacks and fruits, and only 3 % ate once and substituted other meals with snacks. The eating pattern among female, shows that 64 % ate thrice out of which 31 %

combined eating of snacks and fruits with the meals,17 % combined snacks only, 5 % fruits only while 11 % ate neither fruits nor snacks. Eating twice recorded 35 % out of which 12 % ate meals only, 13 % ate meals with snacks only while 10 % added snacks and fruits to the meals. About 5 % of the female ate once and the meal is combined with snacks. From the result, 64 % male and 77 % female ate snacks while 25 % male and 46 % female ate fruits. It can be deduced that female ate more than male in terms of frequency, snacks and fruit intake. Consumption of snacks has been reported to elicit poor consumption of normal meals and also lead to over consumption when compared with other sensory–nutrient combination because of its characteristic high fat and sugar content. This deliberate consumption of energy derived from fat can lead to excessive intake of fat in a single eating episode and can produce a short term positive energy balance (Schrauwen and Westerp, 2000). Consumption of soft drinks was common with female subjects while that of alcoholic drinks is peculiar with the male. Also consumption of beverages and milk was very low compared with carbonated soft drinks.

The results of anthropometric measurements of the subjects were reported on Table 2. The weight, height, waist, hip, biceps, triceps skin-fold thickness and mid arm circumference for both male and female followed the normal trend expected for the age. There were significant differences ($p < 0.01$) in the mean measurement of height, hip, mid arm circumference for male and female whereas other parameters were not significantly different.

The mean BMI (kg / m^2) for male and female subjects are 22.3 and 24.00 respectively, the female mean BMI was significantly higher ($p < 0.01$) than the male. Using the classification of normal BMI as 18 - 24.9 kg / m^2, 63 % male and 56 % female had normal BMI, 21 % male and 31 % female were considered overweight while 3 % male and 8 % female could be classified as obese respectively, whereas 13 % male and only 5 % female were considered undernourished. From the result, it can be inferred that women showed greater tendency towards obesity whereas the percentage of underweight subjects was higher with men. This result is consistent with a higher purchasing power for the female subjects and the higher rate of consumption of energy rich foods (Table 1).

Table 2 presented the calculated nutrient intake from the dietary recall data obtained through food frequency questionnaire and the food size presented to the subjects. The consumption of gross energy (MJ), by the male and female subjects were 10 ± 2.8 and 9.9 ± 3.2; carbohydrate (g) 368 ± 132 and 350 ± 125, protein (g) 86 ± 16 and 83 ± 25, and fat (g) 71 and 70 respectively. The iron intake for both male and female respondents were 15 mg and 13 mg; calcium 311 mg and 319 mg; and phosphorus are 771 mg and 795 mg respectively. There was no significant difference ($p < 0.05$) in the values among the gender. Analysis of energy intake indicated that 60 % of the gross energy was contributed by the carbohydrates, 15 % from protein and 26 % from fats. Thus, this result indicated that the respondents subsisted more on carbohydrate rich diets at the expense of balanced diets. The United States Recommended Dietary Allowance stipulated that a diet sufficient in protein for adolescent growth should provide 30 % of the energy intake, 30 % from fat and 40 % from carbohydrate, only this typical diet can adequately support health and energy balance (Antonio, 2005). The observed macronutrient-energy consumption in this study

did not conform to the above recommendation hence one may expect carbohydrate-protein imbalance that could possibly lead to diet induced health problems on the long run.

The individuals energy intake was compared with reference energy intake of 193 KJ / kg and 168 KJ / kg body weight (energy requirement for moderately active adolescent) in both male and female subjects and it was observed that 49 % female and 35 % male exceeded 100 % requirement for energy intake (Table 2) and 14 % male recorded energy intake below 50 % requirement level. The high energy intake observed could be due to skipping of normal balanced diet and snacking habit which have been reported to have been the cause of prevalence of obesity in the United States (Miller *et al*.,1990) The extra calories consumed are generally stored as fat in the body resulting in a high body fat, overweight and subsequently obesity. The obesity and overweight and some other nutritional disorders have been found to arise from energy protein imbalance that could result from unhealthy eating habit (Prentice and Jebb, 2003). A below average energy intake will mobilize the body carbohydrate and fat storage with attendant loss of weight and in the extreme the body protein will also be mobilized resulting in wasting and ill-health (Guo *et al.*, 2004)..

The protein requirement was calculated based on 1.1 g / kg body weight for moderately active adolescent, and compared with the protein intake of the respondent (Table 3). Almost 40 % of the respondents were unable to meet this requirement, again emphasizing the dearth of protein in the diet of Nigerian adolescents especially the undergraduate students with a pronounced need for dietary protein for the production of hormones and other body secretions, body building and general well-being. The study also revealed that many of the students could not meet the minimum recommended dietary allowance for iron, calcium and phosphorus and this trend may likely be the same for other nutrients not analyzed in this present study.

Prior to 1983, students in Nigeria's higher institutions were offered balanced diets based from the cafeteria system where the cost was subsidized by the government. The present situation whereby there is a pervasive poor eating habit, inadequate food intake, poverty and lack of adequate nutritional knowledge by the students of Nigerian universities calls for concern. If this happens to the students at a tertiary institution, then the food habit of the whole Nigerian population is suspect.

Conclusion

There was a change in the food choice pattern of undergraduate students on campus compared to their choice at home. The change is negative with only a small population making their food choice based on nutritional information despite the abundance of such information in the university. Most students ate less than three meals a day with a majority substituting snacks or convenience foods for their regular meals. This research thus adds to the growing body of literature that suggests that the food choice of the adolescent may be deficient or be a cause for concern; therefore effective nutrition education programs should include specific nutrition topics and information. Nutrition educators can incorporate time management and budgeting skills in educating students about meal planning to improve their diet adequacy. It is obvious that several delivery methods may be needed depending on the topic (e.g. videos

and focus group discussion). To be successful in promoting and reinforcing diets consistent with the Dietary Guidelines, nutrition programs need to target all environments, home, school and the neighbourhood.

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Table 1 Socio-Demographic Data And Food Frequency Analysis Reported As % Response

Major considerations	Range	MALE	FEMALE	TOTAL
		% of respondents		
AGE (years)	15 - 18	6	7	6
	19 – 24	52	62	56
	25 – 30	41	30	36
	31 - 35	1	4	2
DEPARTMENT	Science	55	31	43
	Social Sciences	26	36	32
	Arts	15	19	17
	Education	4	11	8
LEVEL OF STUDY	100	17	30	24
	200	20	19	20
	300	37	28	33
	400	15	17	16
	500	10	6	7
ETHNICITY	Yoruba	84	95	89
	Others	16	5	11
AVERAGE MONTHLY POCKET MONEY (₦)	Below 2000	7	16	11
	2000 - 5000	41	26	33
	5000 – 8000	22	15	19
	8000 – 10,000	16	15	16
	Above 10,000	14	23	19
FREQUENCY OF EATING PER DAY	Once	5	4	5
	Twice	40	27	34
	Thrice	45	58	51
	Others	10	11	10
CHANGES IN FOOD HABIT WHILE IN SCHOOL	Yes	89	88	89
	No	11	12	11
IF YES, HOW OFTEN DO YOU EAT AT HOME	Once	2	10	6
	Twice	22	23	23
	Thrice	51	51	51
	Others	25	16	20
WHERE CONSUMPTION OF SNACKS IS HIGHER	Home	33	22	28
	University	67	78	72

TIME OF EATING SNACKS	As breakfast	7	15	10
	Lunch	21	24	23
	Supper	5	7	6
	Refreshment	67	56	61
REASON FOR EATING SNACKS INSTEAD OF MEALS	Availability	29	38	34
	Convenience	77	62	66
FACTORS OF MOTIVATION FOR FOOD CHOICE	Nutritional awareness	17	17	17
	Availability	25	33	29
	Convenience	39	35	37
	Family / Tradition	2	5	4
	Price / Cost	17	10	13
IF MULTIVITAMIN / MINERAL SUPPLEMENT IS TAKEN	Yes	22	14	18
	No	78	86	82
IF YES, ARE THE MULTIVITAMIN / MINERALS PRESCRIBED?	Yes	45	33	40
	No	55	67	60

Table 2: Anthropometric measurements of students of Obafemi Awolowo University, Ile-Ife.

PARAMETERS	**MALE (n = 98)**	**FEMALE (n = 104)**	**TOTAL (n = 202)**
Age	24	23	23.5
Weight (kg)	61 ± 8.8	59 ± 10	59 ± 8.8
Height (m)	1.7 ± 0.10[a]	1.6 ± 0.10[b]	1.6 ± 0.11
Waist (cm)	31.3 ± 1.94	32.1 ± 3.41	31.7 ± 2.81
Hip (cm)	36.4 ± 2.7[a]	39 ± 3.5[b]	38 ± 3.4
Biceps (mm)	3.6 ± 0.6	3.7 ± 0.7	3.6 ± 0.7
Tricep Skinfold (mm)	2.0 ± 0.5	2.0 ± 0.7	2.0 ± 0.6
Mid-arm circumference (cm)	11.5 ± 1.2[a]	11.4 ± 1.7[b]	11.4 ± 1.5
BMI (kg / m^2)	22.3 ± 3.8[a]	24.0 ± 4.3[b]	23.2 ± 4.2
BMI	% of subjects		
> 30	3	8	5.5
25 – 30	21	31	26
18 – 25	63	56	59.5
< 18	13	5	9

a , b are significantly different P <0.01

Table 3 Estimated Energy and Nutrient Intake

	MALE	**FEMALE**	**% ENERGY**
	MEAN ± SD		
Energy (MJ)	9.6 ± 2.8	9.9 ± 2.7	-
Carbohydrate (g)	368 ± 38	350 ± 125	60
Protein (g)	84 ± 16	83 ± 25	14
Fat (g)	71 ± 30	69 ± 23	26
Fibre (g)	9.8 ± 3	10 ± 4	
Iron (mg)	15 ± 4	13 ± 5	
Phosphorus (mg)	771 ± 219	795 ± 323	
Calcium (mg)	311 ± 110	319 ± 203	

Table 4: Energy and nutrient intake compared with the RDA.

Energy Requirement KJ / kg	**MALE**	**FEMALE**
	% subject	
> 150 %	3	6
120 – 149	9	19
100 – 119	21	24
70 – 99	41	38
50 – 69	10	12
< 50	14	1
100 % of Energy Requirement (KJ / kg)	193	168
	% subject meeting the RDA	
Protein Requirement (1.1 g / kg)	68	66
Iron RDA Male = 10 mg, Female = 15 mg	72	80
Calcium RDA = 800 mg	11	17
Phosphorus RDA = 1000 mg	28	32

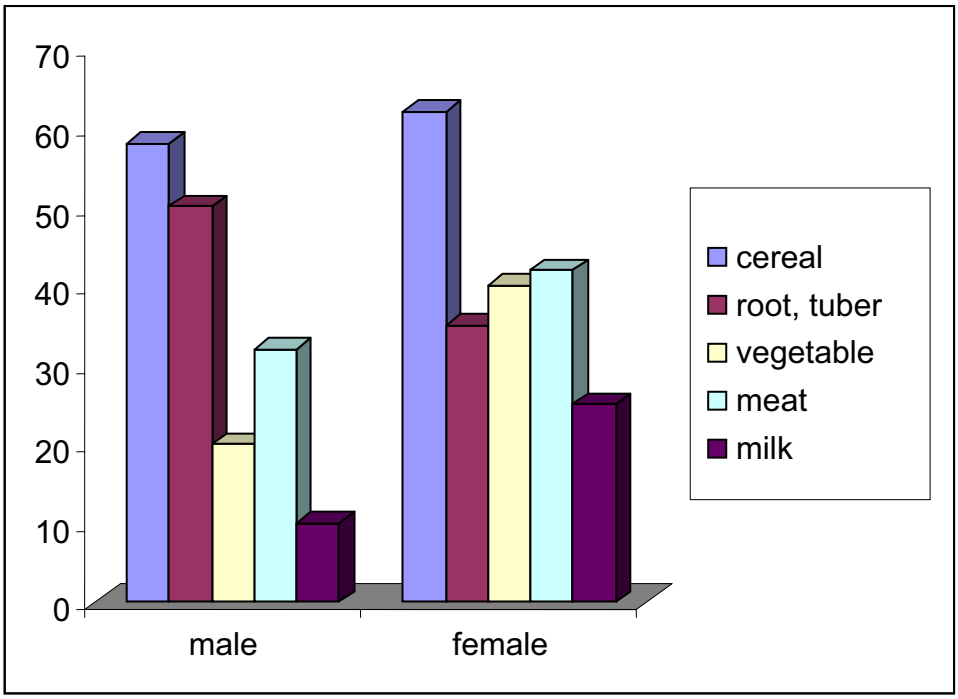

Figure 1: Pattern of Food Consumption Based on Food Groups

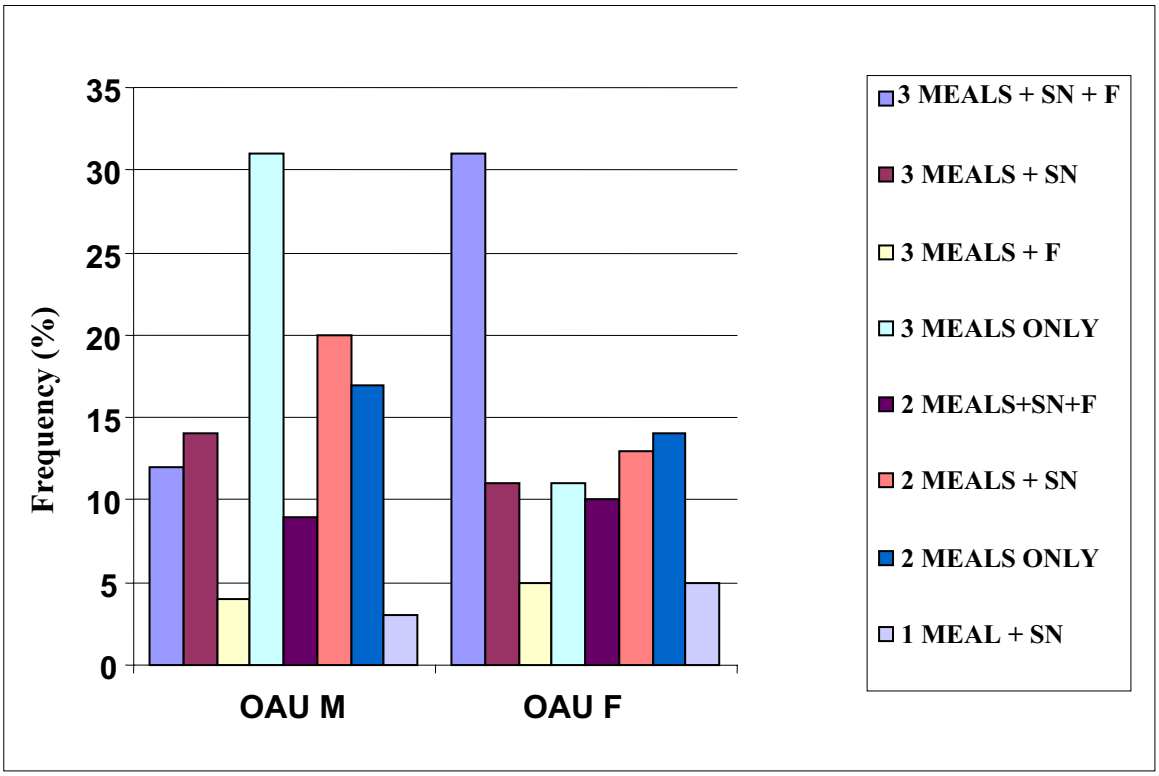

Figure 2: Pattern of Meals and Snacks' Consumption among Undergraduate Students

Seed of Under- Exploited *Cola millenii* (K. Schum): A Rich Source of Nutrients and Fatty Acids.

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Abstract

The search for nutraceuticals, especially in plants, is an on going process. A typical example is the class of fatty acids called the omega-3 fatty acids. As part of an on-going screening process for plant constituents of nutritional and economic significance, we investigated the seed of one of the under-exploited plants - *Cola millenii* K. Schum. Proximate composition revealed a high oil content which is comparable with some conventional oils while the high iodine value suggested that the oil is rich in polyunsaturated fatty acids. The lipid composition of the seed of *Cola millenii* was therefore investigated as their fatty acid methyl ester by gas chromatography. Thirteen fatty acids constituting 33.94 % of the oil were identified, while some other major peaks were not identified. High molecular weight fatty acids (C20 and above) constituted 73 % of the total fatty acids separated by GC. Alpha linolenic acid was 2.6 % of the total fatty acid composition while another omega 3 fatty acid docosahexaenoic acid (DHA) seems to be present at 14.6 % level of the total fatty acid extract. An oily compound was also isolated, characterized by spectral analyses and the structure proposed as 22-ethoxymethoxy-8, 11, 13-trimethyldocosa-8, 10, 12-trien-6-one. This type of compound is not common from plant sources.

Introduction

Cola millenii K.Schum belongs to the Sterculiaceae family; the English name is false or monkey cola, Yoruba; *obi edun*, Ibo; *aju ofla*. It is a West African plant, which grows wild and is sometimes cultivated in Ghana, Cameroon and other West African countries. The tree attains about 20 meters height, flowers between November and January and fruits between June and August (Irvine, 1961).

The fruit is a dicotyledon and red in colour. The fruit consists of the pod husk, which houses the seed (nut). Each seed is wrapped in a whitish or creamy smooth tissue on the outside part of the membrane coat of the seed. The seed has a sugary or sometimes sour taste but always slimy. The seed of this species is not widely eaten though its relations, *C. acuminata* and *C. nitida* are relished and are important in cultural practices in Nigeria. *C. millenii* tree had been successfully used as a root-stock for grafting *Cola nitida* and *Cola acuminata* (Dalziel, 1973; Irvine, 1961). The wood is used in Ibadan (Nigeria) area for making gun-stock and an examination of the wood bark had shown a fairly strong presence of alkaloids which could be pharmacologically important (Adegoke *et al.,* 1968).

There is a dearth of information on *C. millenii* seed despite the fact that during the fruiting season, large quantities (of the seed) are produced in the numerous pods of each plant with only young children licking the mesocarp. Tons of this seed are wasted every year. The purpose of this study was therefore to determine the proximate composition of the seed, chemical characteristics of the seed oil and investigate the lipid composition of *Cola millenii* K. Schum seed.

Experimental Procedures

Sample collection: *Cola millenii* fruits were collected behind Botany Department, Obafemi Awolowo University, (OAU) Ile-Ife. It was identified at the herbarium of the Department of Botany, OAU, where a specimen with voucher number 153333 was deposited.

Preparation of sample: The seeds were removed from the pod and dried at 50^{o} C, ground to a fine powder with a Moulinex Turbo Blender (Model D70, Collogue, Germany). The powdered sample was stored in air-tight containers in the refrigerator.

Proximate analysis and chemical parameters were determined by AOAC (1990) methods. Carbohydrate was determined by difference while nitrogen was determined by the Kjeldahl's method and converted to protein using a factor of 6.25.

Extraction of C. *millenii* seed oil: The finely ground seed material (5.0 g) was extracted in triplicate with 250 ml of n-hexane for 5 hours using a soxhlet apparatus. The n-hexane was distilled off, the round bottomed flask, containing the oil, was dried in an oven at 50^{o} C. The chemical characteristics of the oil were determined using standard methods and methylation of the extracted oil was carried out by the AOAC (1990) method. The homogenized oil sample (100 mg) was saponified with 0.5 M methanolic NaOH solution at 60^{o} C for 10 minutes and neutralized with 0.7 M HCl. Methylation of the fatty acids was carried out with BF_3 / CH_3OH solution and the resulting esters were analysed by GC.

GC determination of the component fatty acids: The analysis of fatty acid methyl ester was performed by a Perkin Elmer Autosampler XL gas chromatograph with a BPX-70.02; 30 m × 0.25 mm i.d.; 0.25 µm film thickness column. Helium was the carrier gas at a flow rate of 20 Psi and a split injector (220^{o} C, split flow rate, 40: 1). The temperature was programmed to increase from 60^{o} C at 10^{o} C min^{-1}, then from 180^{o} C at 4^{o} C min^{-1} and finally 235^{o} C. The total run time was 27.7 minutes. Eluting peaks were detected by FID. Identification and quantification of the methyl esters were made by comparison of quantity and retention times of standard fatty acid methyl esters.

Isolation of compound: Completely dried and coarsely powdered seeds of *Cola millenii* (100 g) was exhaustively extracted twice with distilled ethanol (2 x 500 mL) for two weeks. The solvent was removed under reduced pressure. The concentrate (100 mL) was diluted with an equal volume of distilled water and extracted with n-hexane. The hexane extract was then washed with water, dried over anhydrous sodium sulphate and evaporated to dryness to give a crude dark yellow hexane extract (1.0 g). The dark yellow extract was fractionated on a column of silica gel and eluted with one solvent system of hexane: ethyl acetate (5:1) + 2 drops of glacial acetic acid. 15 Fractions (25 mL each) were collected, monitored by TLC

and combined according to their composition. Combined fractions 7-10, was evaporated (100 mg) and purified by preparative TLC to give a single spot of colorless oily substance (50 mg).

Results and Discussion

The proximate composition of *Cola millenii* seed is presented in Table 1. The relatively low moisture content is an indication that the seed will have a long shelf life especially when properly packaged against external conditions (Eka, 1987). Lipids are essential because they provide the body with maximum energy approximately twice that from an equal amount of protein or carbohydrate and facilitate intestinal absorption and transportation of fat-soluble vitamins A, D, E and K (Dreon *et al*., 1990). The lipid content in *Cola millenii* compared favourably with those of soybean oil, locust bean and cottonseed; 19.1 g / 100 g, 20.30 g / 100 g and 14.05 g / 100 g crude fat respectively. These are commercially exploited and classified as oil seed (Ayodele, *et al*., 2000). This showed that the seed oil could complement conventional vegetable oils, which are very expensive.

Fibre helps in the maintenance of human health and have been known to reduce cholesterol level in the body. The low levels of fibre in *Cola millenii* seed flour may be desirable in their incorporation in weaning diets. Emphasis has been placed on the importance of keeping fibre intakes low in the nutrition of infants and pre-school children (Eromosele *et al*., 1993). *Cola millenii* seed can be considered as a potential source of carbohydrate when compared to the content of conventional source like cereals and could be good supplements to scarce cereal grains as sources of energy in feed formulations.

The chemical properties of the seed oil are reported in Table 2. The degree of unsaturation of oil, expressed as its iodine value, serves as an indicator of the use to which it can be put. The iodine value of *C. millenii* seed oil compared favourably with cotton seed oil (105 - 144), sunflower seed oil (110 - 143) and passion fruit seed oil (133 – 141) (Nyanzi *et al.*, 2005). *C. millenii* seed oil was comparable to sunflower oil in terms of iodine value, which is generally considered as premium edible oil. Oils rich in unsaturated fatty acids have been reported to reduce heart diseases associated with cholesterol (Law, 2000).

The elution of 48 fatty acids from the *Cola millenii* seed oil is presented in Table 3. Only 13 of these peaks were identified. The identified fatty acids ranged from C_{13} to C_{24} with hexadecanoic (C16:0), octadecanoic acid (C18:0) and eicosanoic acid (C20:0) as the predominant saturated fatty acids. The higher molecular weight fatty acids docosenoic (C22:1), eicosenoic (C20:1) and hexadecenoic (C18:1) constituted the monoene fatty acids in descending order. The identified diene content was cis C18:2 and triene C18:3. There is a high possibility of the existence of other polyene among the several unidentified peaks within the C20 to C24 components. In fact high molecular weight fatty acids (C20 and above) constituted 73 % of the total fatty acids separated by GC. Docosahexaenoic acid (DHA) is a polyene fatty acid essential for growth and development, brain integrity and good health even in old age (Kelley *et al.*, 2007; Marszalek and Lodish, 2005; Nyazi *et al.*, 2005; Theobald *et al.,* 2007; Theodoratou *et al.,* 2007). Unfortunately, man does not produce enough of this fatty acid and has to depend on outside sources such as fish oil. The authors

were therefore interested in DHA and a rerun of the DHA standard corresponded to a peak with 14.6 % area. The presence of trans isomers within the unidentified peaks can also not be ruled out.

Attempts were made to isolate some of these unidentified peaks through extraction, fractionation and purification. An oily compound was thus isolated and characterized. The compound was isolated as pale yellow viscous oil that showed a light green spot on TLC when developed in iodine tank. The IR spectra displayed absorption bonds for un-conjugated carbonyl (1727 cm^{-1}) and C = C (1460 cm^{-1}, 1608 cm^{-1}) substituted triene (cal: 272, obs: 273 nm). DEPT experiment indicated the presence of multiple methylene groups while the signal for quarternary carbons was not shown (Table 4). ^{1}H-COSY cross – peaks also indicated the coupling between H_2 and H_4. The coupling between H_{21}, H_{20} and H_{19} also showed the connectivity between the atoms. This also established the planar structure of the compound. The isolated compound gave a positive test to 2, 4-dinitrophenylhydrazine and also to oxidation by $KMnO_4$. These chemical reaction results corroborated the presence of carbonyl moiety as well as double bonds. The molecular formula $C_{28}H_{50}O_3$ was deduced from high resolution mass spectra with [M^+] ion peaks at mlz 434.38 coupled with NMR and IR data and the structure was established with the aid of Advanced Chemistry Department (ACD) elucidator software as 22-ethoxymethoxy-8,11,13-trimethyldocosa-8,10,12-trien-6-one. This compound is a new natural product isolated from *Cola millenii* as indicated by chemical compounds database and not common in plant source. Considering the results obtained in this preliminary study, further investigation is necessary in order to identify some other constituents of the seed lipid.

Table 1: Proximate Composition of *Cola millenii* Seed (g / 100 g) Dry Weight

Moisture	10.0 ± 0.01
Crude protein	9.2 ± 0.62
Crude fat	40.0 ± 1.16
Crude fibre	4.0 ± 0.01
Ash	3.0 ± 0.41
Carbohydrate	37.8 ± 0.71

Table 2: Chemical Characteristics of *Cola millenii* Seed Oil

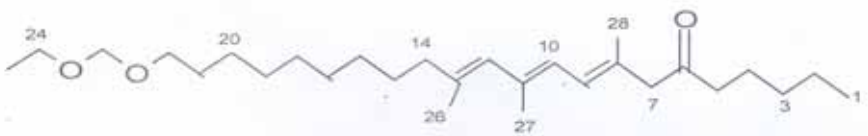
Acid value mg KOH / g	80.5 ± 0.52
% Free fatty acid (as oleic acid)	40.7 ± 0.33
Iodine value g / 100 g	160.4 ± 2.10
Peroxide value (meq / kg)	8.1 ± 0.10
Saponification value (mg KOH / g)	122 ± 1.10

Table 3: Percentage Fatty Acids Composition of *Cola millenii* Seed Oil

Fatty acid	% Composition
C 9: 0 Nonanoic	0.12
C 13:0 Tridecanoic	1.79
C 14:0 (tetradecanoic)	0.13
C 16:0 (Hexadecanoic)	7.70
C 17:0 (Heptadecanoic)	0.31
5 unidentified peaks	1.55
C 18:0 (Octadecanoic)	1.50
C 18:1 (cis 9-Octadecenoic)	1.92
3 unidentified peaks	1.45
C 18:2 (cis 9,12-octadecenoic)	1.92
5 unidentified peaks	6.14
C 18:3 (Cis 9,12,15-Octadecenoic)	2.57
C 20:0 (Eicosanoic)	4.25
2 unidentified peaks	7.41
C 20:1 (Cis Eicosenoic)	3.67
Unidentified	2.21
2 unidentified peaks	1.71
An unidentified peak	8.82
Unidentified	1.37
Unidentified	12.17
2 unidentified peaks	0.49
C 22: 0 (Docosanoic)	0.18
C 22:1 cis (Docosenoic)	7.69
4 unidentified peaks	0.65
Unidentified	6.87
C 24:0 (Tetracosenoic)	0.19
2 unidentified peaks	0.35
Unidentified	14.49
3 unidentified peaks	0.48

Table 4: ^{1}H-NMR and ^{13}C-NMR of 22, Ethoxymethoxy-8, 11, 13-trimethyldocosa-8, 10, 12-trien-6-one.10, 12-trien-6-one.

S/n	^{13}C–NMR	^{1}H-NMR
1	14.3	0.9
2	28.6	
3	31.8	
4	29.2	
5	34.6	22
6	200	
7	38.1	
8		
9	123.6	7.0
10	123.5	72
11		
12	123.55	6.0
13		
14	32.1	
15	29.9	
16	29.9	
17	29.9	
18	29.5	
19	29.6	
20	29.3	
21	31.1	
22	60.4	
23	22.8	
24	22.8	2.2
25	25.1	1.6



22-Ethoxymethoxy-8, 11, 13-trimethyldocosa –8, 10, 12-trien-6-one

Figure 1: The structure of the isolated oily compound

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Ante Mortem Examination of Cattle at Abattoir In Ile-Ife

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Abstract
The study was conducted to investigate the health status of cattle slaughtered at Ile-Ife through ante mortem examination. A total of 100 cattle were examined within a period of one month at the main abattoir located on Ede Road ,Ile-Ife, Nigeria. The ante mortem examination was carried out based on the FAO criteria. Four percent of the animals had nasal discharges, 4% presented anal discharges, 100% of animals slaughtered were male, 70% were agitated, 11% of the animals had skin infection while 23% of the animals were lean. It was concluded therefore with the observations made that, proper ante mortem inspection will go a long way in ensuring that only healthy animals are slaughtered thereby reducing the public health risk posed by consumption of diseased animals and also minimizing the loss incurred by butchers when animals are condemned at post mortem.

Keywords: Ante mortem, cattle, abattoir, Ile-Ife.

Introduction

Zoonoses still represent significant public health threats and at least 61% of all human pathogens are zoonotic (WHO, 1999). The case of emerging zoonosis is further making the well being of animals of great importance to humans. The WHO/FAO/OIE. (2004) joint consultation on emerging zoonotic diseases, defined an emerging zoonosis as a zoonosis that is newly recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range. Emerging zoonotic diseases have potentially serious human health and economic impacts and their current upwards trends are likely to continue. Examples are avian influenza, Bovine Spongiform Encephalitis (BSE) and the Nipah virus. Some of the "lingering" zoonoses are re-emerging in some regions, although they seem to attract less public awareness for example brucellosis, dog rabies and parasitic diseases such as cysticercosis/taeniasis and echinococcosis/hydatidosis.

Many factors have been implicated in leading to the emergence of zoonotic diseases. Environmental changes, human and animal demography, pathogen changes and changes in farming practice are a few of them. Social and cultural factors such as food habits and religious beliefs play a role too. According to WHO (2005) interventions to control zoonoses require concerted action between the veterinary and the human health sectors, because they affect both people and animals. A major way of checking the introduction of zoonotic diseases into human populace is meat inspection. Inspection of meat before consumption is very important and this is done in two phases; ante mortem and post mortem inspection. Ante mortem inspection is the inspection of live animals prior to slaughtering while post mortem inspection is the inspection of animals after slaughtering (NZFSA, 2005). The major objective of ante mortem examination is to screen all animals destined for slaughter so as to prevent the killing of diseased animals and identify cases of reportable diseases (FAO, 2000) .

Diseases with nervous invovlement such as Bovine spongiform encephalopathy and rabies can be detected during ante-mortem examination and also diseases with chronic courses e.g tuberculosis (Ojo,

1998). Another advantage of this inspection is that it prevents the killing of diseased animals so that treatment can be done so that the animals will not be condemned during post mortem inspection. In Nigeria, large number of small abattoir are scattered all over the country, few are licensed and most are not. A greater percentage of licensed places lack modern amenities and Veterinary officers providing meat inspection.

At the Ile-Ife abattoir where this study was carried out all slaughtering, carcass dressing and product handling are done in the same place without proper waste disposal and no inspection either ante mortem or post mortem is carried out on animals. The aim of this study therefore is to provide information on the health status of animals slaughtered at the main Ile-Ife abattoir and come up with relevant suggestions on how to improve on the health situations of these animals thereby preventing zoonosis in human population.

Materials and methods

This work was carried out at the main abattoir along Ede Road Ile-Ife Osun state. 100 cattle were examined over a period of one month. The animals were examined few hours before slaughtering. The criteria for examination is in accordance with the prescription of NZFSA (2005) and these include

- Abnormalities in respiration
- Abnormalities in behaviour
- Abnormalities in gait
- Abnormalities in posture
- Abnormalities in structure
- Abnormal discharges or protrusions from body openings
- Abnormal colour
- Abnormal odour

The animals were examined at rest and in motion. The results were tabulated and the percentages calculated.

Results

Four percent of the animal slaughtered had nasal and eye discharges. All the animals were male. Most of the animals 70% were agitated with 30% being gentle. The skin of 11% was diseased as opposed to 89% with smooth skin, 23% of the animals were lean while 77% were fat. 93% had normal faecal matter consistency.

Table 1: Health Condition of Cattle at the abattoir.

CONDITIONS	PERCENTAGE
Nasal discharge	4
Eye discharge	4
Scrotal lesion	0
Penile lesion	0
Normal faeces	93

Loose feaces	7
Male	100
Female	0
Gentle behaviour	30
Agitated behaviour	70
Smooth skin	89
Diseased skin	11
Lean	33
Fat	77

Discussion

The importance of meat inspection cannot be over-emphasized due to the fact that it is one of the most important ways in which zoonotic diseases can be detected and curtailed. According to (WHO/FAO/OIE, 2004) emerging zoonosis is a major problem further reducing the already scare meat and meat products especially in the developing countries. Ile-Ife is a major town in the South Western part of Nigeria. It has a main abattoir owned by the government and other smaller private abattoir. The abattoir where this study was carried out was the government owned abattoir. From the result, 4% had nasal and eye discharges this could be due to local irritation since the animals looked healthy and showed no other apparent signs of illness. All animals slaughtered were male, this was attributed by the butchers to the fact that consumers prefer male animals because of the belief that female animals meat are normally tough.

About 70% of the animals were agitated with 30% being gentle. This was attributed to the rough handling of these animals by butchers prior to slaughtering and not to any nervous disease. The skin of 11% was diseased and this is an important parameter because the skin is consumed as 'ponmo' by majority of the people and diseases such as foot and mouth disease, lumpy skin disease etc (Sowsby, 1982), some of which are reportable diseases can be detected from the skin. In this case streptothricosis and mange were the major skin diseases seen. Majority of the animals were fat and this is due to the abundant of forage available during rainy season when this study was carried out. Leaness could be due to chronic disease problems such as pericarditis pneumonia, nephritis and tuberculosis (Sowsby, 1982).

Conclusion

In conclusion, adequate inspection of animals to be slaughtered will go a long way in checking the menace of zoonosis. If the goal of WHO (2007) to prepare list of notifiable zoonotic diseases in each country and to initiate pilot studies to test combined integrated prevention and control package will be realised, government at all levels in the developing countries must provide qualified manpower for this exercise. Effective control of zoonotic diseases would mean a decreased disease burden, poverty reduction and increased food supply for large numbers of the rural poor worldwide, thereby contributing towards the achievement of the Millennium Development Goals

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Food security in Nigeria: The Way Forward

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Abstract

Food security exists when people have physical and economic access to food at all times in sufficient quantity and quality. The annual rate of food production in Nigeria is 3.5 %, just slightly above the annual rate of population increase of 3.0 % and far behind the rate of urbanization of 5.5 %. When export and industrial conversion to non-food products are taken into consideration, there is a net deficit between food demand and supply. To solve the problems militating against food security in Nigeria 14 intervention programmes were put in place by successive governments between 1973 and 2003 with varying degrees of success. The current policy thrust of agricultural development in Nigeria is to achieve sustainable human development by raising agricultural productivity, expanding production for export, increasing the supply of farm inputs and improving institutional and administrative support. Factors, crucial to achieving these goals, include a change in the present small holding farming structure through appropriate capitalization, efficient resource use programmes, land reforms, establishment of farm gate industries and the provision of infrastructure to the rural areas. A model which brings together all tiers of government and multilateral agencies is proposed. Crucial to the success of the model, is the cooperative ownership of such farm gate industries by the farmers. Food production can be increased through the production and application of organic fertilizer from organic waste products, and the use of other waste products to produce both single cell organisms and protein analogs for animal husbandry. A second proposal, that cassava should be pronounced a national crop with commensurate level of research and development activities, is also made. Three transgenic cassava varieties should be developed using, as the stock, the International Institute of Tropical Agriculture's (IITA) developed cassava cultivar capable of yielding up to 70 tons per hectare. The first transgenic cassava should be acyanogenic with increased protein content in the root. The second should be targeted to the industrial starch sector with high amylopectin content, while the third should have high amylose content for biofuel production. The development and production of smart foods is now the trend in developed countries and this is advocated for food security in Nigeria.

Key words: food security, accessibility, value added, acyanogenic, amylose, amylopectin.

Introduction

Food insecurity is a problem that has continued to trail the nation since the early 1970s when the military administration had to introduce the "Operation Feed the Nation" programme. The recent phenomenon of escalating food prices at the global level has exacerbated this problem. At the core of the food security crisis in Nigeria are a number of factors including:

- rapid rate of urbanization of about 5.5 %, which is one of the fastest in the world;
- neglect of the agricultural and rural sectors of the economy over time, that has led to a decline in food production per capita;
- misplaced development paradigm that has promoted commerce over production and enhanced the migration of able bodied rural dwellers of both gender to the 'commerce friendly' cities;

- inconsistent and in some cases, wrong policy choices devoid of inputs from the actual stakeholders in the agricultural sector; and,
- failure of research to exert a transformative impact on the development of the agricultural sector.

The major consequence of the factors above is a perennial situation whereby the domestic food production failed to meet the local consumption requirements and national food security had to be met with increasing rate of food import expenditure. With the current food shortages at the global level, the failure of policy to address this more than thirty-year old problem stares the nation in the face, exposing our national vulnerability to external food shocks, and the hardships Nigerians, especially the poor, have to contend themselves with to access food. Put simply, Nigeria is clearly a food insecure nation. International concern for the consequences of food insecurity dated back to 1948 with the declaration of food as a basic human right (United Nations, 1948) and the establishment of "Committee on World Food Security" by the Food and Agricultural Organization (FAO) in 1972. Even so, food insecurity has continued to ravage the world especially the developing nations.

Food security has been defined severally with each definition incorporating multiple concepts. The World Bank (1986) defined food security as access by all people at all times to enough food for an active and healthy life" while FAO (1996) submitted that food security exists when "all people at all times have access to safe nutritious food to maintain a healthy and active life". The World Food Summit in 1996 described food security to exist when people have physical and economic access at all times to food in sufficient quantity and quality needed for their daily activities while Esrey (1997) defined it as "sustained access by all individuals to adequate and safe food for an active, healthy and productive life". As observed by Oluwasola (1999), these definitions as well as others (Maxwell, 1988; Maxwell and Frankenberger, 1993) emphasize the importance of physical and economic access to an adequate supply of food as well as the ability to acquire food by all people including the poor. Thus defined, food security extend beyond production to food processing and distribution to the final consumer thus making it a multifaceted issue.

Pervasive poverty among Nigerians hinder economic access to costly food while failure of infrastructural services, especially roads, to effectively link all sections of the country as in the rural areas means distribution of available food supplies will not reach rural areas where food insecurity could be critical. The World Bank (2001) identified food availability, food accessibility, and food utilization as the three underpinning facets of food security. Food availability means ensuring sufficient food is available to the populace. This, however, is premised on the adequacy of domestic output, processing and storage as well as the regularity of foreign imports. Food access means physical availability of the food as well as the financial capacity of consumers to purchase the available food products. Food utilization means ensuring a good nutritional outcome which connotes a balanced diet (from a combination of a wide variety of foodstuffs). In addition, there must be an adequate provision of supporting services like safe water, improved sanitation, elimination of cultural barriers that deny access of women and children to nutritious food and adequate health care. Given this premise, a number of pertinent questions need to be critically

examined: what are the national goals regarding food production/security in the country? what is the food production situation in Nigeria? What are the potentials available to be exploited to provide adequate food for Nigerians? What are the constraints to achieving this? What has been the impact of articulated policies toward achieving the desired ends? What policy alternatives are needed to stimulate agricultural employment, transform the agricultural sector and make Nigeria food secure? These are the major issues this paper addresses. In section two (2), the paper appraised Nigeria's food security situation and the constraints to farm production while section three (3) addressed the policies and strategies put in place to ensure food security and achieve sustainable agricultural development in the nation. In section four (4), the paper attempted to figure out the causes of the failure of the different policies and in section five (5), suggestions as to the issues the new policy drive should take on hand were discussed. The paper was concluded in section six (6).

The Food Security Situation in Nigeria

Potentials of the Agricultural Sector and Food Production in Nigeria

The issue of food insecurity in Nigeria is a paradox because the enormous potentials of the agricultural sector are not only capable of producing food over and above the national food need but also solving the problems of unemployment and poverty in the country. The nation has a total of 924,000 square kilometers (98 million hectares) of land, 80 % of which is arable (Federal Environmental Protection Agency{FEPA}, 1992). Currently, only 50 % of this is under cultivation. Out of a total of 2.5 million hectares of land that could be brought under irrigation in the country, only 974,900 hectares, representing 39 %, is now under irrigation (Federal Ministry of Water Resources {FMWR}, 1995**).** The sector employs 60 % of the national labour force and accounts for 90 % of the non-oil export earnings (United Nations Systems {UNS}, 2001).The small scale farmers constitute the bulk (about 60 %) of the farmers in Nigeria (Toluyemi, 1990; Oluwasola, 1999). It has also been estimated that 90 % of the cultivated land in the country is still in the hands of the small scale farmers (Federal Ministry of Agriculture, Water Resources and Rural Development {FMAWR & RD}, 1986; Nigerian National Committee on Irrigation and Drainage {NINCID}, 2006) and the agricultural sector accounts for nearly 40 % of the total GDP.

Although the emphasis, until recent times, has been on exportable crops, Nigeria produces substantial quantities of food products ranging from grains, roots and tuber, legumes, fruits and vegetables. Up to the first decade of independence, the agricultural sector constituted the bulwark of the Nigerian economy. Not only was agriculture the major foreign exchange earner, it also provided all the food needs of the Nigerian nation. Then, Nigeria was food secure as a nation. After 1970, however, with the advent of the petroleum, the agricultural outlook of the nation changed. As shown in Table 1, food output for all categories of food crops have exhibited a similar pattern of growth between 1970 and 2004. The food situation for these years is better appreciated along phases.

The Pre-Structural Adjustment Programme (SAP) Period: 1970 - 1985

Between 1970 and 1985, food production declined for all products in the food crop sub-sector and indeed, for all products in the agricultural sector (Table 1). In 1984 and 1985 however, an increase in food output was recorded for all crops. Agricultural production, during this period, declined at an average annual rate of 0.9 % with the crops sub-sector declining at an annual rate of 1.6 % and fish production declined at an average of 2.0 % per annum (Table 2). In fact, an annual negative growth rate of 2.6 % was recorded for the sector between 1970 and 1980 (UNS, 2001). In this era, the index of agricultural production (Table 3) revealed a consistent decline of all crops and also for staples and livestock. It was only in the fisheries subsector where the index of production exceeded the benchmark of 1984 marginally. The contribution of agriculture to the overall GDP during this period also fell to an average of 36 % (Table 4). Inflation rate during the 1970 – 1985 era was an average of 16.2 % every year as shown in Table 4. Although it was clear that Nigeria was becoming vulnerable to domestic food production, shortfalls were enthusiastically bridged by massive importation which further depressed domestic production. As shown in Table 5, the food import bill rose from ₦57.7 million in 1970 to a peak of ₦1,819.6 million in 1981. The food import bill, during the period, was on the average, ₦846.0 million annually representing an

annual growth rate of 26.1 %. Food import, as a percentage of total import, increased throughout the period and peaked in 1983 when it stood at 19.8 %. During this period, Nigeria transited from a food secure to a food insecure nation. The manifestation of the insecurity in food access came with the dwindling resources available to continue food importation consequent on the changing international economic order, increasing rate of inflation, burgeoning debt, and the economic crisis resulting from servicing these debts (Oluwasola, 1993).

The nation's overall economic policy of import substitution for industrialization and trickle down strategies, during this period, meant little attention was paid the rural area where farmers lived and food was produced. The enormous national income from petroleum in the 1970s worsened the situation as the agricultural sector was virtually neglected. Development was concentrated in the few urban areas while public service wage was massively increased in 1973. Consequently, there was a massive migration of rural dwellers especially able bodied youths, who provided the required labour and impetus to food production. This led to the massive build up of people in cities at a rate of 5.5%, a trend that has not ceased since then. The response of government to avert a national urban food crisis was to engage in massive food importation which further depressed the price of locally produced food crops, discouraged farmers and triggered another succession of migration from the rural areas to the festering cities. Other factors, implicated in the agricultural crisis during the period include, over-valuation of the nation's currency, over-protection of the local industries, and the forces of globalization that induced a change in the taste and preference of Nigerian consumers for foreign and imported food products instead of the locally produced substitutes.

The Structural Adjustment Programme (SAP) Period: 1986 - 1993

By 1986 when the economic realities finally caught up with the nation, the Structural Adjustment Programme (SAP) was introduced and greater attention was paid to the agricultural sector. The goal of this national policy was the re-structuring of the economy to diversify it from its near total dependence on the petroleum as well as importation of foreign goods. While it lasted, the agricultural landscape experienced a positive turn-around of its fortunes. As shown in Table 1, all the sub-sectors of agriculture, notably food crops, experienced a massive increase in output. The annual growth of the agricultural sector during the period was an average of 8.6% (Table 2). The index of agricultural production (Table 3) revealed that all sub-sectors of agriculture, especially the food crops consistently increased and by 1993 had achieved nearly 150 % increase while the contribution of agriculture to the GDP increased to 40% (Table 4). Only the agricultural production index for fishery declined during the period. Inflation was however very high as shown in Table 4, averaging 30.5% for the period. The volume of food imports, though still substantial (Table 5), decreased to an average of 9.3% representing 1.9% of the national GDP. In terms of value, the food bill rose from ₦801.9 million in 1986 to ₦13,952.4 million in 1993. The increase in the monetary value of imports was however due to the massive devaluation of the Naira following a quest to establish a market determined exchange rate for the national currency. This situation is further supported by the fact that volume of food imports increased only from 1,896.4 million tonnes in1986 to 2,081.1 million tonnes in

1993 representing an average of just 1,908.2 million tonnes per annum. This is in spite of the fact that population increased during the same period from about 60 million to 88.5 million.

Clearly, food production increased during the period but the issue of food security was dichotomized between the rural and urban sectors. While the rural area could be said to have access to local food production, the same could not be said of the urban dwellers that had to pay more for the food because of the devaluation thus reducing economic access to food. This was more so as there was no wage increase during the period. The SAP policy adopted during the period engendered market reforms that saw to the abolition of Commodity Boards and elimination of government functionaries in the purchase of agricultural commodities and input. Farmers, through cooperative societies and private interests, imported farm input and exported farm products at market determined rates that energized agricultural production in the country. However, the extension of agricultural export to food crops, until it was later banned, created problems of food insecurity in the nation. On the whole, food production increased, however, the problem of food insecurity remained.

Post SAP Military Period: 1994 – 1998

During this period, change in government led to a shift in policy from the SAP to guided deregulation. As revealed in Tables 1 and 3, agricultural output during this period continued to increase over time although the annual growth rate decreased from the 8.6% achieved in the previous phase of 1986 - 1993 to 3.6% (see Table 2). However, the fishery sub-sector, which had earlier been characterized by a steady decline, experienced substantial growth. The contribution of the agricultural sector to the national GDP averaged 39% (Table 4) while the annual growth rate for the sector was 3.6%. Inflation continued to rise (Table 4) and averaged 35.5% during the period. Data presented in Table 6 indicated that during the period, the food balance sheet was consistently negative similar to the previous periods and so, importation had to be continued. The volume of food imports (Table 5) grew at a reduced rate of 6.2% even though the value rose astronomically during the same period by 111.2% representing 11.8% of total imports and 3.7% of GDP. The increased value of food imports relative to its volume was sequel to the further depreciation of the Naira during the period. The depreciation of the Naira and its inflation fueling impact on food products was a major constraint to food security during the period.

Post SAP Period under the Democratic Administration: 1999 - 2004

The transition to democratic governance was a great relief and a new lease of life for a country where agricultural development was largely threatened by insecurity. The government also paid greater attention to agricultural development and as shown in Table 1, the trend of increasing agricultural output was sustained. The index of agricultural production (Table 3) also reflected the increasing output of all agricultural commodities. However, the annual growth rate (Table 2) was lower than that achieved during the SAP years as it averaged 3.5 % during the period. Contribution to total GDP also fell to an average of 36% (Table 4). Inflation was however brought down during the period (Table 4) to an average of 12.4% although food balance during the period (Table 6) remained negative. Consequently, the volume as well as the value of food imports increased substantially (Table 5). The reduced growth rate in agriculture, which

was barely ahead of the annual population growth rate of 3.0% and far below the annual rate of urbanization of 5.5%, was the harbinger of the current food shortage confronting Nigeria.

Constraints to food production / security in Nigeria

The problems militating against the performance of the agricultural sector are well known and have been discussed in the literature by several authors (Akande, 1998; Oluwasola, 1999; UNS, 2001; Okuneye, 2004.). These are summarized below and include:

i. A major problem of Nigerian agriculture is the poor visioning of the sector by Nigerian leaders. When the global economic situations are favourable and the petroleum sector is buoyant, the agricultural sector is neglected or at best ignored only for the sector to become the doyen of the economy in times of economic downturn. As noted by UNS (2001), while the oil boom of the 1970s created relative disincentive for agriculture, the oil slumps of the 1980s rekindled interest in the sector.

ii. Poor infrastructural support of facilities such as roads, electricity, irrigation facilities, education and health centres for rural farming communities.

iii. Lack of investible funds to increase farm productivity and conserve the natural resource base to ensure sustainability of resource use.

iv. Technical problems related to the non-availability and/or inadequacy of appropriate modern inputs and technology that can enhance productivity. Related to this is the shortage of experienced professionals to build capacity of small holder farmers in tractorization, mechanization and input utilization.

v. Socio-cultural and institutional problems relating to the tenural system and the desire for commercialization.

vi. High price of inputs like fertilizer, herbicide, labour, etc. that have risen beyond the financial capacity of most farmers thus making them to depend more on nature.

vii. Insensitivity to gender issues in agriculture especially in terms of access to extension, and resources of credit, land, etc.

viii. Emerging environmental problems of pollution, erosion, degradation, desertification, drought, pest infestation and climate change adversely affect food crop production. Incidentally, the small holder farmers lack the managerial capacity and the financial resources to sustainably manage these problems to ensure increased food production.

ix. Poor linkage between the farm production sub-sector and the urban industrial sector results in poor value addition to food crops and wastage during peak harvesting periods.

x. Poor coordination of the myriad of programmes developed to enhance agricultural productivity.

xi. Inconsistent and in some cases conflicting policy signals in the agricultural sector. Top-down policy formulation and management of agricultural programmes culminated in the failure of

government to appreciate the economic, managerial and technological capacity of small holder farmers to participate effectively in the current drive for market driven economic system.

xii. Post harvest losses arising from inadequate storage facilities, absence of farm gate industries to process the farm products and the lack of coordinated market to ensure appropriate pricing, timely marketing, and guarantee steady income to rural farmers. It is estimated that nearly 25 % (Okuneye, 2004) of crops are lost before reaching the consumers' table.

xiii. Poor extension systems. This arises from lack of equipment and loss of morale by the few extension staff. In fact, while the extension staff could service the cash (export) crop subsector, the large number of food crop farmers and their wide distribution over the Nigerian landscape make it impossible for the extension agents to be effective.

Policies and Strategies put in place to tackle the Problem of Food Insecurity and achieve Sustainable Agricultural Development in Nigeria

The distortion in the agricultural sector is enormous and must be eliminated to achieve accelerated development, and ensure food security in Nigeria. There is therefore the need for good and well articulated agricultural policy and necessary institutional framework for its implementation. The government policy and strategies will now be discussed in line with the periods previously outlined.

The Pre-1970 Period.

The policy thrust of government during this period was that of minimum intervention. Agricultural development depended on the efforts of private investors and the myriads of small scale farmers scattered over the Nigerian landscape. Efforts of government were limited to support in terms of research, extension, export crop marketing and pricing. In the Western region, for instance, government intervention was through the establishment of farm settlements but operated privately by the settlers, so, the private sector was the fulcrum of agricultural development and food production. Though the outbreak of the civil war in 1966 adversely affected the output of export crops, the small holder farmers were able to feed the nation with minimal importation of food products.

The Pre-Structural Adjustment Programme Period 1970 - 1985

The outcome of the civil war and the resultant dislocation affected the agricultural sector adversely. Incidentally, the period also marked the advent of increasing petroleum wealth in the country. Government that had limited its participation to providing necessary support began to think in terms of getting involved maximally in direct production to bridge the increasing food gap resulting largely from rural-urban migration. A plethora of polices, programmes, projects and institutions to manage the process were consequently put in place. These spanned direct agricultural interventions and indirect ones.

The agricultural sector specific policies, as noted by Manyong *et al*. (2005), focused on facilitating marketing, reducing agricultural production cost and enhancing agricultural product prices as incentives for

increased agricultural production and employment. Major policy instruments to achieve these objectives included those targeted to:

- agricultural commodity marketing and pricing through six national (instead of the erstwhile regional marketing boards) boards for cocoa, cotton, ground nut, palm produce, rubber and grains.
- input supply and distribution through the creation of the National Seed Service in 1972; creation of agro-service centers throughout the country and centralization of fertilizer procurement through the Federal Government in 1975.
- input price subsidy ranging from 75% on fertilizer between 1976 and 1979; minimum of 50% on improved seeds and agrochemicals.
- land resource use through the Land Use Decree in 1978 to free land for would be land users.
- agricultural mechanization through operation of tractor hiring services, reduced import duties on tractors and the promotion of tractor ownership through farmers' cooperatives in 1980.
- establishment of River Basin Development Authorities (RBDAs) in 1977 for agricultural water resource management and irrigation development. Between 1979 and 1983, the RBDAs were used by government for direct large scale mechanized farming.
- agricultural extension through the abolition of region-based extension system to project specific extension agents.
- technology transfer to shift emphasis in agricultural production to food crops through the promotion of the adoption of new technology. To achieve this, the National Accelerated Food Production Programme (NAFPP) was launched in 1972 while the Agricultural Development Programmes (ADPs) were introduced in 1975.
- agricultural research through the establishment of the Agricultural Research Council (1971); the National Seed Supply Institute (1972); take over of all State Research Institutions (1973); reconstitution of the Nigerian Agricultural Research Council network into 14 Institutes (1975); the National Science and Technology Development Agency (1977); National Centre for Agricultural Mechanization [NCAM] (1977).
- the establishment of the Nigerian Agricultural and Cooperative Bank (NACB) in 1973 to provide financial support for farmers and farmers cooperative groups.

Non-agricultural strategies and policies, put in place, with indirect effect on the agricultural sector included the establishment of Agricultural Credit Guarantee Scheme (ACGS) (1977); and the Rural Banking Scheme (1977). Other strategies were the tax incentives to favour the sector; increased minimum wage policy to stimulate agricultural demand and trade policy to enhance agricultural commodity exports through abolition of export duties on scheduled crops (1973); and, the abolition/reduction in import duty regime to facilitate the importation of critical farm inputs and machinery. The Agricultural Development Programme (ADP) had been put in place to improve the productivity and hence income earning potentials of farmers in the rural areas. During the Third National Development Plan (1975 to 1980), conscious effort

was made to shift emphasis in agricultural production from tree to food crops with Operation Feed the Nation (OFN). These campaigns were of course necessitated by sudden food shortages and reduced foreign exchange earnings to sustain continued food importation.

The Structural Adjustment Period: 1986 – 1993

The government's direct involvement in the production and management of agriculture (as in other sectors) resulted in a colossal failure. This coupled with the problem of unsustainable debt burden, dwindling fortune in the petroleum export market and unhealthy investment climate engendered by massive corruption and an over-valued national currency forced a paradigm shift from state-led approach to achieving national development in all sectors of the economy including agriculture. This culminated in the adoption of the Structural Adjustment Programme (SAP) in 1986. In the main, (see Manyong *et al.*, 2005) the SAP aimed at restructuring the economy through

i. demand management policies using fiscal and monetary policies;
ii. expenditure-switching policies aimed at altering domestic prices in favour tradable commodities and improving the price competitiveness of export commodities and import competing goods. The most important policy instrument used to achieve this was the devaluation of the national currency;
iii. market liberalization policies that were designed to entrench market determined forces free from the encumbrances of government and institutional interventions and control; and
iv. institutional policies aimed at eliminating structural constraints that had the capacity to hinder other adjustment policies.

A new conception that viewed the agricultural sector primarily as a business that should be led by the private sector and which should form the cornerstone of the economic diversification initiative emerged. Consequently specific and indirect impacting policies were enacted. In 1988, the Federal Government launched the National Agricultural Policy which articulated policies and strategies to provide incentives for agricultural and rural development. The document was to be in operation till year 2000. The focus of the agricultural policy related to the small scale farmers, who assumed a predominant role in the country's agricultural recovery and rural development process. The strategy was to increase agricultural production and productivity by improving on the agricultural support systems serving the small scale farmers through improved input supplies; improved extension services; appropriate storage and processing facilities; access to improved technology; and the promotion of off-farm income and employment opportunities mainly through increased private investment in rural agro-processing; provision of credit facilities, infrastructural supplies and other incentives to investors in agriculture.

Major fallouts of the SAP programme provided resounding impact on the agricultural sector. These included the withdrawal of subsidy from most inputs and increase in energy prices that has been sustained ever since. The RBDAs were reorganized in 1986 and their functions restricted to land

development and water resources management and development, including the provision of irrigation facilities. In 1992, the RBDAs were partially commercialized. Agriculture related research institutes were also restructured and relocated round the country. Government also established the Directorate of Food, Roads and Rural Infrastructure (DFRRI) in 1986; and the National Agricultural Land Development Authority in 1991 to implement land development policy. In addition to these policy measures, monetary and fiscal policies that culminated in the devaluation of the national currency were implemented. Trade policies were directed towards liberalization of the import and export markets. To promote local enterprises, items like rice, maize, wheat, barley and vegetable oil were banned while high tariffs were imposed on imported goods that had local substitutes. Exporters were encouraged to keep their foreign exchange earnings in domiciliary accounts to further give impetus to private sector investment in the sector. On the institutional side, National Directorate of Employment (NDE) and the National Agricultural Insurance Company were established in 1986 and 1987 respectively.

The New Nigerian Agricultural Policy; 2001 till date

The new policy came into effect in 2001 and its main objectives which were similar to the previous ones include:

i. the achievement of self-sufficiency in basic food supply and the attainment of food security;
ii. increased production of agricultural raw materials for industries;
iii. increased production and processing of export crops, using improved production and processing technologies;
iv. generating gainful employment;
v. rational utilization of agricultural resources, improved protection of agricultural land resources from drought, desert encroachment, soil erosion and flood, and the general preservation of the environment for the sustainability of agricultural production;
vi. promotion of the increased application of modern technology to agricultural production; and
vii. improvement in the quality of life of rural dwellers.

The key features of the new policy involves policies that will facilitate the introduction and use of improved inputs, adoption of improved technology, efficient utilization of resources and the encouragement of crop specialization along ecological lines. It also entails minimizing agricultural risks through insurance, a nation-wide unified and all-inclusive extension system under the ADP, and the provision of social and physical infrastructures to enhance life and productivity in the rural areas. According to the policy document, the direction to follow will involve:

- creating an enabling macro-economic environment that will stimulate greater private sector investment in the sector;

- rationalizing the roles of the three tiers of government and the private sector in their promotion and supportive efforts to stimulate agricultural growth;
- reorganizing the institutional framework for government intervention in the sector;
- articulating and implementing an integrated rural development programmes to raise the quality of life of rural dwellers;
- increasing budgetary allocation and other fiscal incentives to agriculture and promoting the necessary developmental, supportive and service oriented activities to enhance agricultural productivity, production and market opportunities; and
- rectifying import tariff anomalies in respect of agricultural products and promoting the increased use of agricultural machinery and input through favourable tariff policy.

Seven years after the adoption and implementation of the new agricultural policy document, Nigeria has failed to attain the goals enunciated and today is faced with high food prices and food insecurity problems. What are the causative factors for this?

Why the Policies did not Work

A number of factors ranging from policy, technical, management, environment, socio-cultural and economic have been implicated in the failure of agricultural policies to achieve their set goals overtime and provide the necessary impetus necessary to foster a catalytic national development and ensure national food security. These are well documented in the literature (Manyong *et al.*, 2005; UNS, 2001) and are summarized below.

i. The major factor in policy failure is the problem of policy inconsistency. On one hand the policies implied enhancing food production while on the other hand cheap imported food flooded the Nigerian market. This was not just a disincentive to local food production but a death knell to the fledging agricultural sector. Local production that would have filled the food gap over time was sacrificed for political expediency. The importation of such food items like rice, wheat, and vegetable oil simply succeeded in killing local initiatives.

ii. Closely linked to the above problem is the fact that the SAP was not critically thought through before adopting all the elements. In a country where most, if not all the inputs required to increase food output are imported, withdrawing subsidies in a massively devalued currency economic environment simply placed the price of these inputs beyond the reach of the average farmer. The locational advantage provided by the erstwhile Agricultural Input Supply Units / Farm Service Centres located near the rural farmers was lost with its closure. The fact remains that highly developed nations like USA, Britain and France, who actively supported the withdrawal of subsidies in the Nigerian agricultural sector provides the highest policy support for their local farmers in the world. The clear issue that Nigerian leaders failed to realize is that food goes beyond an economic or social issue, it is a major determinant of national security.

iii. Poor implementation of the policies was another problem that bedeviled the policies. The civil service system, even as now, is not properly positioned to implement these polices. The main

factor here is the size of the Nigerian landmass and the over-centralization (thanks to military adventurism in politics) of the polity. The size of the country coupled with an inefficient civil service led to the poor implementation of the policy documents. This is manifested in the poor planning and coordination of programmes and projects and the mismanagement of critical resources earmarked for the sector.

iv. With the exception of the DFRRI programme that integrated rural and agricultural development, all other programmes and policies were narrowly conceived as they dichotomized the agricultural and rural development efforts. The truth is that agriculture takes place largely in the rural areas and ignoring the physical, social and economic infrastructural needs of the rural areas rob agriculture of the necessary space for local, internal as well as external investment beyond public patronage.

v. Top-down approach in programme management, and lack of active involvement of small holder farmers in decision making. Thus, the people (farmers, processors, marketers, etc) critical to the success of the policies were sidelined and their views not sought. Incidentally, the world has moved from this approach into a more participatory development planning system.

vi. The inability of local research, science and technology to respond to provide affordable and environmentally friendly technology needed to achieve production breakthrough was another major problem. Till date, the capacity is still very low. This makes farming to be dependent on nature and to be drudgery as farm work is done manually.

vii. Poor land tenure system, limited access of poor farmers to land and the failure of planning authorities to provide land maps showing their fertilizer needs, productive capacity and agronomic characteristics.

viii. Inadequate and timely access to critical farm inputs like improved seedlings, fertilizer and agrochemicals; high cost of farm inputs; high level of poverty of farmers and rural dwellers; and inaccessibility to credit and working capital. In this regard, women are largely discriminated against in accessing inputs and credit.

ix. Environmental degradation in several regions of the country through desertification, soil erosion, leaching and degradation. In many urban regions, rich agricultural lands and fishing grounds are lost to pollution and urbanization process, and,

x. High post harvest loss is also critical. On the whole, substantial increases have been recorded in food output although shortages exist in Nigeria's food demand vis-à-vis supply. Yet, the absence of infrastructures and roads adversely affect the production system as substantial part of the output are lost through wastage before they get into the food distribution system.

Suggested Approaches to Solving Food Insecurity in Nigeria

The foregoing discussions clearly show that urgent steps must be taken to positively affect the food security plan of the nation. Two factors make this imperative. First the increasing rate of population

growth which currently stands at 3.0 % per annum is a major reason to worry. Second, the high rate of urbanization which also stands at 5.5 % per annum is also a cause for concern. Fortunately, over time especially since the introduction of SAP, there has been a sustained increase in food production even though it has fallen short of the total national food requirement. Two broad strategies are clearly called for to mitigate the problem. The first strategy involves implementing policies that will increase food output per unit of resources and per capita while the second strategy will involve implementing strategies that will not only consolidate the present gains but utilize the current food output to minimize wastage. The following suggestions are presented here to facilitate these assertions.

i. Conscious plans that will transform the small holder farming structure from its near subsistence level to medium and even large scale farms that are fully mechanized is very imperative now than ever before. The current national average farm size of 2 ha, where hoe, cutlass and fire (Oluwasola, 1999) with minimal input hold sway, is not going to provide food for the increasing national and urban population. Efforts should thus be made to access farmers with appropriate technology that is environmentally friendly and economically affordable.

ii. The land resource component of agriculture needs to be thoroughly reevaluated and appropriate reforms implemented. First, the current concept of land as a social and/or public good is not conducive to commercial agriculture. Land resources must transform into economic goods that is tradable. This will enhance its use as collateral for credit transactions with financial institutions. In addition, all lands should be mapped indicating their capability and fertilizer needs in terms of type and quantity.

iii. To achieve an enhanced production of food products as suggested, there is the need to revisit the policy of subsidy withdrawal on critical farm inputs. This is because the necessary transformation of small farm holdings to large scale commercial enterprises requires infusion of capital. As pointed out by Oluwasola (2008), resources to obtain the required capital can either be obtained from within the agricultural sector in the form of savings or from without it in the form of credit. With low productivity and low earning potentials, farmers have very little to save. In addition, with low personal savings, the only other alternative to increasing farm capitalization is to use credit. Unfortunately, the operations of the credit market have not been favourable to the small scale farmers who do not possess the necessary collateral that formal banks require to guarantee loans (Zeller *et al*., 1997). Suffice it to say that in developed nations where the farmers have the wherewithal to purchase farm inputs and even at reduced costs, the governments still heavily subsidize the agricultural sector. The reason is not far fetched. The developed nations see food security as a major component of national security. This concept of food is missing and need to be factored into the pricing policy of farm input.

iv. Nigeria spans several ecological zones ranging from the equatorial rain forest in the southern part of the country to the Sahel (semi desert) region in the far north. Food production therefore varies with the different ecological zones and food types are therefore restricted to certain zones. The immediate impact of this restriction is exacerbated by lack of storage facilities and technology. Thus, food crops are sold at, or even below, the production cost during the harvest season with the middlemen exploiting the situation. These problems are further compounded by the substantial level of post harvest loss.

The way out of this morass, to increase food crop production and to stimulate rural employment, is the establishment of farm gate industries to add value to the food crops and achieve an enhanced income to farmers. We suggest a model to bring together all tiers of government in Nigeria, multilateral agencies, the processors and the farmers to establish sustainable farm gate industries. The Federal Government of Nigeria, through her Poverty Alleviation Programme, in cooperation with the multilateral agencies should supply the necessary infrastructural facilities, especially road, electricity and credit, as well as facilitate the establishment of the farm gate industries. The State Government should provide the land and the extension services required while the local government(s) should provide subsidy for the input. The traditional institution should coordinate the farmers into a loose cooperative for ease of land preparation, and essential input procurement. The farmers should be given part ownership of the farm gate industries to ensure a continuous flow of raw materials to the industry and increased productivity.

v. A constraint to food security in Nigeria already identified, is the use of food crops in industrial processes. Starch and biofuel, produced from rice, sorghum, corn and cassava, are typical examples. Biofuel production in Nigeria is at the developmental stage while the quality and quantity of starch produced in Nigeria and those imported cannot be ascertained. The proposal here is to pronounce certain food crops as national crops with a commensurate level of research and development activities. This is where biotechnology as a tool for food security comes into play. The case of cassava is a good example. Nigeria is the leading producer of cassava with about 35 million tonnes per annum in 2004 resulting from improved high yielding cassava cultivars. Cassava has two drawbacks. First, cassava normally contains two cyanogenic glucosides – linamarin and lotaustralin, which on hydrolysis yield cyanide. The second drawback is the low protein content (< 2 %) of the cassava root. It is proposed here that three transgenic varieties of cassava should be produced using the IITA developed cassava capable of yielding up to 70 tonnes per hectare as the stock. The first transgenic cassava, which is targeted for food purposes should therefore be acyanogenic and with increased protein content in the root. The second should be targeted to the industrial sector with high amylopectin content. The third should have high amylose content for biofuel production since its production and utilization is inevitable.

vi. Food production within the context of the current shortage must become innovative. Food production can be increased through the production and application organic fertilizer from organic waste products. The per capita production of waste in low income countries such as Nigeria has been estimated to

be between 0.4 to 0.6 kg/person/ day (Cointreau, 1982). The waste generated in 14 cities of Nigeria (MEnvH, 2001) was estimated to range between 0.22 – 0.65 kg/person/day with about 50 % of this being organic and therefore compostable. This would translate to between 31 - 91 million tonnes of waste every day. If 20% of the organic waste is converted to compost then 3 – 9 million tonnes of compost is expected to be produced in Nigeria every day. Thus, it is possible to turn waste to wealth, save foreign exchange expended on the importation of inorganic fertilizer and in addition, produce organic foods, which will attract better market price to the benefit of the farmers. It is pertinent to point out at this juncture that some state governments, particularly those of Lagos, Oyo, Ondo and Niger (in collaboration with the UNDP) have gone into this project but the organic waste being utilized in the waste to wealth programme is infinitesimally small compared to the waste produced and the need of the country for organic fertilizers.

Also, one of the principal diary products is "warankasi" – soft cheese locally manufactured from cow milk and a plant enzyme from *Calotropis procera* (Ogundiwin and Oke, 1997). During the processing, whey, which contains a lot of protein and lactose, is produced as a waste product. Collecting the whey for use at the farm gate in the production of single cell organisms and protein analogs for use in animal husbandry is crucial to increasing the availability of protein for Nigerians as well as increased earnings to the farmers. Furthermore, the production of smart foods is now the trend in developed countries. For instance, acha (*Digitaria exilis)*, is a grain produced locally around Jos plateau and a few other locations in Nigeria. This grain contains a high level of the sulfur amino acids - methionine and cysteine - these are the amino acids in short supply in legumes (de Lumen *et al.,* 1986, de Lumen and Kho, 1987). The introduction of the acha methionine rich protein (MRP) gene, into legumes or other grains, could produce new crops with balanced amino acid content with better nutritive value for all. Finally, it has recently been demonstrated that docosahexaenoic acid (DHA) is an essential fatty acid for growth and development, brain integrity and good health even in old age (Kelley *et al*, 2007; Marszalek, 2005; Pyle *et al*, 2008; Theobald *et al*, 2007; and, Theodoratou, 2007). Unfortunately, man does not produce enough of this fatty acid and has to depend on outside sources such as fish oil. DHA is produced by microalgae and becomes increasingly concentrated in organisms as it moves up the food chain. This seed (*C. millenii*) is not edible and the many tons produced annually are usually wasted. These seeds could be fed to cattle which would then accumulate the fatty acid in their milk. The milk could then be subsequently fed to small children and adult.

vii. Nigeria has over 70 universities, many polytechnics and several research institutes yet, there have been very few breakthroughs to increase food production and curtail post-harvest loss and improve storage technology. The few research output have not been translated into national food security. No nation can ever boast of food security without massive input from her research and tertiary institutions. This will however, mean a commitment to massive funding of research in targeted agricultural areas.

viii. Policies that will consciously link the rural areas with the urban markets should be pursued. Currently, most rural areas are linked with extra regional economies as a result of export crop promotion yet, the urban centres in Nigeria could provide the required capital, technology and market which the rural areas badly need (Oluwasola, 2008). Achieving this will involve a conscious development of agriculture and rural development in an integrated whole. Consequently, policies that enhance agricultural productivity must be complemented by policies that enhance living conditions in the rural areas and facilitate access to the urban markets. Social overheads like roads, electricity, potable water, schools, health facilities, recreation, modern markets, storage facilities and security must be provided the rural areas.

Conclusion

The trend of high global food prices have impacted negatively on Nigeria where domestic food production is not enough to meet the national food demand. The high cost of imported goods coupled with high inflation resulting from the devaluation of the national currency has clearly shown that both economic and physical access of Nigerians to adequate food has been severely constrained. In a plain language, Nigeria is food insecure. Although food production has been on the increase since 1986, the rate of population growth as well as urbanization has made Nigeria a food deficit nation. The situation is compounded by substantial post harvest loss of food products and the dependence on the forces of nature by the small holder farmers.

In a bid to tackle the problems confronting the food production sector, Nigeria has passed through several policy phases with mixed results. The bottom line however is that some elements of the policy were not thoroughly thought through as food security was conceived mainly in terms of its socio-economic impact without linking it to the broader but critical issue of national security. The paper therefore suggests measures to enhance agricultural production as well as sustain present gains to make the nation food secure. Such measures include the transformation of small holdings into large scale commercial enterprises, provision of rural infrastructural support, and establishment of small scale farm gate processing enterprises and restoration of subsidy on farm inputs.

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Table 1: Output of Major Food Crops ('000 Tonnes)

Year	Cassava	Millet	Sorghum	Rice	Wheat	Beans	Maize	Potato	Yams	Coco-yam	Plan-tain	Vege-tables	Total
1970	5.224	3,106	4,053	280	19	884	1,443	24	12,033	1,381	985	1,098	30,548
1971	4,516	2,834	3,794	279	20	801	1,274	26	9,766	880	1,008	1,136	26,352
1972	2,573	2,391	2,298	447	20	408	639	27	6,900	1,357	994	1,175	19,243
1973	2,912	3,794	3,125	487	15	530	808	27	6,936	1,106	996	1,211	21,961
1974	3,582	5,554	4,738	525	18	1,097	528	27	7,160	480	1,018	1,259	26,003
1975	2,324	2,550	2,920	504	18	858	1,332	28	8,620	504	1,016	1,303	21,993
1976	1,786	2,893	2,950	218	18	727	1,068	30	6,470	532	1,022	1,134	18,862
1977	1,656	2,579	3,286	410	20	408	650	32	6,376	346	1,026	1,025	17,828
1978	1,620	2,386	2,409	280	20	498	658	34	5,866	182	1,032	976	15,977
1979	1,446	2,366	2,604	160	22	624	488	38	5,256	132	1,038	931	15,121
1980	942	2,354	3,346	105	24	510	612	40	5,248	208	1,042	972	15,421
1981	620	2,682	3,364	158	26	560	720	38	5,212	270	1,048	986	15,704
1982	592	2,666	3,740	212	26	616	766	40	5,385	280	1,054	1,048	16,445
1983	513	2,783	3,292	145	26	583	594	38	4,047	224	1,068	909	14,240
1984	11,800	3,349	4,608	157	27	477	2,058	42	4,600	205	1,086	1,120	29,552
1985	13,500	3,684	4,911	196	113	611	1,190	43	4,738	223	1,113	1,254	31,601
1986	12,388	4,111	5,455	283	132	732	1,336	46	5,209	373	1,127	1,293	32,512
1987	13,876	3,905	5,455	808	139	688	4,612	45	4,886	354	1,071	1,241	37,106
1988	15,540	5,136	5,182	2,081	565	887	5,268	44	9,132	693	1,103	1,354	47,015
1989	17,404	4,770	7,265	3,303	554	1,232	5,008	50	9,609	649	1,413	1,480	52,772
1990	19,043	5,136	4,185	2,500	554	1,354	5,768	54	13,624	731	1,215	1,761	55,964
1991	26,004	4,109	5,367	3,226	455	1,352	5,810	66	16,956	829	1,339	2,025	67,581
1992	29,148	4,501	5,909	3,260	515	1,411	5,840	73	19,781	940	1,417	2,243	75,085
1993	30,128	4,602	6,051	3,065	33	1,576	6,290	80	21,633	1,066	1,623	2,494	78,691
1994	31,005	4,757	6,197	2,427	35	1,545	6,902	90	23,153	1,128	1,665	2,843	81,802
1995	31,404	5,563	6,997	3,203	44	1,751	6,931	95	22,818	1,182	1,632	2,608	84,286
1996	32,950	5,803	7,514	3,122	47	1,847	6,217	99	23,928	1,295	1,688	3,506	88,080
1997	33,510	5,997	7,954	3,230	49	1,957	6,285	101	24,713	1,380	1,753	3,816	90,817
1998	34,092	6,328	8,401	3,486	51	2,054	6,435	105	25,102	1,450	1,809	4,018	93,401
1999	35,980	6,423	8,504	3,522	53	2,100	6,515	109	26,007	1,491	1,841	4,151	96,769
2000	36,750	9,743	8,824	3,841	55	2,261	6,491	118	26,421	1,592	1,995	4,480	102,646
2001	37,949	7,088	9,508	3,989	57	2,409	6,592	128	27,589	1,702	2,163	4,788	104,043
2002	39,410	7,231	9,687	4,085	59	2,612	6,698	138	28,979	1,912	2,378	4,992	108,269
2003	41,815	7,741	10,322	4,365	61	2,712	7,185	142	30,573	1,954	2,453	5,286	114,702
2004	44,693	8,212	10,896	4,605	66	2,794	7,909	146	32,550	1,996	2,503	5,473	121,937

Source: CBN Statistical Bulletin, 2005

Table 2: Average Growth Rate of the Agricultural Sector (%)

Period	Crop	Staples	Other Crops	Livestock	Fisheries	Forestry	Aggregate
1970 – 1985	- 1.6	- 2.4	2.0	2.4	- 2.0	1.6	- 0.9
1986 – 1993	11.3	12.8	4.5	7.1	3.4	2.6	8.6
1994 – 1998	3.0	3.7	4.6	2.3	3.6	1.5	3.1
1999 – 2004	3.4	3.6	3.0	3.0	2.7	1.5	3.5

Source: CBN Annual Reports and Statements of Accounts (Various Issues)
CBN, Statistical Bulletin, 2005.

Table 3: Index of Agricultural Production by Activity (1984 – 2004) (1984 = 100)

Year	Crops	Staples	Other Crops	Livestock	Fishery	Forestry	Aggregate
1970	144.5	171.6	82.5	75.1	101.6	81.5	126.0
1971	126.8	146.7	81.2	76.1	111.7	83.6	114.2
1972	98.0	101.1	76.9	74.6	119.3	85.8	94.0
1973	109.1	122.3	79.0	73.6	126.7	88.6	102.2
1974	132.1	144.5	103.1	73.6	128.9	90.4	118.7
1975	111.7	122.4	87.0	74.7	127.0	94.1	104.3
1976	100.6	105.0	90.6	77.1	134.9	96.8	97.6
1977	98.3	98.3	96.0	79.3	137.3	99.6	96.7
1978	92.8	88.0	101.6	81.7	141.4	102.4	93.5
1979	89.9	84.2	102.9	84.7	145.8	105.1	92.4
1980	92.0	85.9	106.2	75.1	153.4	106.5	92.5
1981	93.6	87.4	107.7	88.4	132.7	106.5	95.2
1982	95.7	91.4	105.5	96.1	136.8	105.7	98.3
1983	90.5	89.0	93.6	91.9	146.9	99.0	93.9
1984	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1985	103.5	103.3	103.8	104.3	62.3	102.9	104.6
1986	111.2	110.0	115.7	108.1	69.5	106.1	108.3
1987	123.4	125.6	115.1	103.9	66.8	106.3	116.1
1988	151.7	159.1	123.7	110.4	85.7	109.1	138.5
1989	169.6	178.6	137.1	117.8	89.2	112.7	153.0
1990	180.0	189.4	144.9	157.1	77.4	117.1	167.5
1991	212.5	228.7	151.6	160.7	84.3	119.5	191.7
1992	233.3	264.4	154.6	159.3	84.3	122.2	206.4
1993	241.1	266.3	146.1	161.6	62.9	124.7	211.4
1994	249.4	276.8	146.0	164.1	67.0	128.0	209.7
1995	255.5	285.2	149.8	171.0	77.6	128.0	216.8
1996	270.0	298.1	158.0	176.0	89.4	131.4	224.8
1997	277.7	307.3	171.5	180.4	99.5	132.7	234.1
1998	288.0	316.1	182.4	181.3	105.7	133.5	242.4
1999	294.5	322.4	189.6	190.4	108.8	136.3	249.1
2000	308.0	337.3	194.2	190.7	112.9	138.4	258.2
2001	318.8	349.0	200.8	195.8	117.4	140.9	267.7
2002	329.2	363.6	205.3	204.0	124.8	142.0	278.5
2003	349.3	385.1	219.7	212.6	129.9	144.1	294.1
2004	372.3	409.3	238.8	222.8	135.8	147.0	312.3

Source: CBN Statistical Bulletin,2005

Table 4: Contribution of Agriculture to GDP at 1984 Factor Cost and Annual Inflation Rate in Nigeria

Year	Contribution (%)	Inflation Rate (%)
1970	45.2	13.0
1971	41.7	16.0
1972	36.5	3.4
1973	24.9	4.6

1974	27.6	13.5
1975	24.8	33.9
1976	25.2	21.1
1977	24.8	21.5
1978	23.0	13.3
1979	22.5	11.6
1980	29.0	10.0
1981	34.1	21.4
1982	38.9	7.2
1983	36.3	23.2
1984	40.1	40.7
1985	40.2	4.7
1986	39.2	5.4
1987	40.0	10.2
1988	41.5	56.0
1989	39.1	50.5
1990	39.4	7.5
1991	39.1	12.9
1992	38.6	44.5
1993	39.1	57.3
1994	39.3	57.0
1995	39.0	73.1
1996	39.0	29.1
1997	40.4	8.5
1998	40.1	10.0
1999	35.7	6.6
2000	35.8	6.9
2001	35.6	18.9
2002	35.9	12.9
2003	34.6	11.3
2004	39.9	17.6

Source; National Accounts of Nigeria (FOS) and CBN Annual Reports and Statements of Accounts (Various Issues)

Table 5: Food Imports as Proportion of Total National Imports (₦ Million)

Year	Total Imports	Food Imports	Food Component as a % of Total Imports
1970	756.4	57.7	0.1
1971	1,078.9	88.3	8.2
1972	990.1	95.8	9.7
1973	1,224.8	126.3	10.3
1974	1,737.3	154.8	8.9
1975	3,721.5	298.8	8.0
1976	5,148.5	441.7	8.6
1977	7,093.7	780.7	11.0
1978	8,211.7	1,027.6	12.5
1979	7.472.5	1,254.3	16.8
1980	9,095.6	1,437.5	15.8
1981	12,839.6	1,819.6	14.2
1982	10,770.5	1,642.3	15.3
1983	8,903.7	1,761.1	19.8
1984	7,178.3	1,349.7	18.9
1985	7,062.6	1,199.0	16.9
1986	5,983.6	801.9	13.4
1987	17,861.7	1,873.8	10.5
1988	21,445.7	1,891.6	8.8
1989	30,860.2	2,108.9	6.8

1990	45,717.9	3,474.5	7.6
1991	87,020.2	3,045.7	3.5
1992	145,911.4	12,840.2	8.8
1993	166,100.4	13,952.4	8.4
1994	162,788.8	13,837.0	8.5
1995	755,127.7	88,349.9	11.7
1996	562,626.6	75,392.0	13.4
1997	845,716.6	100,728.3	11.9
1998	837,418.9	102,165.1	12.2
1999	862,515.7	103,489.8	12.0
2000	985,022.4	113,630.5	11.5
2001	1,371,409.1	160,209.1	11.7
2002	1,457,091.4	138,993.5	9.5
2003	1,507,422.8	146,122.5	9.7
2004	1,638,353.7	147,380.4	8.9

Source: CBN Annual Reports and Statements of Accounts (Various Issues)
CBN, Statistical Bulletin, 2005.

Table 6: Balance Sheet of Food Production, Demand, and Imports (Million Tonnes) (1994 – 2001)

Year	Food Production	Food Demand	Food Balance	Food Imports
1994	86.70	87.23	(0.53)	0.67
1995	89.25	89.55	(0.30)	0.58
1996	93.35	96.26	(2.91)	2.95
1997	95.64	99.03	(3.43)	3.47
1998	98.74	101.87	(3.13)	3.24
1999	100.41	104.63	(4.22)	4.48
2000	102.12	107.46	(5.34)	5.59
2001	103.86	110.37	(6.51)	6.91

Source: FOS Review of the Nigerian Economy (Various issues)

Gearing quality of tropical fruits and vegetables towards U.S. and E.U. markets

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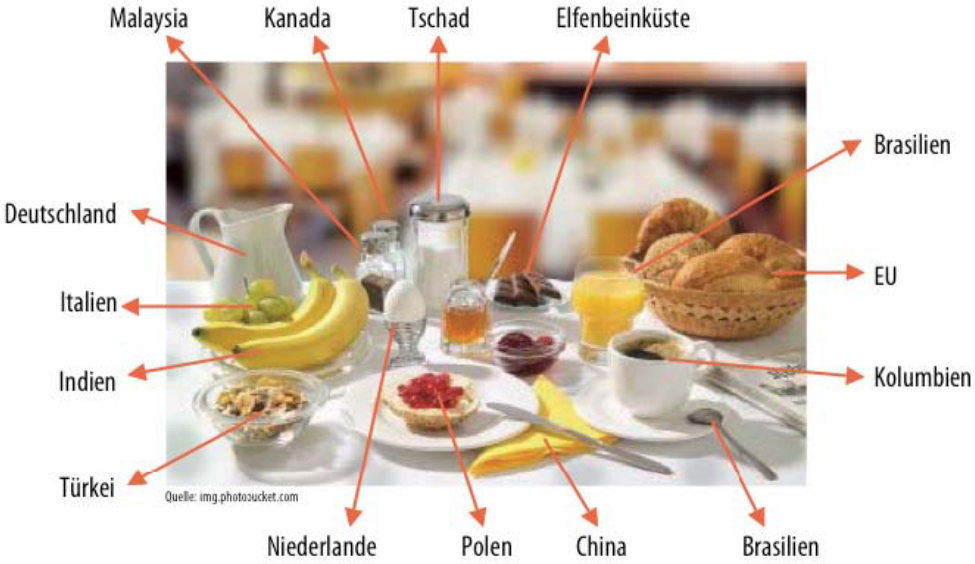
Abstract
Adapting horticultural production schemes in tropical countries to meet changing market requirements and regulations in Europe and the US is a key to success. Conversely, requirements of tropical crops for local markets should not be a copy of export markets. Examples will be given of how to improve production schemes in tropical countries for product quality, be it in terms of pesticide residues, outlook, size or product form. The better management of contradictory requirements between local and export markets should be a point of concern. The energy aspects of horticultural production for quality will be highlighted. New approaches are necessary to combine sustainable quality production with market requirements.

Keywords: Energy balances; export standard; food miles; fruit quality, tropical fruits and vegetables; primary energy requirement; US and EU markets

Introduction

Origin of breakfast

When looking at a typical German breakfast, one is struck by the wide origin of the food (Figure 1). This situation results from a deliberate choice in favour of industrial development, leaving a second role to agriculture during the last 60 years. It also explains, why the worldwide horticultural sector wants to export produces into this high value currency markets.



Import of selected tropical fruits into Germany

Since 1990, the import of tropical fruits into Germany is more or less stable as shown in Table 1. There is a slight increase though for avocado and for mango. If one wants to enter this market with either the same tropical products or with new fruit types, one has to be prepared for a serious competition, where not only price, but also quality and consumer acceptance will play a major role.

Table 1. Import of selected tropical fruits to Germany in tons from 1980 – 1996

Year	Banana	Kiwi fruit	Pineapple	Avocado	Mango	Papaya	Litchi	Passion fruit
1980	653 900		13 000	1 600	368	139		
1986	660 636	30 000	36 342	7 880	3 083	876		
1990	1 171 571	103 857	40 530	8 435	6 356	2 109	493	
1991	1 352 596	108 587	42 207	9 402	8 449	2 421	721	
1992	1 378 356	125 938	45 154	10 017	9 088	2 694	1 126	
1993	1 222 517	107 622	48 013	7 963	8 732	2 344	1 094	
1994	1 175 045	112 938	39 002	9 866	10 375	2 332	1 469	
1995	1 305 968	110 404	44 299	13 343	11 800	2 562	1 685	1 275
1996	1 199 197	112 217	46 278	15 618	12 851	2 539	2 284	1 582

Fig 1: Origin of components at a typical German breakfast

Fig 2. Unripe (left) and ripe (right) red Rambutan fruits

Rambutan production in Mexico for export to Florida

Origin, botanical description and distribution

Rambutan (Fig 2) belongs to the family of the *Sapindaceae*; the fruits are characterized by a fleshy juicy arillus. Several important tropical fruit species belong to this family such as e.g. litchi, longan in Asia, guarana in Latin-America and ackee in Africa along the Guinean coast (Table 2)

Guarana (Fig 3) is known in Brazil for providing for a refreshing drink, whereas Ackee is eaten in Africa and in Jamaica where it was brought by the former slaves and where it became a national symbol. Rambutan is indigenous to the Malay Archipelago and has been widely cultivated throughout the region in Thailand, South Vietnam, Indonesia, the Philippines, India and Sri Lanka. The tropical climate of the above mentioned countries is characterized by high and evenly distributed rainfall, high humidity, low evaporation rates and average minimum temperatures above 20°C. Rambutan thrives well under these conditions and produce good quality fruits. A warm climate is ideal for its growth and high yield. It is suitable for most types of soil, except the waterlogged and peat areas. Rambutan requires a lot of moisture, is not suitable on hilly terrain and it does not perform well on sandy areas. Deep alluvial soils and soils containing high organic matter are ideal for its growth and development. These soils require appropriate drainage. Rambutan prefers a pH around 5.5-6.5. On alkaline soils, micronutrient problems often develop.

Table 2. The most important species of *Sapindaceae* and their ecophysiological requirements

Common name	Rambutan	Pulasan	Longan	Lychee (Litchi)	Guarana	Ackee
Species	*Nephelium lappaceum* L.	*Nephelium mutabile* Blume	*Dimocarpus longan*	*Litchi chinensis* Sonn.	*Paullinia cupana* Kunth ex H.B.K.	*Blighia sapida* Konig
Origin	Philippines/ Malaysia	Philippines	East-India/ Thailand Vietnam	South-China/ Vietnam	Brazil/ Venezuela	West-Africa
Tempe-rature	> 22ºC	Max. 26º to 35º C, Min. > 14º C	Frost tolerant during dormancy	Max. 23º to 32º C, Min. >6º C		>20º C
Annual rainfall	2000 - 3000 mm	1800 - 2500 mm	1200-1800 mm	1500 - 2000 mm	1400 - 4500 mm	>1200 mm
Fruit	Round, 3 to 5 cm, 4 to 8 cm long, green, yellow (shown above) or red, spinterns	Round, 2.5 to 4 cm, 5 to 6 cm long, yellow or red shell	Round, 2.5 to 3 cm, yellow-rot. Smooth shell	Round, 2.5 to 4 cm, yellow-red shell	2.5 to 5 cm long, green-yellow, flatter, orange-colour.	Round, 2.5 to 4 cm, 5 to 6 cm long, red, shell. Toxic fruits

Rambutan has a short history in Latin America. It has been introduced into Mexico during the last century in the fifties or sixties. In the wet tropical province of Mexico, Chiapas, coffee farmers are now producing rambutan, not only for local markets but particularly for the US market in Florida. The commercial cultivation of rambutan in the Soconusco started only very recently. In Africa, it is only known as back yard plant but no large scale commercial plantings are reported so far.

Pomology

Rambutan is a medium-sized tree producing a red or yellow, round to oval fruit with hairs or tubercles on its skin (Figures 1 and 2). The edible flesh or aril is translucent and sweet. Most rambutan trees propagated from seed are not true-to-type and usually sour. Depending on the location, the rambutan tree produces one or two crops a year. In Asia, the rambutan has a small crop in June to July and a heavy crop in November to January. Selected clones produce fruit with thick, firm flesh, which are sweet and acceptable as export standard. Mexico is growing its local varieties.

Mediterranean fruit fly problem

The most important constraint for rambutan export from Chiapas, Mexico was the prohibition of rambutan fruit export caused by the assumption of rambutan plant hosting the Mediterranean fruit fly and fruit flies of the *Anastrepha* species. During 10 years of investigation in the rambutan areas of the Soconusco, in three different rambutan nurseries and under laboratory conditions, the observations demonstrated that it is possible to capture these fruit flies in the rambutan fruit area. However, these fruit flies never attacked the rambutan fruits. This proven observation resulted in the cancellation of export prohibition for rambutan fruits to Japan and the United States since September 2003.

Pre-harvest practices to improve rambutan fruit quality at harvest

Different growing practices like cultivar selection, pruning methods, nutrition and irrigation methods can affect the fruit quality significantly at harvest. Generally, direct links exist among tree nutritional status, fertiliser application and yield. It is essential to work out an appropriate fertilization program so that nutrient applications will lead to a consistently higher production of good fruit quality. Rambutan irrigation requirements during fruit filling can be calculated by using a simple evaporation formula as follows:

Irrigation Requirements = canopy area (m^2) * Evaporation Rate (mm/week) * Crop Factor

Flowering is poor or impaired in orchards, where leaf N exceeded 1.8% and in particular, where leaf N is near or over 2%, despite climatically favourable conditions. Scientists have also questioned the effect of leaf nitrogen level and flowering success in a range of terminal flowering tropical crops in Florida. It has been suggested that low leaf N is required, because trees enter a rest period (dormancy) prior to flower induction. However, further research is required to establish the relationship between pre-flowering leaf N concentrations and flowering.

Among the fertiliser treatments, $N:P_2O_5:K_2O$ ratios of 20:20:10 and 10:10:20 ratios produced maximum fruit size and aril weight.

Maturity indices at harvest
Fifteen weeks after fruit set fruits ripen and their colour changes from green to yellow-green, yellow, yellowish-orange or red. Farmers currently harvest rambutan based on knowledge accumulated over the years by growers and farm advisors, who decide on the appearance of the fruit, or by counting the days from fruit set. Development of a red colour is the main harvest index for red cultivars. These colour changes need to be related to other features such as flavour, taste and physical properties. The weight of the fruit, pericarp or skin, pulp and seeds are considered to determine the maturity. A minimum content of 16% soluble solids may also be used as an indicator. However, cultivars vary in their maximum content of soluble solids from 17 to 21% at full maturity. Studies on the chemical composition of R3 and R165 rambutan varieties at different stages of maturity indicate that total soluble solids, sugars and starch increase and that titratable acidity decreases with maturity. At full colour development of rambutan fruits, total soluble solids (TSS) and sugar percentage are highest, whereas total acidity (TA%) is lowest for both clones (Pohlan *et al*., 2007). Fruit colour plays an important role not only for optimal aril weight, but also for optimal fruit quality. At colour stage 6 flavour, juiciness, taste and appearance are all rated highest (Figure 4).

Harvesting period and methods
In the Soconusco region, in the state of Chiapas, Mexico, three fruiting types have been observed: early, normal and late. The harvest of the early trees begins at the first week of May and finishes by the end of June; the normal trees are harvested from the end of July to the end of August and the late trees from the beginning of August, being finished by the end of October. The adult trees produce 100 to 300 kg of fruits each. In order to harvest the fruits several types of hooks, knifes and secateurs exist, which are tied to long bamboo twigs or aluminium telescope tubes. Normally a bag-formed net should be attached to these instruments to avoid fruits falling to the ground. The entire fruit cluster can be cut from the branch, or single fruits can be picked, as long as a piece of the stem remains attached to avoid damage to the rind. Figure 2 shows the variance components of the various fruit characteristics of rambutan.

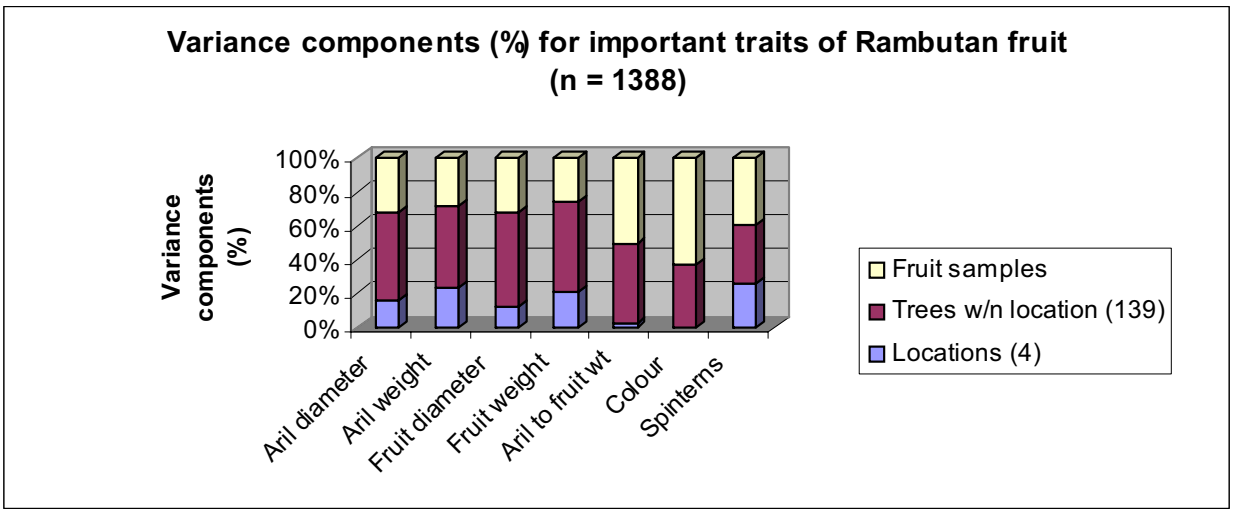


Figure 2. Relative importance of variation between locations, between trees w/n location, and among fruit samples w/n trees, for important fruit traits in the Rambutan

Fruit quality indices
A formally published quality standard for international trade in fresh rambutan does not exist, although export markets have similar preferences. Quality standardization for two commercial varieties of Thai rambutan (Rongrien and Seechompoo) was set up in 1992 by the Chanthaburi Horticultural Research Centre. The draft standard that was developed for these varieties could be categorized into Extra, Class I and Class II. Only the highest-quality fruit should be exported. Adoption of this standard by all countries could result in a fair market system, faith and promotion of sale.

Following are general quality standards obtained from published technical articles and interviews with rambutan producers in the Soconusco:

- export markets require the rambutan to be fresh in appearance, clean, practically free from insects, diseases and blemishes;
- the rind should be bright in colour, uniform and true to type, with fresh spinterns;
- a section of the stem should be attached to all fruit to avoid its deterioration;
- the fruits should weight at least 30 g (less than 33 fruits per kg), with a flesh recovery ratio of more than 45%;
- the aril must be firm, sufficiently developed, with minimum 18% soluble solids It should be thick, without an off-flavour due to over-ripening or fermentation;
- the aril should separate easily from the seed, which should be small. In some rambutan cultivars, the hard testa comes away with the aril, which makes these cultivars less desirable;
- shape, smell and taste must be typical of the nature of the produce.

External quality parameters are:

- **fruit diameter:** the diameter of the fruit (in mm) was taken with slide callipers. In most cases the rambutan fruit is not round in cross-section, but has a 'large' and a 'small' diameter. To obtain more or less the average diameter, the fruit was measured at 45°;
- **fruit length:** the length of the fruit (in mm) was taken with the same slide callipers;
- **fruit weight** (number of fruits per kilogram)
- **rind colour:** the fruits were classified in five groups: yellow (1), yellow-orange (2), orange (3), orange-red (4) and red (5). It was sometimes difficult to decide, in which group a fruit belonged. In many cases the fruit was red at one side (sun-exposed) and yellow at the other. In this case, the 'average' colour was taken, i.e. orange in this example;
- **spintern appearance:** The fruits were classified in 7 groups (0 to 6). Group 0 contains fruits with fresh, firm spinterns without any form of dehydration. Group 6 contains fruits with totally dehydrated, black spinterns;
- **presence of fungi**;
- **presence of insects**;
- **presence of an undeveloped fruit:** the presence or absence of a little, undeveloped fruit nestled at the stem of the mature fruit was considered. These little fruits are concerned as a part of the fruit weight. Namely, at the market, the consumer pays for this extra weight. The presence of such a little fruit is undesirable.

Internal quality parameters are:

- **aril diameter:** the diameter of the aril (this is the fruit without rind) (in mm) was measured with the same slide callipers as the fruit diameter in a position so that more or less the average diameter could be measured;
- **aril length:** the length of the aril (in mm) was measured with the slide callipers;
- **aril weight:** the aril (in g) was weighed with the same balance as the entire fruit;
- **flesh colour:** the colour of the fruit flesh was practically the same for all fruits and therefore not used in this study to determine the fruit quality.
- **flavour:** from almost every tree, two fruits out of ten were tasted by the same person. Their flavour was classified as follows: sweet (1), sweet-sour (2), sour-sweet (3) and sour (4). Some fruits were sweet, but had very little flavour;
- **succulence:** the fruits were classified in: juicy (1), juicy-medium (2), medium (3), medium-dry (4) and dry (5). This is a subjective rating, tested by eating two fruits from each tree. Succulence is also associated with texture (fine, coarse, tough) of the pulp, but is not noted separately;
- **separation of flesh from seed:** This parameter was observed while tasting the fruits. The fruits were classified into 5 groups which express the ease of separation: easy (1), easy-medium (2), medium (3), medium-difficult (4) and difficult (5);

International commercialisation standards

The international commercialisation standards require export fruits to weigh at least 30 g (less than 33 fruits per kg). Six major groups of rambutan fruits could be identified in the Soconusco (Mexico) and sorted according to potential commercial grades (Fig 3). Only two groups (clusters 1 and 6) have a fruit weight above 30 g/fruit, the required commercial standard for export. One cluster (nr 3) presents small fruits (<20 g/fruit), which is far below commercial standards (Table 3).

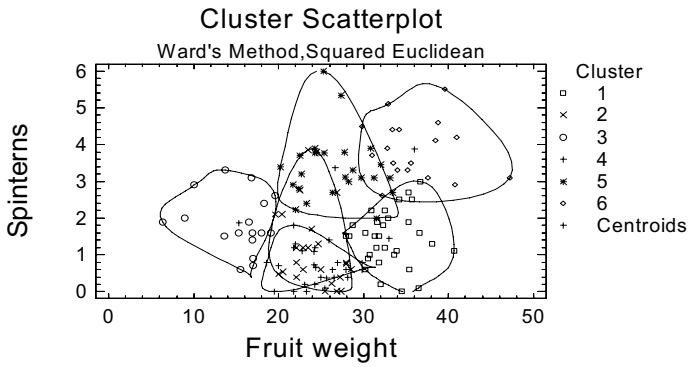


Fig 3: Cluster representation of rambutan quality groups

Table 3: Assortment of cluster group numbers (1-6) according to possible market criteria

Colour (units)	Fruit weight (g)		
	<20 g	20-30 g	>30 g
	Spinterns (units) < 2		
<3	n.a.*	2	1
>3	3	4	
	Spinterns (units) > 2		
<3	n.a.	n.a.	n.a.
>3	n.a.	5	6

* not applicable

Post harvest handling and storage

The rambutan fruit is highly perishable and non-climacteric. The fruits should be cut carefully from the clusters to maintain quality and suitable storage conditions are required. The organization of storage at low temperatures (5 to 10°C) and quick packing in controlled conditions (perforated polyethylene bags) are necessary to avoid transpiration and excessive dehydration and to prevent decolouration and darkening of the spinterns.

In order to improve packing and storage and to know shelf-life in detail, investigations under different temperature and packing conditions have been carried out. The advantages of cages at low temperatures (5 to 10°C) and storage in polyethylene bags are obvious (Figures 7 to 10). Packaging studies were performed in order to compare the capacity of micro-perforated LDPE film, non-perforated LDPE film, advanced films, and clamshell containers for maintaining fruit quality and extending shelf-life. Packages that provide the longest shelf-life have been tested under simulated air shipment and retail conditions.

The national and international commercialization experiences of the orchard San Alberto indicates that the fruits, once cut, are transferred in plastic crates to the packing area, where they are selected by colour, sweetness, pulp loosening from seed, and by size. Fruits that weigh more than 30 grams and meet the other characteristics are sent to the international packing area. The other fruits are destined for the national, regional and local markets. Agrochemicals are not used and the fruits are not washed. The fruits for the international market are packed in cardboard boxes, formed by a bottom and a cover. The box measures 34 cm in length x 30 cm width and 8.6 cm in height, with a net capacity of three kilograms of rambutan fruits per box. The packing is realized as follows: first a strip of white Chinese paper of 30 cm wide and 70 cm long is laid on the bottom of the box in such a way that the ends of the paper strip protrude on both sides of the box. The rambutans, previously inspected visually to avoid transporting deteriorated or damaged fruits, are placed immediately in lines. Once the bottom of the box is full, another strip of paper of 34 x 30 cm is placed covering the fruits and a second level of fruits is arranged in the same way. Once finished with the second level, the fruits are first covered with the free ends of the Chinese paper and then with the cover of the box.

Edge protectors are placed on the boxes which are strapped or bound with iron bands in packages of five to ensure that they arrive undamaged at their final destination. After packing, the packages are transported over land – in trucks with hermetically sealed containers – to the international airport. From there they are sent to

the final destination by plane. Previously, the legally required proceedings are carried out. Until now, approximately 33 tons of rambutan fruits have been exported from the San Alberto orchard.

In the Soconusco many trees are grown in family house-orchards and the great majority of the obtained fruits are sold locally. Moreover, it is very common to sell the production to intermediaries, who transport the fruits in bulk and vend them to retailers, who sell the fruits to the customers in polyethylene bags of half a kilogramme up to five kg. Fruits are not selected, neither by size nor by quality standards. The Rambutan experience in Chiapas demonstrates that if product quality in Chiapas can be mastered there is a good market opportunity in the US to be exploited. It also tells us that by producing a tropical crop that can not be produced in the market area there is a clear competitive advantage. Nigeria might offer a good production area for Rambutan as an export commodity into the EU.

The African pear or African avocado

The African pear, *Dacryodes edulis* H.J. Lam. *(Burseraceae),* possesses outstanding nutritive qualities and it has been extensively investigated at the University of Bonn, Germany by Okorie (2001)

Fig 4: Some fruiting types of African pear *(Dacryodes edulis)*

Dacrodes edulis originated from Central Africa and the Golf of Guinea. It is referred to as a multi-purpose plant; but unfortunately it is not quite known in the scientific world. The distribution sphere of the tree range between the Guinea-Congo and the Sudano-Zambia region (Maponmetsem, 1994). It plays a key role in the area of food and economics, especially in the rural areas. Ndoye (1998) asserts for example that in 1996, Cameroon exported 1772 tons of African pear fruit to neighbouring countries, amounting to about 568.5 million CFAF. The people of the Western humid regions and Central Africa like the fruits; they can be eaten in different forms: smoked, boiled, and roasted. In addition, *D. edulis* can be occasionally used as a medicinal plant against abscesses, dental pains and burns. It can also be used as wood in some agro forestry systems, and also as food for some rodents.

In view of the importance of the African pear to the population of the sub region, and its future potentials, it is necessary to examine the diversity of this species for better exploitation, management, and revitalization. We have three classes small, medium and large fruit types of African pear [*Dacryodes edulis* (G. Don) HJ Lam]. While the total fat content of the fruit pulps were 46.8%, 44.4% and 55.8% for the small, medium and large fruit types respectively while the corresponding values for the seeds were 14.3%, 15.0% and 10.7% respectively. A significant ($p = 0.01$) correlation was obtained between the fatty acid profile of the seeds and those of the fruit pulps. The R^2-values were 78.6%, 80.4% and 76.4% for the small, medium and large fruit types, respectively.

Whereas the fruit pulps contain appreciably higher levels of *palmitic (16:0)* and *oleic (18:1)* acids, the seeds were comparatively higher in *linoleic (18:2)* and *stearic (18:0)* acids. Four fatty acids – *palmitic, oleic, linoleic* & *stearic* acid, make up 98.2% of *D. edulis* fruit pulp total fatty acids (TFA), and 88.2% of the seed ´TFA`. The values of these fatty acids in the fruit pulps ranged from 45.6 –49.6%, 28.6 –32.2%, 13.5 –20.4% & 3.1 –3.7% for *palmitic, oleic, linoleic* and *stearic* acids, respectively. But their corresponding values in the seeds were 26.8 –33.2%, 18.2 –21.4%, 28.9 –29.1% and 8.0 –11.0%, respectively. *D. edulis* contains relatively very high levels of nutritionally important essential fatty acids (EFA) that justifies its role as a strategic food supplement. Its potentials in animal feed formulation or other industrial uses were also indicated. A high degree

of variation exists in the fatty acid profile of this important but neglected tree species to warrant the initiation of a planned selection and improvement programme.

Table 4:Fatty acid composition (%) of *D. edulis* fruit pulps and seeds relative to some crops *(Okorie 2001)*

Plant	*Variety*	*Palmitic (16:0)*	*Stearic (18:0)*	*Oleic (18:1)*	*Linoleic (18:2)*	*Iodine Value*
African pear *(D. edulis)* - Fruit pulps	Large Medium Small	49.6 45.6 47.8	3.1 3.3 3.7	32.2 28.6 29.5	13.5 20.4 17.2	55.0 66.0 60.0
African pear (*D. edulis*) - Seeds	Large Medium Small	33.2 26.8 28.4	8.0 11.0 10.1	18.2 20.9 21.4	28.9 28.9 29.1	80.0 80.0 80.0
African Oil Bean°°	_	3.8 (± 0.03)	2.8 (± 0.30)	29.7 (± 0.15)	45.0 (± 0.27)	_
Soybeans^ *(Glycine max)*	*GE 104* *GE 109*	9.7 11.0	3.1 2.9	27.3 23.4	43.8 55.3	53.7 60.5
Cowpeas^ *(Vigna Unguiculata)*	*Ife Brown* *Prima* *Farv – 13*	30.6 23.1 23.9	5.5 4.7 4.3	7.6 7.3 12.9	28.4 35.6 24.8	43.8 58.2 48.5
Oil palm^^ *(Elaeis guineensis)*	*E. oleifera (syn. Melanococca)* *E. oleifera X E. guineensis*	22.9 33.4	1.0 5.1	54.8 51.8	20.0 10.9	81.5 63.0

African pear offers a tremendous potential were it not that taste barriers outside the Guinean gulf should be overcome. Hence, it would be wiser to concentrate marketing in the same Guinean countries. It implies a totally different production and marketing approach. Nevertheless, there is a huge market to be filled. As the Guinean countries are on both sides of the equator, excess production could be shipped throughout the year. Indeed, it could become the "African avocado"

Displacing subtropical Kiwi production towards Europe

Fig 5: Mature and ripening fruits of Kiwi gold (*Actinidia chinensis* Planch) compared with common Kiwi fruit

Kiwi is the example of a most interesting fruit crop of subtropical origin, the production area of which is now extending more and more into the mild temperate climate zones. The Golden Kiwi is a point in case where a different species in the genus "Actinidia" offers a good alternative for the original Kiwi "*Actinidia deliciosa*". The hardy or Siberian Kiwi, *A. arguta* is now tested in the colder temperate zones of the EU and the US. If offers winter frost tolerance and the added advantage of being eaten with peel which is easy for the consumer and gives the full nutritive benefit of the whole fruit. Hence, the production area of this fruit type is likely to be moved closer to the major market regions.

Table 5: Ascorbic acid content of Kiwi Gold fruit as influenced by storage conditions

	Kiwi Green (*Actinidia deliciosa* (A. Chev.) C.F. Liang & A.R. Ferguson)	Kiwi Gold (*Actinidia chinensis* Planch)
Actinidin*	significant	Negligible
Calories	62 /100 g	55 /100 g
Antioxidant content	1.017 mmol /100 g	1.632 mmol /100 g
Viamin C	71 mg /100g	140 mg /100g
Vitamin B	0.7 mg /100g	
Monosaccharides	9112 mg /100g	
Sucrose	1346 mg /100g	
Essential Amino Acids	315 mg /100g	
Dietary Fiber	3900 mg /100g	

Energy requirements of horticultural crops

Apple growing in New-Zealand vs./ Germany
Off-season exports from temperate fruits from the Southern hemisphere are now competing with longer lasting CA (controlled atmosphere) storage facilities of home grown fruits. The energy balance of a same commodity like e.g. apple is as one would expect very different according to the origin of the production area. The advantage of the home-grown apple is even larger when on-farm sale is practiced. The initial cooling cost can also differ considerably according to the ambient temperature at harvest.

Tropical fruit growing
Due to economies of scale, fruit saps e.g. from Brazil can be produced more cost- and energy-efficiently than in Germany. Export quality of tropical horticultural products improved tremendously over the last fifty years. Fruit transport within Europe by car or train is much more energy-consuming than shipping. Several tropical humid countries are importing fruits without developing strong fruit export activities. They face a dilemma of choosing between cheap imports and investing substantially in the future.

Table6: Effects of latitude and cultivation practice on energy efficiency of selected crops

	Countr	Total input GJ/ha	Total output GJ/ha	Output/ Input	MJ Output/ Labor hour
Banana	Australia NSW	81.2	52.2	0.64	87
Banana	Hawaii	77.8	63.8	0.82	160
Banana	Taiwan, Central	58.5	55.1	0.94	22
Banana	Taiwan, South	69.8	95.8	1.37	31

Once packaging is included in the energy balance the outcome for banana is very poor. Existing data showed that the best outpu/input ratio was found in South Taixan with 1.37. In Mexico this this ratio reaches 1.53 without packaging but only 0.03 with packaging. Indeed, not less than 88 kg of polyethylen bags (at 90 GJ/kg) for wrapping the bunches are required per ha and per year.

Table 6 : Energy balance of fruit crops in Mexico (GJ/ha/y)

Crop (Yearly yield t/ha)	Mango cv. Ataulfo (13.5)	Papaya cv. Maradol (5-13)	Banana cv. Dwarf Cavendish (67.5)
Fuels	25.80	82.40	107.90
Labour force	1.20	15.36	6.00
Agrochemicals	31.83	77.67	70.91
Irrigation		78.90	
Packaging	446.16		8100.00
Total	*504.99*	*254.33*	*8284.81*
Energy from yield	40.63	45.5	282.15

Source: Borgman, J.; Gehrke Velez, M.R.; Pohlan, J. (2000)

If tropical countries want to export tropical crops their road network from the production area to the nearest seaport has to be secured and finally seaport handling facilities ought to be up to international standards. Ships want to unload and reload within 48 hours.

The kola nut: an underestimated tropical crop

Production of tropical nuts can be advantageous within the limits of the African continent. A good example is given by the important market of kola nuts throughout intertropical Africa, but yet totally underestimated. Neither the statistical figures nor the supportive research are up to standards.

Table Harvested area, yield and annual production quantity for all countries

	Area (ha)		**Yield (kg/ha)**		**Production (t)**	
Country	**2000**	**2007**	**2000**	**2007**	**2000**	**2007**
Benin	1800	1900	278	300	500	570
Cameroon	95000	95000	379	379	36000	36000
Côte d'Ivoire	110000	100000	682	680	75020	68000
Ghana	70000	71000	286	289	20000	20500
Nigeria	91000	95000	901	926	82000	88000
Sierra Leone	15000	17000	267	265	4000	4500

Source : FAOSTAT | © FAO Statistics Division 2008 |

Conclusions and recommendations

- Energy requirements of fruit crops is a critical issue
- Internal market opportunities deserve better attention
- Timing of market penetration
- Export vs. Import dilemma should be addressed.
- Tropical countries should exploit their competitive advantages and chose the export crops accordingly.
- After harvesting, Rambutan fruits darken quickly. In order to conserve the colour of the rind and the taste of the pulp, two conditions are required: a) a humid atmosphere and b) the storage of the fruit at low temperature (between 5 and 10°C).

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Kinetic, equilibrium and thermodynamic studies of the biosorption of cadmium(II) and nickel (II) by *Basella alba* L (Malabar spinach)

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Abstract

The ability of a fast growing plant, Malabar spinach (*Basella alba* L.), to remove cadmium(II) and Ni(II) ions from aqueous solutions has been studied in a batch system. The effects of various parameters such as pH, biomass dosage, agitation time, and initial metal ion concentrations were examined. The parameters have been found to have direct influence on the uptake of Cd(II) and Ni(II) by the biosorbent. pH 6 and pH 5 were used for the uptake of Cd(II) and Ni(II), respectively. Time dependence experiments for the Cd(II) and Ni(II) showed that optima binding to the *Basella alba* L. occurred within 20 min and 60 min of agitation, respectively. Analyses of the experimental data obtained showed that Cd(II) and Ni(II) uptake increased from 10 mg to 50 mg biosorbent dose and from 1.19 mg/g to 44.26 mg/g, respectively. For the Cd(II), the kinetic data fitted only to the pseudo-second-order model and the value of the rate constant, k_2, was found to be 0.2235 g $mg^{-1}min^{-1.}$ For nickel(II), the kinetics of the biosorption process can be described by both the pseudo-first- order and pseudo-second-order models but a better fitting was achieved by pseudo-second-order model. The value of the rate constant, k_2, was found to be 0.2124 g $mg^{-1}min^{-1}$. Equilibrium data followed both Langmuir and Freundlich models. Using the thermodynamic equilibrium coefficients obtained at different temperatures, the thermodynamic parameters of the biosorption process were evaluated. The biosorption process was found to be endothermic for the two metals. For Cd(II), the ΔH^o and ΔS^o values obtained were 22.35 $kJmol^{-1}$ and 0.078 $kJK^{-1}mol^{-1}$, respectively. For Ni(II), the ΔH^o and ΔS^o values obtained were 3.471 $kJmol^{-1}$ and 0.015 $kJK^{-1}mol^{-1}$,respectively. The negative values of ΔG^o obtained for the biosorption of the metals indicate the feasibility and spontaneity of each of the biosorption processes.

***Key words*:** Biosorption, cadmium(II), nickel(II), kinetics, thermodynamics, *Basella alba* L.

Introduction

Among heavy metals, mercury, lead and cadmium are three of the most toxic with the greatest potential hazard to humans and the environment (Volesky, 1994). Heavy metals such as cadmium, nickel, lead and zinc are released into the environment via effluents from manufacturing industries, especially electroplating and those manufacturing batteries, pigments and ammunition (Al-Garni, 2005). Lead and cadmium are potent neurotoxic metals (Puranik and Pakniker, 1997). Cadmium has been observed to accumulate throughout the food chain (Volesky, 1990; Wase and Forster, 1997). Conventional techniques, such as chemical precipitation, solvent extraction, ion exchange, electroplating, activated carbon adsorption and membrane separation process have been employed to remove heavy metals from wastewater (Matheickal and Yu, 1999; Yan and Viraraghavan, 2001; Rorrer, 1998). These methods have become inefficient and expensive especially when the heavy metal concentration is less than 100 ppm (Leusch *et al*., 1995; Eccles, 1999).

Alternatively, biosorption of heavy metals by bacterial fungal or algal biomass and agricultural waste biomass have been identified as one of the most promising technologies involved in the removal of toxic metals from industrial waste streams and natural water (Singh *et al.*, 2003; Feng and Aldrich, 2004; Vegilo *et al*., 1998). Biosorption is a process whereby certain types of inactive, dead biomass may bind and concentrate heavy metals from aqueous solutions (Naja *et al.*, 2005; Volesky, 2003). The use of non-expensive waste biomass, the low cost of biomass immobilization, competitive performance, heavy metal selectivity, no sludge generation and the possibility of biomass regeneration are some of the advantages of biosorption over other conventional techniques (Gasbarro, 1997; Quintelas and Tavares, 2002; Siegel *et al*., 1990).

Many types of biomass have been reported to have high uptake capacities for heavy metals (Bailey *et al*., 1999; Wase and Forster, 1997). Some agricultural waste/materials that have been investigated for heavy metal uptake include waste maize bran (Singh *et al*., 2006), maize leaf (Babarinde *et al*., 2006), sugarcane bagasse (Karnitz *et al*., 2007), banana pith (Low *et al*., 1995), coconut copra meal (Ofomaja and Ho, 2006) and rice bran (Zafar *et al*., 2006). All these biomaterials have shown adequate heavy metal sorption capacity to be considered for process applications.

Cadmium and nickel were the focus of this study. The aim of the work was to determine the ability of *Basella alba* L. to remove cadmium(II) and Ni(II) from aqueous solutions. *Basella alba* L. (Malabar spinach) is a fast growing plant that is spread throughout the tropical world including Africa. It is one of the best tropical spinach widely adapted to a variety of soils and climates (Palada and Crossman, 1999). Due to the ability of this plant to accumulate water in its tissue, it is hoped that the plant could serve as an effective biomaterial in the removal of heavy metals, especially cadmium and nickel from industrial waste-water. First, the effects of pH, agitation time, biosorbent dose, and initial metal ion concentration were studied. Furthermore, the data obtained were fitted using two kinetic models (pseudo-first-order and pseudo-second-order) and two equilibrium models (Langmuir and Freundlich). The thermodynamics of the biosorption system were also investigated.

Materials and Methods

Materials

The leaves of *Basilla alba L.* were collected from a house hold garden located within the metropolis of Ibadan, South-West, Nigeria. They were washed with running tap water and then with de-ionized water to remove dirt and other particulate matter. These were subsequently oven dried, pulverized and sifted using a 150 size mesh screen. This prepared biosorbent was then stored in air-tight polyethylene bags.

Preparation of Stock Solutions

Cd(II) solutions with different initial concentrations were prepared by dissolving known masses of $Cd(NO_3)_2.4H_2O$ in deionized water, and made up to the marks in appropriate standard volumetric flasks. Solutions of Ni(II) of different concentrations were prepared by dissolving known masses of $Ni(NO_3)_2.6H_2O$ in deionized water, and made up to the marks in appropriate standard volumetric flasks.

Biosorption experiments

The effect of pH on the removal of Cd(II) and Ni(II) was studied by adding 30 mg of the prepared biosorbent (*Basella alba* L.) to 15 ml of 0.3 mM solution of each metal solution in 250 mL plastic bottles at 28 ^oC. The bottles with the mixtures were agitated on a thermostatic shaker at 200 rpm for 2 hours and then centrifuged at 8,000 rpm for 10 min to separate the supernatant. The pH experiments were carried out using a glass electrode (Jenway 3510 model pH meter) at pH range of 2 to 6. pH adjustments were made using 0.1 M HNO_3 and 0.1M NaOH. Effect of biosorbent dosage was studied with different adsorbent doses (10, 30, 50, 70, 90 and 110 mg) in 15 mL of 0.3 mM metal solution, adjusted to pH 6 for Cd(II) and pH 5 for Ni(II). These were then agitated at 200 rpm for 2 hours and centrifuged at 8,000 rpm for 10 min. to separate the supernatant.

To determine the contact time required for equilibrium biosorption, 30 mg of the biosorbent was contacted with 15 mL of 0.3 mM solutions of metal solution in 250 mL plastic bottles and under constant agitation at 200 rpm in a thermostatic shaker at temperature of 28^oC. The pH of the solutions was adjusted as mentioned above. Samples were withdrawn from the shaker at different time intervals of 2, 5, 10, 20, 30, 60, and 120 min.

In studying the effect of initial metal ion concentration, 30 mg of the biosorbent was shaken with 15 mL of metal solutions of varied concentration (0.1, 0.3, 0.5, 0.75, 1 and 2 mM) in different plastic bottles in a thermostatic shaker at a constant speed of 200 rpm, temperature of 25 ^{o}C and at the predetermined agitation time for each metal. The supernatants were then separated by centrifugation at 8,000 rpm for 10 min. For the thermodynamic study, biosorption of 15 mL of 0.3 mM metal solution by 30 mg biosorbent was carried out at 15, 25, 37 and 50 ^{o}C in a thermostatic shaker bath for the predetermined agitation time for each metal, and then centrifuged at 8000 rpm for 10 min to separate the supernatants.

In all the studies, the resulting residual metal ion concentration supernatants were determined using Thermo S4 Atomic Absorption Spectrophotometer (AAS) manufactured by Thermo-Fisher Electronic Corporation and each experiment was carried out in duplicates with average of the experimental data considered.

Metal uptake was determined using the following equation:

$$q = \frac{(C_o - C_e)V}{S} \quad \text{.....(1)}$$

where, q is the metal uptake (mg/g); V is the solution volume (L); C_o is the initial concentration of metal in solution (mg/L); C_e is the final concentration of metal in solution (mg/L); and S is the mass of biosorbent added (g) (Vijayaraghavan *et al*., 2006; Vieira and Volesky, 2003).

Results and discussion

Effect of pH on biosorption

The removal of metal ions from aqueous solutions by biosorption is dependent on solution pH as it affects biosorbent surface charge, the degree of ionization, and the species of biosorbates (Karnitz *et al*., 2006; Yin *et al*., 1999). pH effect on biosorption equilibrium has been reported to be necessary for an accurate evaluation of biosorption process (Wase and Forster, 1997). Investigation of the capability of this biosorbent to remove cadmium at different values of pH 2–6 (figures not shown) showed that biosorption of metal ions increases with increase in pH. Maximum removal of Cd(II) and Ni(II) was observed at pH 6 and 5, respectively. The biosorption experiment was not conducted beyond pH 6 because at higher pH values, precipitation of the metals to occurs (Parvathi *et al*., 2006; Mahamadi *et al*., 2007). Karnitz *et al*. (2006) have also reported pH above 5 for Cd^{2+} in their work on adsorption of heavy metal ion from aqueous single metal solution by chemically modified sugarcane bagasse.

Effect of biosorbent dose

It has been reported that dose of biomass added into the solution determines the number of binding sites available for adsorption (Zafar *et al.*, 2006). Analysis of the experimental data obtained (figure not shown) showed that Cd^{2+} ion uptake increased from 10 mg to 50 mg biosorbent dose, and then decreased with further increase in biosorbent dosage. An increase in biosorbent quantities strongly affects the quantities of metal removed from aqueous solutions. This could be attributed to the fact that at high biosorbent dosages the available metal ions are insufficient to cover all the exchangeable sites on the biosorbent, usually resulting into low metal uptake (Vijayaraghavan *et al*., 2006; Fourest and Roux, 1992). Similar observations were reported by other reseachers (Al-Asheh and Duvnjak, 1995; Sampedro *et al*., 1995). But for the purpose of this present study, biomass dose of 30 mg was selected for further studies. For the biosorption of Ni(II), metal uptake values decreased with an increase in biomass dose. Reduction in metal uptake with increasing biomass concentration has been attributed to an insufficiency of metal ions in solution with respect to available binding sites (Fourest and Roux, 1992). Higher specific uptake at lower mass concentrations of biosorbent could be due to an increase in metal-to-biosorbent ratio, which decreases with increase

in mass concentration (Puranik and Pakniker, 1999). But for the purpose of this present study, biomass dosage of 30 mg was chosen for all the experiments.

Effect of contact time

Agitation time is another factor that greatly affected the biosorption of Cd(II) and Ni(II) by *B. alba* L (figures not shown). Maximum biosorption was observed for Cd^{2+} ions at 20 minutes of agitation, after which a decrease in metal uptake was noticed until equilibrium was reached after 30 min. For nickel, time dependence experiments showed that optimum binding to the *B. alba* occurred within 60 min of agitation and was maintained for a long time. This maximum agitation times were subsequently used for other experiments under this study.

Kinetic studies

Kinetic models have been used to investigate the mechanism of the biosorption of cadmium ions by *Basella alba* L. The two models used were pseudo-first-order and pseudo-second-order models (Ho and McKay, 1998). The pseudo-first-order model is based on sorbent capacity and considers that the rate of occupation of adsorption sites is proportional to the number of unoccupied sites. The pseudo-second-order equation is also based on the adsorption capacity of the solid phase (Aksu and Tunc, 2005). The linearized forms of the pseudo-first-order and pseudo-second-order models are represented below by equations 2 and 3, respectively (Ho and McKay, 1998).

$$\log\left(q_e - q_t\right) = \log q_e - \frac{k_1 t}{2.303} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^{\,2}} + \frac{t}{q_e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where, q_e is the amount of metal biosorbed at equilibrium (mg/g); q_t is the amount of metal biosorbed at time, t (mg/g); k_1 is the rate constant of pseudo-first-order biosorption ($min.^{-1}$); k_2 is the rate constant of pseudo-second-order biosorption (g/mg min.).

The validity of the two models was investigated by studying the kinetics under different agitation times. For pseudo-first-order kinetics, the straight-line plots of $\log(q_e - q_t)$ against t were made, but pseudo-first-order model was found not to achieve a good fitting for the biosorption of cadmium. This is because the coefficient of correlation for first-order kinetic model was far less than one ($R^2 << 1$). In most cases in the literature, the pseudo-first-order model does not fit the kinetic data well for the whole range of contact time, and generally underestimate the q_e values (Ho and McKay, 1998; Reddad *et al*., 2002). The better fit in the data range was found to be the pseudo-second-order model (Fig. 1), which is in agreement with a chemisorption mechanism being the rate-controlling step (McKay *et al*., 1999). The pseudo-second-order model is based on the assumption that rate of occupation of adsorption sites is proportional to the square of the number of unoccupied sites (Zafar *et al*., 2006).

The values of the parameters, K_2 and q_e and the correlation coefficient, R^2, are presented in Table 1. The correlation coefficient obtained is approximately one ($R^2 \approx 1$), and the adequate fitting of theoretical and experimental q_e values suggest the applicability of second-order kinetic model based on the assumption that the rate limiting step may be the biosorption of cadmium and *B. alba* in explaining the kinetics of biosorption (Donmez *et al*., 2002).

For nickel(II), the kinetics of the biosorption process can be described by both the pseudo-first-order and pseudo-second-order (Fig. 2), but the better fitting was achieved by pseudo-second-order model, with the coefficient of correlation (R^2) of 0.9998.

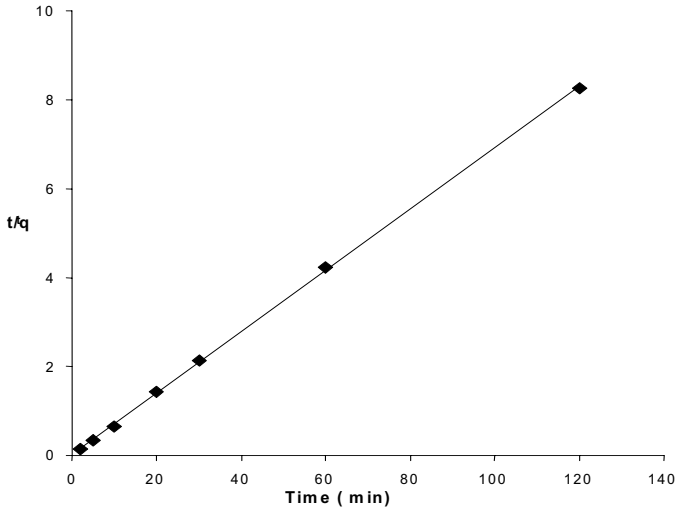

Fig. 1: *The pseudo-second-order plot for the kinetic study of Cd^{2+} biosorption by Basella alba* L. *(pH 6; conc., 33.9 mg/l; biomass dose, 30 mg; agitation time, 20 min. ; temp., 28^o*

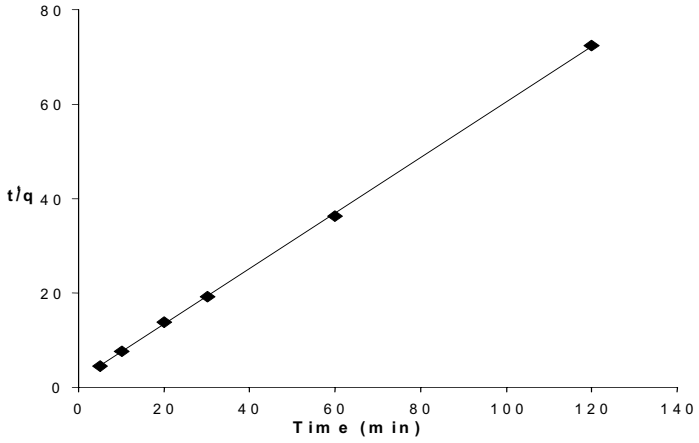

Fig. 2: *The pseudo-second-order plot for the kinetic study of Ni^{2+} biosorption by Basella alba* L. *(pH 5; conc., 17.6 mg/l; biomass dose, 30 mg; agitation time, 30 min. ; temp., 28^{o}C)*

Table 1: ***The pseudo-second-order parameters for the kinetic study of*** **Cd(II) and Ni(II)** ***biosorption by Basella alba*** **L.**

Metal	R^2	k_2 (g mg^{-1}min^{-1})	q_e**(calc)**	q_e**(expt)**
Cd^{2+}	**0.9998**	**0.2235**	**14.49**	**15.30**
Ni^{2+}	**0.9998**	**0.2124**	**1.702**	**1.659**

Effect of initial metal concentration

For the biosorption experiments conducted in a series of aqueous solutions of cadmium with different initial concentrations, it was observed that biosorption capacity of *Basella alba* L. increased from 3.8 mg/g to 100.0 mg/g for cadmium ion (figure not shown). This sorption characteristic indicated that surface saturation was dependent on the initial metal ion concentrations. At low concentrations, biosorption sites took up the available metal more quickly. However, at higher concentrations, metal needed to diffuse to the biomass surface by intraparticle diffusion and greatly hydrolyzed ions will diffuse at a slower rate (Zafar *et al*., 2006).

Equilibrium studies

The Cd(II) and Ni(II) uptake capacity of *Basella alba* L. was evaluated using the Freundlich (1907) and Langmuir (1918) isotherm models. These two models are the earliest, most common and simplest known relationships describing the ad/bio-sorption phenomenon (Jalali *et al*., 2002). The Langmuir equation is widely used for modeling the biosorption equilibrium, which is valid for monolayer sorption onto a surface with finite number of binding sites, which are homogeneously distributed over the adsorbent surface (Aksu and Tunc, 2005). These binding sites have the same affinity for adsorption of a single molecular layer and there is no interaction between adsorbed molecules (Langmuir, 1918).

The empirical Freundlich model also takes into account the monomolecular layer coverage of solute by the sorbent, but it assumes that the sorbent has a heterogeneous surface, which means that binding sites are not equivalent and/or independent (Freundlich, 1907). The linearized forms of the Freundlich and Langmuir isotherm models are represented below by equations 4 and 5, respectively:

$$\log q = \log K_f + \left(\frac{1}{n}\right)\log C_e \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\frac{1}{q} = \frac{1}{q_{\max}} + \frac{b}{q_{\max} C_e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where, q is the heavy metal biosorbed on the biosorbent (mg/g dry weight); C_e is the final concentration of metal (mg/L) in the solution; K_f is an empirical constant that provides an indication of the adsorption capacity of biosorbent; n is an empirical constant that provides an indication of the intensity of adsorption; b is the equilibrium constant related to the affinity of the binding sites for the metals; and q_{max} is the maximum possible amount of metallic ion adsorbed per unit weight of adsorbent.

For the Freundlich isotherm model, the adsorption constants (K_f and $1/n$) were obtained by plotting log q as a function of log C_e. While the adsorption constants (q_{max} and b) for the Langmuir sotherm model were obtained by plotting $1/q$ as a function of $1/C_e$ (Parvathi *et al*., 2007). The experimental data points for the biosorption of cadmium by *Basella alba* L., at temperature of 25 ^{o}C were fitted to Langmuir and Freundlich isotherm equations (figure not shown). The Freundlich and Langmuir models present good fits of the experimental data and are both adequate for modeling the isotherm of sorption, respectively.

Table 2 shows the different parameter (R^2, q_{max}, b, K_f, n) obtained from both Langmuir and Freundlich isotherm models. The parameter $q_{\max}$ represents the maximum metal adsorption and b is an affinity parameter (a high value of b reflects the high affinity of the biosorbent for the sorbate), K_f relates to biosorption capacity, and n is an empirical parameter that varies with the degree of heterogeneity.

Table 2: *Langmuir and Freundlich isotherm parameters for the biosorption Cd(II) and Ni(II) by Basella alba L*

Metal Ion	R^2	q_{max}	b	R^2	K_f	*N*
Cd(II)	0.9621	-9.050	-0.0391	0.9871	3.539	0.258
Ni(II)	0.9935	-46.95	-0.0147	0.9784	0.192	0.632

Thermodynamic studies

The thermodynamic parameters such as standard Gibb's free energy change (ΔG^o), enthalpy change (ΔH^o) and entropy change (ΔS^o) were estimated to evaluate the feasibility and nature of the biosorption of Cd(II) and Ni(II) by *Basella alba* L. Experiments were carried out at different temperatures in the range of 288–323 K and the following relationships have been used to evaluate the thermodynamic parameters:

$$\Delta G^o = -RT \ln K_c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$\ln K_c = \frac{\Delta S^o}{R} - \frac{\Delta H^o}{RT} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where, T is temperature (K), R is ideal gas constant ($8.314 Jmol^{-1}K^{-1}$) and K_c is equilibrium constant.

The values of enthalpy change (ΔH^o) and entropy change (ΔS^o) were calculated from the slope and intercept of van,t Hoff plot of ln K_c versus 1/T (figure not shown) (Sarin *et al*., 2006).

The equilibrium constant, K_c, was determined as follows

$$K_c = \frac{C_a}{C_e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where, C_a is mg of adsorbate biosorbed per litre, and C_e is the equilibrium concentration of solution, mg/l (Sarin *et al*., 2006).

The standard Gibb's free energies of the biosorption process at different temperature are presented in Table 3. The negative values of ΔG^o confirm the feasibility and spontaneous nature of the biosorption process (Aksu and Tunc, 2005). The change in free energy decreased with increase in temperature. This indicates that biosorption of cadmium was endothermic as it was favoured by increase in temperature. The values of the thermodynamic parameters are presented in Table 3. The positive values of ΔH^o suggest the endothermic nature of the biosorption process and possible strong bonding between the metal ion and *Basella alba* L. (Aksu and Tunc, 2005). The positive value of ΔS^o also shows increased randomness at solid-solution interface during the biosorption of the metal ions on *B. alba* L. (Sarin *et al*, 2006).

Table 3: *Thermodynamic parameters for the biosorption of Cd(II) and Ni(II) by Basella alba* L

Metal ion	R^2	ΔH^o $(kJmol^{-1})$	ΔS^o $(kJKmol^{-1})$	ΔG^o (288K) $(kJmol^{-1})$	ΔG^o (298K $(kJmol^{-1})$	ΔG^o (310K) $(kJmol^{-1})$	ΔG^o (323K) $(kJmol^{-1})$
Cd(II)	0.9133	22.352	0.078	-1.645	-0.946	-1.405	-2.903
Ni(II)	0.9430	3.471	0.015	-1.010	-1.105	-1.343	-0.013

Conclusion

Basella alba L. was found to be an effective biosorbent for the removal of CdII) and Ni(II) from aqueous solutions. The study showed that pH, biomass dosage, agitation time and initial metal concentration highly affected the overall metal uptake capacity of the biosorbent. The fit of the biosorption data into the pseudo-second-order kinetic model gave better fit than the pseudo-first-order kinetic model for the two metals. The equilibrium data have been found to follow the Langmuir and Freundlich isotherm models. Thermodynamic studies confirm that the process was spontaneous and endothermic.

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