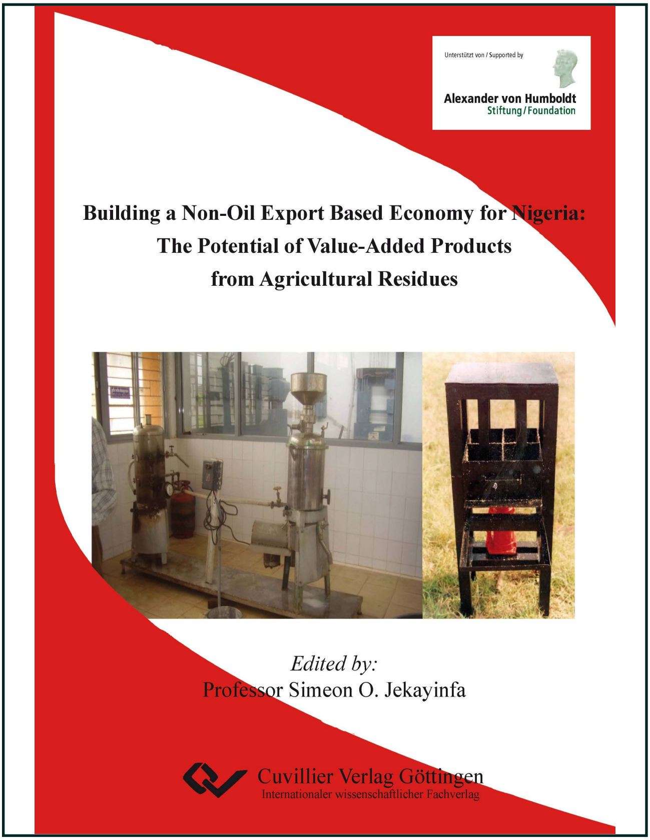
Simeon O. Jekayinfa (Autor)

Building a Non-Oil Export Based Economy for Nigeria: The Potential of Value-Added Products from Agricultural Residues



https://cuvillier.de/de/shop/publications/6077

AGRO-BASED ALTERNATIVES TO PETROLEUM ECONOMY[+]

Adewumi B.A.

Department of Agricultural Engineering,
University of Agriculture, Abeokuta, Nigeria
Email: babatunde_adewumi@yahoo.com

Abstract
Petroleum is a natural resource that has contributed immensely to the industrial and economic developments of many nations. It has simultaneously contributed to the ruin of such nations. While industrial activities of nations endowed with petroleum resources increased, the national technological advancement of such nations has not been significant. The discovery and exploration of petroleum has diverted focus on (Agricultural Produciton) and other sectors of national economy. The serious negative effects of the exploration of petroleum on the agrarian economy of Nigeria, as a case in Africa, are very sad. The agriculture sector which used to be the main stake of the economy of Nigeria in the pre and early independent periods, until the 1980s, was destroyed as a result of the discovery and exploration of petroleum. While Nigeria should celebrate the exploration of petroleum and properly manage the resource, this volatile petroleum resource should not be allowed to destroy the agricultural and other viable sectors of the national economy. The paper presents some viable agro-based alternatives to petroleum economy. The industries and programs that can emerge from the output of the agriculture sector are many. These include energy industry from bio Fuel and bio diesel, solar and wind; pharmaceutical industry from fruits and vegetables; tourism industry from wild life parks and forest resources; furniture and construction industries from forest resources; agro processing industry from arable and cash crops; leather industry from animal skin; textile industry from cotton; agro machinery manufacturing industry to serve agro based industries; product development and added value; and women and youth empowerment through agricultural clusters.

Key words: Agrarian economy, Agro-industry, Petroleum economy, National development

INTRODUCTION
One of the key economic forces ruling and ruining the world is petroleum. While petroleum exploration has contributed significantly to the economy of many nations, it has simultaneously led to the following serious problems:

- global pollution (land, water and air)
- deviation of focus on (Agricultural Produciton) and other sectors of national economy
- enhanced a high cost of living
- local and international disputes and wars
- youth unrest
- natural disaster
- Mass unemployment
- Increased crime and corruption rates, etc

NEED FOR A SHIFT FROM PETROLEUM ECONOMY
Any reasonable economist or scientist cannot completely relegate the roles of petroleum in the world economy, but considering the problems associated with petroleum exploration, as earlier

enumerated, it is recommendable to de-emphasis the main dependence of nations on petroleum resources. It is also essential to note that petroleum is a depletable resource.

Unlike most Western and Eastern nations, Africa and Asia are especially blessed by nature with agricultural resources (SHDI 2006). Africa has the following advantages (UNEP 2007; OAU 2003; Blaikie 1989; World Bank 2003; Kiss 1990; Frazier 1999):

- Second largest continent in the world
- 27% of the world's population
- Land area of more than 3,025.8 million hectares
- Abundant land, water, forest, mountain and coastal resources with adequate climate
- Agrarian continent extremely rich in crop, forest, fish and animal resources with agriculture as the dominant economic sector

In Africa, with Nigeria as an example, agrarian economy has been relegated because of petroleum and this has resulted in the under listed problems as identified by OAU (2003) and World Bank (2003):

- Increasing natural disasters
- Increasing under nourished population
- 25 African countries have problem of food emergencies for reasons including drought, civil strife, internal displacement, economic disruption and refugees

LESSONS FROM INDIA

India, Japan and China are striking examples of Asian countries that do not have petroleum but emerging as very strong nations because they appreciated agriculture, technology and industry. The highest percentage of GNP of Nigeria and India in the pre independence and 1960's to 80s was derived from the agricultural sector (Adewumi, 2006). Despite the economic recession experienced by India in the 1980s, the nation is back to economic stability because of the emphasis on agriculture. India, despite her large population, has drastically and consistently improved (Agricultural Produciton) both for the supply of national needs and export via viable policies. The agricultural sector in India has developed bio Fuel from Jatropha for utilization as bio diesel for energy generation and raw materials for the textile and food processing industries.

Nigeria and India were both colonized by Britain. Both nations became sovereign after independence and had similar problems to contend with after independence. In the late 1950s and up to late 1970s, both nations relied heavily on agriculture as the main sustenance of their economies with up to 80% or more of the population involved in peasant crop and animal farming. Groundnut, cocoa, oil palm, palm nut, cotton and other cash crops were produced and exported from Nigeria in large quantities as of raw materials to develop nations (IMF, 1994; Adewumi, 1998a, b & 2000). Cashew, legume grains, pulses, dairy products and other agricultural materials were produced in India and exported to countries all over the world (IMF, 1994; FAO, 1987; ILO, 1983). When the exploration of petroleum started in Nigeria, especially from the 1980s, the focus on agriculture and technological development diminished but the economy of Nigeria was booming because of the earning from petroleum but India had economic recession and many Indians have to migrate to other parts of the world amass, including Nigeria for survival. In fact there was a great influx of Indians to Nigeria during these periods.

India however overcame the economic recession because of the focus on technological development and the effect of the five - years plan policy. The planning commission of Indian, set up in March 1950, has steady 5 - years plan policy/ programme for the nation since independence to give a focus to the nation (Five years plan policy, 1950). India was classified together with Nigeria as developing nations after independence. While Nigeria remain in the group of developing nations, India is fast emerging as a global giant, especially in the last five years, consequent to her very rapid technological developments resulting in self-reliance and economic growth. India, like other Asian countries started her technological development with copy technology but now developing technologies for many other nations. India has inherent disadvantage of very large population, about ten times the population of Nigeria, yet India is becoming self sufficient because of her emphasis and priority on science and technology.

The five - years plan policy has strengthen institutional structures to guide developmental process in India. This has improved the GDP of India and positioned the nation among the 1st ten fastest growing nation toward the end of the 20th century (Five years plan policy, 2002). This planning policy takes to account all the sectors of the economy and the reforms in India (Five years plan policy, 1987).

The economic recession made India to think inwards and identify national priorities for development. Technology, agriculture and social/ human well being were given priority (Five years plan policy, 1987). India therefore started an aggressive technological growth with copy technology, like other key Asian countries such as China and Japan during this period. Indigenous or traditional knowledge approach (CSIR, 2004) was adapted for solving national problems, including technological problems. The issue of local content was also addressed early enough in India. India addressed the problem of economic recession and embanked on developing some essential sectors of their economy especially iron and steel, manufacturing, agriculture and education. India also devoted time to raw material development for industrial development during this period. The policy of India does not support indiscriminate importing of goods and services.

The effect of such actions and policies became glaring towards the end of the 20th century when India was ranked one of the 1st ten fastest growing nations (Five years plan policy, 2002). India now have fully developed automobile, aeronautical, nuclear, iron and steel, construction, manufacturing, textile, communication, railways, computer and agricultural sectors that can favorable compete with developed nations. India is also fast gaining technological recognition and becoming a global giant in science and technology. USA has recently acknowledged the potential of the nuclear power of India.

AGRO-BASED ALTERNATIVES

Agricultural products, including plant and animal materials, are not only good sources of food but basic industrial raw materials. The agricultural sector is therefore essential for the development of various industries and highly required for national development. There are several agro-based alternatives to petroleum. The industries and programs that can emerge from the output of the agriculture sector include:

- Energy industry from bio Fuel and bio diesel, solar and wind
- Pharmaceutical industry from fruits and vegetables
- Tourism industry from wild life parks and forest resources
- Furniture and construction industries from forest resources
- Agro processing industry from arable and cash crops
- Leather industry from animal skin
- Textile industry from cotton
- Agro machinery manufacturing industry to serve agro based industries
- Product development and added value
- Women and youth empowerment through agricultural clusters

ENERGY INDUSTRY FROM BIO Fuel AND BIO DIESEL, SOLAR AND WIND

There is the need to focus on alternative energy, especially solar, wind and other renewable energy sources. Methane is a bio gas derivable from agricultural Wastes such as cow dung and poultry Wastes using a digester. This can be used as cooking gas. It is convertible to other forms of energy (Ague farm is an example). Solar and wind energies are harvestable and convertible to electrical and heat energy for whatever applications (solar house in Jos is an example). Jatropha, wild caster (lapa lapa), mostly regarded as useless and Waste crop, is a ready raw material for the production of

bio diesel. Fig. 1 shows a solar incubator. Fig. 2 shows Jatropha stem, pods and seeds. Fig. 3 shows the bio diesel from Jatropha.
India is aiming at generating 40% of its energy from bio diesel using Jatropha in the next 10 years (Mangaraj et al, 2009). Sugar cane is another major source of bio Fuel utilized in Brazil. Cars are now developed using Fuel produced from sugar cane.

Fig. 1: Solar Incubator

Fig. 2: Jatropha seed & Stem

Fig. 3: Bio diesel from Jatropha

PHARMACEUTICAL INDUSTRY FROM FRUITS AND VEGETABLES

Fruits and vegetables are natural, rich and ready sources of vitamins and minerals, which are in high demand in the pharmaceutical industry. The largest concentration of fruits and vegetables are produced in the tropical regions of the world, including Africa, because of the favorable climatic conditions (Adewumi and Amusa, 2004).

TOURISM INDUSTRY FROM WILD LIFE PARKS AND FOREST RESOURCES

Nations such as India, Kenya and Qatar earn heavily through tourism. Libya has also invested much on tourism. Wild life parks inherent in forest reserves are major sources of environmental friendly national income.

FURNITURE AND CONSTRUCTION INDUSTRIES FROM FOREST RESOURCES

Wood and timber derived from the forest are the major raw materials for the furniture and construction industries. Wood has acoustic properties and are highly priced for interior decorations.

AGRO PROCESSING INDUSTRY FROM ARABLE AND CASH CROPS

The vast fertile land in the African nations favors the production of both arable and cash crops in large quantity. Many tropical crops have high international commercial values. These include cocoa, groundnut, cashew, pine apple, etc. These agro materials consequently support the establishment of different types of agro processing industry which are vibrant sources of national income and rural development. These agro processing industry however requires regular power supply to operate efficiently.

LEATHER INDUSTRY FROM ANIMAL SKIN

Leather from animal skin is used for the production of high quality thermal wears, decorations, shoes and bags. Ethiopia has a high record of national income through the leather industry. The leather industries are organized into innovative clusters to enhance their efficiency.

TEXTILE INDUSTRY FROM COTTON

The textile industry is a major sector that creates mass employment and contributes to national income. While we are busy destroying our textile industry in Nigeria, India is expanding hers. The textile industry in Nigeria MUST be revived.

AGRO MACHINERY MANUFACTURING INDUSTRY TO SERVE AGRO BASED INDUSTRIES

Agrarian nations must encourage mechanized agriculture, not by exporting agricultural machinery but by developing and manufacturing indigenous agro machinery suitable for there conditions (Adewumi, 1998a, 2000, 2004, 2005, 2007). Such nations should further graduate to become exporters of such machinery and fit into the global market. India is an example. Figs. 4 – 9 show some agricultural and food machines.

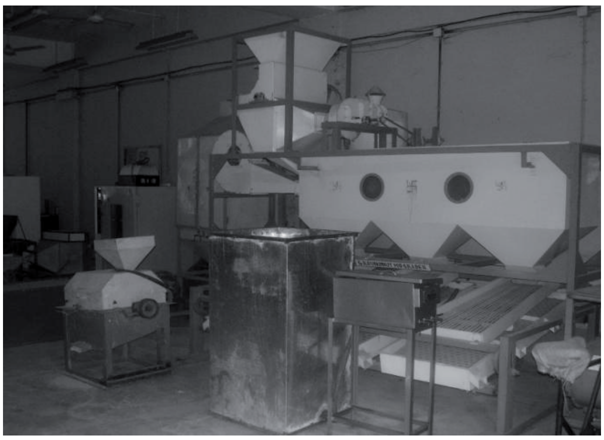


Fig. 4: Threshers and Cleaners

Fig. 5: Fruit Graders

Fig. 6: Silo Storage Structures

Fig. 7: Hand Operated Seed Planters

Fig. 8: Land Cultivating Machines and Planters

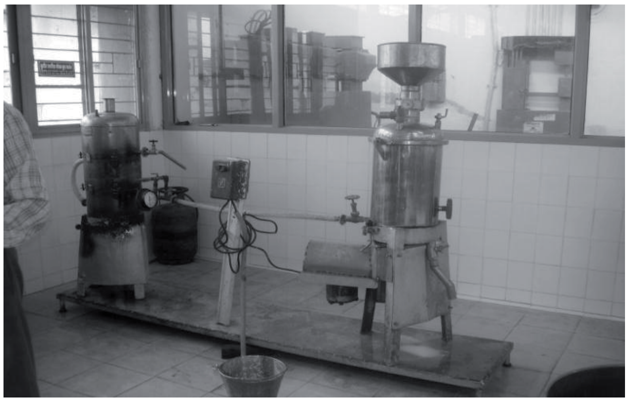


Fig. 9: Soy Milk, Cake and Cheese Machine

PRODUCT DEVELOPMENT AND ADDED VALUE

One of the greatest problems in the agricultural sector in the developing nations is the inability to develop high commercial and industrial products with added value from agricultural products. Example, the development of modified starch from cassava would add value to cassava and make it become a high commercial and export crop.

Development of a high protein based weaning food from pigeon bean (feregede) and maize for commercial production would earn more from maize and add value to pigeon bean. The commercial value of 'lesser crops' such as locust bean with high protein values could thereby be up graded. Locust bean can be upgraded from its present use as food condiment to flavoring agent, food additives and food supplement.

WOMEN AND YOUTH EMPOWERMENT THROUGH AGRICULTURAL CLUSTERS

The innovative cluster system is a proven global concept of developing national economy. The naturally occurring women and youth clusters in agriculture could be transformed into innovative clusters to alleviate poverty and empower both the women and youth. This is practiced in Uganda and Tanzania.

CONCLUSION

Petroleum economy is enviable but has a lot of terrible associated problems. Nations that rely solely on petroleum economy often slum into unforeseen fatal problems. Agro based economy is therefore recommendable because of its lasting effects, particularly for the African nations that are agrarian

REFERENCES

Adewumi, B. A. (1998a). *Developing indigenous machinery base for crop and food processing industry in Nigeria,* Proceeding of the International Engineering Conference and Annual General Meeting of the Nigerian Society of Engineers, Maiduguri, Nigeria, pg 43-49.

Adewumi, B. A. (1998b). Status of cocoa processing industry in Nigeria. Proceeding of the 20th Annual Conference and General Meeting of the Nigerian Society of Agricultural Engineer, Lagos Nigeria. 20:175-187.

Adewumi, B. A. (2000). Appropriate technology for small scale production of Cashew Nut Shell Liquid (CNSL) for poverty alleviation. Proceeding of Millennium Engineering Conference & Annual General Meeting of the Nigerian Society of Engineers, Abuja, Nigeria, pg 236-241.

Adewumi, B. A. (2004). Appropriate and indigenous technologies for small and medium scale agro allied industries in Nigeria. Proceeding of the International Conference of the Nigerian Society of Engineers, Warri, Nigeria, Pg 124-131.

Adewumi, B. A. (2005). Providing livelihood for rural dwellers through efficient, simple technology, low cost mechanical systems. Proceedings of the III World Congress on Conservation Agriculture, organized by the African Network on Conservation Agriculture Nairobi, Kenya, 4pp. www.act.org.zw/postcongress/theme_10.asp.

Adewumi, B. A. (2006). National content in technological development: Experience of India, lessons for Nigeria. Proceeding of the Nigerian Society of Engineers, Abeokuta, Nigeria. 4 – 8th Dec., 2006, pp 8.

Adewumi, B. A. (2007). Indigenous technology and local content in a liberalized economy. Proceedings of Conference of the Institute of Engineers, Kenya, July, 2007, 8pp.

Adewumi, B. A. and Amusa, B. A. (2004). Status and prospect of the emerging fruit processing industry in Nigeria. Proceeding of the 2nd International Conference of the West African Society of Agricultural Engineers, Ghana. Pg 145 -154.

Blaikie, P. (1989). Environment and access to resources in Africa. Journal of the International African Institute, 59 (1): 18-40.

CSIR (2004). CSIR annual report. Publication of the Council of Scientific and Industrial Research, India. www.csir.res.in.

FAO. 1987. Statistics. FAO monthly bulletin. Rome.

Frazier, S. (1999). Ramsar sites overview: A synopsis of the world's wetlands of international importance. Wetlands International, Wageningen.

Five years plan policy. (1950). 1st five years plan. Publication of the Planning Commission, Government of India. http://planningcommission.nic.in/ plans/planrel/fiveyr/ welcome.html).

Five years plan policy. (1987). 6th five years plan. Publication of the Planning Commission, Government of India. http://planningcommission.nic.in/ plans/planrel/fiveyr/ welcome.html).

Five years plan policy. (2002). 10th five years plan Publication of the Planning Commission, Government of India. http://planningcommission.nic.in/ plans/planrel/fiveyr/ welcome.html).

ILO, (1983). Small scale oil extraction from cashew. Technical Memorandum of the International Labour Organisation, Vol. 5, No 1. pp 12-25.

IMF. 1994. World economic outlook. IMF Publications. Pp 124-125.

Mangaraj, S., Singh, R and Adewumi, B. A. (2009). Wild caster *(Jatropha curcas, L)*: A viable raw material for bio- diesel production in developing nations. Raw Material Update 2(2): 32-34

OAU (2003). A look at water resources in Africa. http://www.wateryear2003.org/en/ev.php-URL_ID=4874&URL_DO=DO_TOPIC&URL_SECTION=201.html.

Kiss, A. (1990). Living with wildlife: Wildlife resource management with local participation in Africa. http://md1.csa.com/partners/viewrecord.php?requester=gs&collection=ENV&recid=2605855&q=agricultural+resources+in+africa&uid=791551503&setcookie=yes

SHDI, (2006). Agriculture in Kenya. http://www.selfhelp. ie/selfhelp/Main/Projects 2004_Kenya.htm

UNEP. (2002*).* Africa environment outlook. *Publication of UNEP.*

UNEP. (2007), *Land resources in Africa,* http://www.eoearth.org/article/ Land_resources_in_Africa.

World Bank (2003). Land policies for growth and poverty reduction. World Bank Policy Research Report, The World Bank, Washington, D.C.

TRANSFORMING WASTE TO WEALTH: *GMELINA ARBOREA* FRUIT-PULP POTENTIALS FOR ETHANOL PRODUCTION AS BIOFUEL RESOURCE

Onyekwelu, Jonathan.C.[1]; Adeniji, Abiodun.O.[1] and Sanni, David.M.[2]

[1] Department of Forestry and Wood Technology,
Federal University of Technology, Akure, Nigeria;
Tel: ++234-803-4721633; email: onyekwelujc@yahoo.co.uk
[2] Center Department of Biochemistry,
Federal University of Technology, Akure, Nigeria.
Email: moraksanni@yahoo.co.uk

Abstract

Enormous amount of Biomass are Wasted annually in Africa as they are not utilized, thus their conversion to forms beneficial to man will amount to transforming Waste to wealth. The identification of Ethanol as a universal energy source has stimulated worldwide investigations in both high Ethanol yielding strains and cheaper raw materials. *Gmelina arborea* Fruit-Pulp was investigated for Ethanol yield as potential Biofuel resource. Fruits were collected six age series of Gmelina plantations at Oluwa forest reserve, Nigeria. The fermentation agents used in fermenting the fruit pulp were baker's yeast (*Saccharomyces cereviacae*) and palm wine. Distillation was carried out at 90°C, the distillate was subjected to spectrophotometry technique using Ethanol standard solution (0.5%). Mean Ethanol yield ranged from 1.45 to 9.71% and 1.21 to 9.38% for Fruit-Pulp fermented with baker's yeast and palm wine, respectively. Baker's yeast yielded a significantly higher Ethanol than palm wine. A significant effect of plantation age on Ethanol yield was obtained. However, since there was no discernable pattern of Ethanol yield with respect to plantation age, the significant effect of age could not be attributed to the effect of plantation. It was concluded that *Gmelina* Fruit-Pulp has good potential for Ethanol production and thus a good Biofuel resource. The potential is better appreciated if the huge annual *Gmelina* fruit production and large extent of *Gmelina* plantations are considered. Utilizing *Gmelina* Fruit-Pulp for Ethanol production will amount to transforming "Waste to wealth" since *Gmelina* fruits are always left to Waste as no use currently exist for them. Using Ethanol from *Gmelina* Fruit-Pulp for Biofuel could be a cheaper substitute for fossil Fuel, would produce "zero emission" since it is renewable, thus leading to less environmental pollution and contributing to climate change adaptation.

Key words: Gmelina arborea, fruit pulp, Ethanol yield, Biofuel, plantation, fermentation agent

INTRODUCTION

Recently, Ethanol has been identified as a universal energy source, which has stimulated worldwide investigations, not only with respect to high Ethanol yielding strains, but also to cheaper raw materials. The conversion of wood or Agricultural Residues to Ethanol and industrial chemicals is an attractive option for utilizing all major components of Biomass to produce a liquid automotive Fuel (Akin-Osanaiya *et al*., 2006). The search for alternative raw material for Ethanol production has led to the use of agricultural or biological residues such as wheat straw, wood Waste, sugar beets, corn cob, bitter kola Waste, etc (Doppelbauer et al.,1987; Ahmeh *et al*., 1988; Chen and Wayman, 1991; Aiello et al., 1996; Abd El-Nasser et al., 1997; Cao *et al*., 1999; Nguyen et al., 1999; Akin-Osanaiya *et al*., 2006; Nzelibe and Okafoagu, 2007; Saha and Cotta, 2007).

Biological Waste from agricultural and forestry crops could be as high as between 40 and 60% of the initial crop weight depending on the species. These Wastes are not usually utilized for any purpose and could sometimes constitute environmental hazard if not properly handled. Biological Waste could be generated from a number of sources like crop production, inedible crop parts, livestock farming, forest and forest industry operations, domestic and industrial food processing, social and commercial human activities. The effective conversion of these ‘Wastes’ to forms beneficial to man will demand the identification of the possible product(s) and their uses, the sources of raw materials, the quality and quantity of their supply, the quantity or quality of product derivable from them, the cost implication of the conversion, uses and demand of the products.

There is growing interest in converting biological Wastes to forms beneficial to man. The search for alternative sources of energy, especially renewable energy, should involve exploitation of the potentials of biological residues, which have long been considered as Waste and useless. Some of these “Waste” materials are always in abundance and where they are fund to be good sources of bioenergy, their utilization would amount to transforming “Waste” to wealth. The utilization of these materials would also reduce the incidence of environmental pollution and economic empowerment of poor farmers in developing countries. In addition, the dependence on fossil Fuel will be reduced and thus the incidence of global warming will to some extent be mitigated.

The investigation of Biomass raw material for Ethanol production is by no means exhaustive. Some biological Wastes from forest tree species and forest operations can also be transformed to wealth. The fruit pulp of *G. arborea* contains appreciable amount of sugar, which can be processed to Ethanol as Biofuel resource. *G. arborea* is a popular fast growing plantation tree species that is widely planted in the tropics. The species begin to fruit between 4 – 5 years after planting and yields abundant fruits every year (Onyekwelu and Stimm, 2002) and continues to do so for many years. The fruit is a fleshy and succulent drupe, with a leathery shining epicarp, a succulent, sweetish and phenolic pulp (mesocarp) and a hard stony endocarp (fruit stone). The succulent mesocarp (the fruit pulp) accounts for about 60% of the fruit weight. In Nigeria and many parts of the tropics, *Gmelina* fruit is not utilised for any purpose. After natural fall, the fruit is left to decay and Waste. Consequently, the conversion of the abundant yearly *Gmelina* fruit pulp will amount to transforming Waste to wealth. Consequently, this study was designed to investigate the potentials of *Gmelina* fruit pulp from plantations of different ages for Ethanol production as Biofuel resource.

MATERIALS AND METHODS

The fruits used for this study were collected from *Gmelina arborea* plantations in Oluwa forest reserve, Nigeria. The reserve covers an area of about 87,816 ha and lies between latitude 6° 55' and 7° 20'N and longitude 4° 32' and 4° 85'E in south western Nigeria. Over 20,000 ha of the reserve have been converted to forest plantations while the remaining area is mostly accounted for by degraded natural forests (about 27,000 ha) and arable farmland (about 31,000 ha). Large scale plantation establishment in Oluwa began in the 1970s. Currently, *Gmelina arborea* is the dominant plantation species in Oluwa forest reserve, accounting for about 89% of the total plantations (Onyekwelu et al., 2006) in the reserve.

The climate of Oluwa is tropical, comprising of two distinct seasons: rainy and dry seasons, with high mean annual temperature (26^{o}C). The rainy season lasts about 8 months (April–November), with mean annual rainfall range of 1700 to 2200 mm. The dry season lasts from December to March. Annual average daily relative humidity is about 84%. Soil type is Alfisols (Soil Survey Staff, 2003). The soil parent materials were formed from crystalline rocks of the undifferentiated basement complex of pre-cambrian series. The soils are well-drained, mature, red, stony and gravely in the upper parts of the sequence, grading into the hill wash overlying original parent material or hard-pan layers in the valley bottom (Smyth and Montgomerry, 1962). Texture of topsoil is sandy loam.

Matured *Gmelina* fruits were collected from plantations of six different ages (13, 16, 18, 21, 23 and 25 years). The fruits were bagged in the field and immediately taken to laboratory for analysis. The fruits were then thoroughly washed with distilled water, after which the fruit pulp was sliced open with the aid of a sharp knife and the fruit stones (seeds) removed.

Baker's yeast (*Saccharomyces cereviasae*) and palm wine yeast (Sedimented residues from palm wine juice) were used as fermenting agents. The yeasts were obtained from "Oja Oba" market in Akure, Ondo State, Nigeria. The reagents used for the analysis were: Dinitrosalicyclic acid (DNS), urea, Potassium di-hydrogen phosphates, Activated Charcoal, Distilled water and Sodium hydroxide (NaOH).

Extraction and treatment of wort

The extraction of *Gmelina* wort was carried out by blending the fruit and homogenizing it with minimal amount of distilled water, after which the sample was sieved with clean cheese cloth. The initial pH of the wort was taken using pH meter and then adjusted to 5.5 pH level by adding 0.1M Sodium Hydroxide (NaOH). Ten grams of urea and Potassium di-hydrogen phosphate and 2g of Potassium sulphate were added to 1000ml of the wort from the fruit pulp for each plantation age.

Fermentation of wort

To ensure the elimination of any micro-organism that may be present in the sample (wort), the wort was sterilized inside an autoclave at 121^{o}C for 45 minutes and then allowed to cool at room temperature. For the purpose of adaptation, 10g of yeast (*Saccharomyces cerevisiae*) and 10g of palm wine were added to 100ml each of wort. Adaptation was carried out for 4 hours to enable fermentation agents (yeast and palm wine) to acclimatize to the substrate to enhance growth. The medium was stirred for homogeneity, which facilitated yeast growth. The adapted yeast was poured into the wort in different fermentors (a plastic laboratory vessel with a 2 litre capacity). To ensure anaerobic fermentation, the fermentors were covered and made airtight during fermentation. Each fermentor was manually agitated daily to facilitate uniform yeast cell distribution in the wort. The fermentors were kept sterile throughout the period of the experiment by washing with detergent and rinsing with Ethanol and stain remover to prevent the growth of microbes. The CO_2 liberated during the fermentation process was eliminated daily through one of the outlets to enhance more formation of the products. Fermentation was allowed to take place for a total of seven days.

The fermented *Gmelina* worts were filtered and distilled using standard distillation apparatus. The solution (wort) was heated to vapourise the solvent, and the vapour passed through a condenser. This re-condensed the vapor into a liquid form (distillate), which was then collected in a receiver. After distillation, the distillates were subjected to spectrophotometry technique to determine the percentage alcoholic content according to AOAC (1990). A standard calibration curve of absorbance against alcoholic concentration was constructed before extrapolating for the samples.

The experiment was arranged in Randomized Complete Block Design (RCBD). Thus, two way analysis of variance (ANOVA) was used to test for significant differences between the fermentation agents and Ethanol yield of the fruits from different age series *Gmelina arborea* plantations using SPSS 13.0 for Windows. Means found to differ significantly were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

The appropriate wavelength of maximum absorption was found to be at about 540 nm. This is because the Ethanol solution had the highest absorbance at this wavelength (540 nm). Consequently, the samples were read at 540 nm and the absorbance for each sample was obtained. The spectrophotometry absorbance of the samples ranged from 0.03 to 0.19 and from 0.02 to 0.18 for yeast and palm wine, respectively (Table 1). The concentration of Ethanol in the samples varied from 0.14 to 0.78 for yeast and from 0.10 to 0.81 for palm wine (Table 1). The concentration of Ethanol increased with increase in the absorbance values for both fermentation agents. With yeast as fermentation agent, the highest Ethanol concentration was obtained from the fruit pulp of 21 years plantation, followed by 25 and 16 years plantations. On the other hand, the highest concentration was obtained from 13 years plantation and followed by 21 and 25 years plantations when palm wine was used as fermentation agent. Except for 23 year old plantation, the results indicated that absorbance value and the concentration of Ethanol was generally higher in fruit pulp from older plantations than the younger ones when yeast was used as fermentation agent (Tab. 1). With palm wine as fermentation agent, the highest Ethanol concentration was obtained from fruit pulp of 13 year old plantation. However, there a trend that intends to suggest that higher Ethanol concentration was generally obtained from fruit pulp of the fruits from older plantations than from younger ones (Tab. 1).

Table 1: Absorbance of 8 ml of each sample distillate and their corresponding concentration

Age (years)	Absorbance at 540nm		Concentration (8 ml)	
	Yeast	Palm wine	Yeast	Palm wine
25	0.17	0.10	0.71	0.43
23	0.03	0.09	0.14	0.36
21	0.19	0.15	0.78	0.63
18	0.10	0.04	0.43	0.15
16	0.15	0.02	0.61	0.10
13	0.14	0.18	0.57	0.81

The Ethanol yield from *G. arborea* fruit pulp from plantations of different ages fermented with baker's yeast and palm wine is presented on Table 2. Generally, mean Ethanol yield raged from 1.45% to 9.71% for fruit pulp fermented with yeast and from 1.21% to 9.38% for fruit pulp fermented with palm wine. For fruit pulps fermented with baker's yeast, the lowest and highest Ethanol yield were obtained from the fruit pulp from 23 and 21 years plantations respectively, while the lowest and highest Ethanol yield were obtained from the fruit pulp of 16 and 13 years plantations respectively for fruit pulps fermented with palm wine (Table 2). The trend of Ethanol yield from *Gmelina* fruit pulps from the different plantations followed the same trend as that of the absorbance values of the fermentation agents and their corresponding Ethanol concentration. Thus, the plantations with the highest absorbance values and Ethanol concentration yielded the highest Ethanol while those with the lowest values yielded the lowest Ethanol (Tab. 2).

Table 2: Ethanol yield (in %) of *Gmelina* fruit pulp from plantations of different ages using yeast and palm wine as fermentation agents

Plantation age (years)	Yeast	Palm wine
25	8.88 ± 0.20	5.42 ± 0.31
23	1.45 ± 0.33	4.54 ± 0.39
21	9.71 ± 0.31	7.84 ± 0.23
18	5.42 ± 0.31	1.88 ± 0.33
16	7.63 ± 0.16	1.21 ± 0.15
13	7.13 ± 0.34	9.38 ± 0.41

Values are means of three replicates ± standard error.

Since the Ethanol yield obtained in this study ranged from about 1 to 10%, the data were not subjected to Arcsine transformation prior to statistical analysis. Akindele (1996) noted that the transformation of percentage data prior to analysis of variance is not necessary if the data falls within the range of 0 to 20%. The results of analysis of variance revealed a significant effect of fermentation agent on the mean Ethanol yield from *G. arborea* fruit pulp (Tab. 3). Except for fruit pulps from 23 and 13 years plantations, using yeast as fermentation agents resulted to significantly higher Ethanol yield than using palm wine as fermentation agent (Tab. 3). The results of analysis of variance also revealed that plantation age had significant effect on Ethanol yield. The results of mean separation revealed that *Gmelina* fruits from 21 and 13 years plantation gave the highest Ethanol yield for fruit pulp fermented with yeast and palm wine respectively, which were significantly higher than the Ethanol yield of the fruits from all the other plantations (age series) investigated (Tab. 3). The results indicated that low Ethanol yield were obtained from 18 and 23 years old plantation. Except for 23 and 18 years plantations (for fruit pulp fermented with yeast) and 23 and 13 years plantations (for fruit pulp fermented with for palm wine), older plantation generally yielded higher Ethanol than younger plantations for both fermentation agents.

Table 3: Results of mean separation for the effect of plantation age on Ethanol yield

	Plantation age (Years)					
Fermentation agent	25	23	21	18	16	13
Yeast	8.88^{a}	1.45^{b}	9.71^{c}	5.42^{d}	7.63^{e}	7.13^{e}
Palm wine	5.42^{f}	4.54^{g}	7.84^{h}	1.88^{i}	1.21^{j}	9.38^{k}

Values with different letters (superscript) are significantly different.

DISCUSSION

Most Biofuels currently in use are mostly derived from corn, palm oil, sugarcane, soybeans, rasp seeds, sun flower seeds, etc. These resources are either edible or are used in the manufacture of edible products. In fact, some of these Biofuels feedstocks are major cash crops for food, cosmetics and fodder. One of the current and contentious issues on the commercial use of Biofuels is its role in food price hikes (Cotula *et al.*, 2008), the accompanying food crises and hunger, especially in developing countries of Africa, Asia and South America. It is feared that the continued use of edible resources as Biofuel feedstocks will lead to competition with food crops and a significant negative impacts on food security, the so-called "food versus Fuel" debate (Cotula *et al.*, 2008). Though the recent world food price hikes is not primarily caused by Biofuels, the competition between Biofuels and food may increase pressures over world food prices during the next few years. Thus, significant future increase in world food prices due to demand in Biofuel feedstocks is expected (OECD-FAO, 2007). Competition between resource use as food and Biofuel feedstock will always exist. Since the use of Biofuels is expected to drastically increase in the coming decades, food scarcity occasioned by the use of edible crops as Biofuel raw material will also increase. These concerns are particularly relevant for large-scale commercial Biofuel production, which tends to consume a large amount of food crops as raw materials as well as take place on lands that would otherwise have been used for food production. Consequently, there is the need for reconsideration of current Biofuel policy.

One consideration is to use resources that are inedible, cost-effective and high yielding as Biofuel feedstock. Inedible materials that have been used as bioenergy feedstock include Jatropha, Neem and other non-food seeds. The second consideration is to source Biofuel feedstocks from Wastes from forestry and agro-food industries (e.g. wood and crop residues), domestic and industrial Waste products (e.g. Waste paper, household rubbish) (Cotula *et al.*, 2008), especially those for which no other alternative use exists. In the developed counties, there are significant advances in the exploitation of industrial and agricultural Waste primarily to reduce pollution with the realization that there are commercial gains. By exploiting Waste, the poor farmers could boost their incomes from sources other than the current practice of selling their meager food crops. The Waste exploitation in poor farming communities is sustainable and beneficial due to their abundance.

The result of study is an indication that *G. arborea* fruit pulp possess good potential for Ethanol production as a result of the relatively high Ethanol yield obtained. Utilizing *Gmelina* fruit pulp for Ethanol production will amount to transforming “Waste” to wealth since large quantity of *Gmelina* fruits are usually left on the forest floor to Waste every year. Biomass (e.g agricultural Wastes, cassava, maize, fruits, sugar cane, etc) has the potential of being the most important renewable energy option within the next 25 years (Lal and singh, 2000). The results of this investigation have shown that *G. arborea* fruit pulp contains a considerable amount of Ethanol, thus making it a potential bioenergy resource. As much as 10% Ethanol yield could be obtained from the fruit pulp of the species. If the large quantity of fruits produced by *Gmelina* trees every year (with the ability to continue doing so throughout its average 25 – 30 years life expectancy (Schneider, 1997; Onyekwelu and Stimm, 2002)), the large extent of its plantations as well as the steady increase in the area occupied by the plantations in many tropical and sub-tropical countries are taken into consideration, the potentials for Ethanol production from *Gmelina* fruit pulp will be enormous. With about 18,385.0 ha (89% of total plantations) and 24,486.0 (91% of total plantations) of *Gmelina* plantations in Oluwa and Omo, respectively, (Onyekwelu et al., 2006) the species is the dominant plantation tree species in Nigeria. With an average of 800 trees per hectare, there are 19,588,800 and 14,708,000 *Gmelina* trees in Omo and Oluwa forest reserves, Nigeria respectively that yields thousand of kilograms of seeds every year. When processed, this resource has the potential of yielding thousand of volume of Ethanol.

There was a significant effect of plantation age on Ethanol yield of *G. arborea* fruits pulp. Although the significant difference did not follow any clearly defined trend with respect to plantation age for both fermentation agents (i.e. the yield of Ethanol neither clearly increased nor decreased with plantation age), there is an indication that older plantation generally yielded higher Ethanol than younger plantations irrespective of the type of fermentation agent used, which is evident from the decreasing trend of Ethanol yield with age, with only few exception. The implication of this result is that fruits from older *Gmelina* plantations have higher Ethanol concentration than those from younger plantations. This is attributed to the generally large fruit size from older *Gmelina* plantations than from younger ones.

The Ethanol yield in our study is generally higher than the 3.97% Ethanol yield obtained for *Gmelina* by Akachukwu (1990). The lower Ethanol yield reported by Akachukwu (1990) is probably due to natural fermentation method adopted in his study. The higher results in this study is an indication that the use of fermentation agent (e.g. baker’s yeast, palm wine yeast, etc) to accelerate the process of fermentation resulted in higher Ethanol yield than natural fermentation. The introduction of fermentation agents enhanced the reduction of sugar in the fruit pulp to produce Ethanol thereby increasing the percentage Ethanol yield. The presence of Urea (H_2NCONH_2) and potassium dihydrogen phosphaste (K_2HPO_4) makes the yeast activities more efficient when compared to the natural fermentation which lacks the additional nutrients.

Out of the two fermentation agents used in this study, baker's yeast gave a consistently higher Ethanol yield than palm wine, indicating that baker's yeast is a more efficient fermentation agent for Ethanol production from *Gmelina* fruits. For most plantation age, baker's yeast gave a significantly higher Ethanol yield than palm wine (Table 3), which is consistent with the reports of earlier studies. In a preliminary study on Ethanol production from *Garcinia kola* (bitter kola) pod, Akin-Osanaiye *et al*. (2006) reported optimum yield of Ethanol with bakers' yeast in comparison with brewers' yeast. Also, Nzelibe and Okafoagu (2007) observed that baker's yeast yielded significantly higher Ethanol than EMCEferm active yeast from Germany.

The increased need for Ethanol as a universal energy source has stimulated worldwide investigations, not only with respect to high Ethanol yielding strains, but also to cheaper raw materials (Ahmed *et al*., 1988; Cao *et al*., 1999; Nguyen *et al*., 1999). Consequently, several plant products and Agricultural Residues such as corn-cob, grass-straw, *Carica papaya* Waste, *Garcinia kola* pod, wheat straw, sugar beets etc, have been investigated for Ethanol content for possible use as Biofuel. The conversion of these Agricultural Residues to Ethanol and industrial chemicals is an attractive option for utilizing all major components of Biomass to produce a liquid Fuel and for environmental remediation. Also, some nuts when pressed into oil can be used to run electricity generator. A good example is *Jatropha curcus*, a plant widely found in Africa, especially in East Africa. The unrefined oil is not only suitable as a diesel substitute, but also useful as Fuel for clamps or as cooking oil, soap, candle as well as fertilizer production (Stefan, 2007). Currently, *Jatropha* oil refinery is being planned and generator that will be powered by *Jatropha* oil is being produced. More *Jatropha* plantations are being established to ensure sustainable supply of raw materials for the industry (Stefan, 2007). This can be extended to *Gmelina* fruit pulp in the light of current results.

Generally considered a Biofuel alternative to gasoline, Ethanol provides Fuel for automobiles and other forms of transportation. Currently produced from starch or sugar from a wide variety of crops, there is some debate about the viability of bio-Ethanol as a replacement for fossil Fuels. Public concerns include the large amount of arable land required for crops, and the energy/pollution balance of the Ethanol production cycle. For Ethanol to be suitable for use as a replacement to fossil Fuel, it must be distilled to at least 70-80% purity by volume. For use as an additive to petrol, almost all water must be removed, otherwise it will separate from the mixture and settle to the bottom of the Fuel tank, causing the Fuel pump to draw water into the engine, which will cause harm to the engine.

CONCLUSION AND RECOMMENDATION

This research has shown that *G. arborea* fruit pulp contains a considerable amount of Ethanol, thus making it a potential bioenergy resource. Higher Ethanol yield is obtained when the fruit pulp of the species is fermented with a fermentation agent than when it is naturally fermented. However, the Ethanol yield is dependent on the type of fermentation agent used, with baker's yeast giving higher yield than palm wine. Result did not reveal any clearly defined pattern of Ethanol yield with plantation age (i.e. Ethanol yield neither increased nor decreased with increase in plantation age and vice-versa) but there is general indication that older plantations yielded higher Ethanol than younger ones. Bearing in mind that this is a preliminary research, further research on how to improve on the extraction of Ethanol from the fruit pulp of this species is recommended. A better extraction method than what was used in this study might give higher Ethanol yield.

REFERENCES

Ahmeh, J. B., Okagbue, R. N., Ahmadu, A. A. and Ikediobi, C. O, 1988. Ethanol production from corn-cob Wastes and Grass-straw. Nigerian Journal of Biotechnology, 6:110-112

Abd El-Nasser, N.H., Helmy, S.M. and El-Gammal, A.A., 1997. Formation of enzymes by biodegradation of agricultural Wastes with white rot fungi. Polym. Degrad. Stab. 55: 249-255

Aiello, C., Ferrer, A., and Ledesma, A., 1996. Effect of alkaline treatments at various temperatures on cellulase and Biomass production using submerged sugarcane bagasse fermentation with Trichoderma ressei QM9414. Bioresour. Technol. 57: 13-18

Akachukwu, A.E., 1990. A project report on "The nutritive value and sugar content of *Gmelina arborea*" University of Ibadan, Nigeria

Akin-Osanaiye, B.C., Nzelibe, H.C. and Agbaji, A.S., 2006. Preliminary studies on Ethanol production from *Garcinia kola* (bitter kola) pod: Effect of scarification and different treatments on Ethanol yield Biokemistri, 18 (2): 105-109

Akindele, S.O., 1996. Basic Experimental Designs in Agricultural Research. Montem Paperbacks, Akure, Nigeria, 122pp.

AOAC, 1990: Official Methods of Analysis of the Association of official Analytical chemists 15th edition

Cao, N.J., Krishnan, M.S., Du, J.X., Gong, C.S., Ho, N.W.Y., Chen, Z.D. and Tsao, G.T., 1999. Ethanol production from corn cob pretreated by the ammonia steeping process using genetically engineered yeast. *Biotech letters* 18:1013-1018

Chen, S. and Waymann, M., 1991. Cellulase production induced by carbon sources derived from Waste newspaper. Process Biochem. 26: 93-100.

Cotula, L., Dyer, N., and Vermeulen, S., 2008. Fuelling exclusion? The Biofuels boom and poor people's access to land. FAO and IIED, London. 72pp

Doppelbauer, R., Esterbauer, H., Steiner, W., Lafferty, R., and Steinmuller, H., 1987. The use of cellulosic Wastes for production of cellulases by Trichoderma reesei. Appl. Microbiol. Biotechnol. 26: 485-494

Lal, M. and Singh, R., 2000. Sustainable forestry as a source of bioenergy for fossil Fuel substitution. In: Innes, *et al.* (eds), Advances in global change research (vol 3) - Biomass burning and its inter-relationships with the climate system. Kluwer Academic publishers, Boston, pp 281-298

Nzelibe, H.C. and Okafoagu, U.C., 2007. Optimization of Ethanol production from *Garcinia kola* (bitter kola) pulp agroWaste. African Journal of Biotechnology, 6(17): 2033 – 2037.

Nguyen, Q.A., Keller, F.A.,Tucker, M.P., Lombard, C.K ., Jenkens, B.M., Yomog, D.E. and Tiangco, V.M., 1999. Bioconversion of mixed solids Waste to Ethanol. Applied Biochemistry and Biotechnology, 79:455-471

OECD-FAO, 2007. Agricultural Outlook 2007-2016. Organisation for Economic Cooperation and Development and Food and Agriculture Organization of the United Nations, Paris and Rome.

Onyekwelu, J.C. and Stimm, B., 2002. *Gmelina arborea* in Enzyklopädie der Holzgewächse - 28. Erg. Lfg. Ecomed -publishers, Munich, Germany 8pp.

Onyekwelu, J.C., Mosandl, R. and Stimm, B., 2006. Productivity, site evaluation and state of nutrition of *Gmelina arborea* plantations in tropical rainforest zone in South-western Nigeria. Forest Ecology & Management, 229: 214–227.

Saha, B.C., Cotta, M.A., 2007. Bioconversion of lime pretreated wheat straw to Fuel Ethanol. In: Proceedings of the U.S.-Japan Food and Agricultural Panel 36th Annual Meeting, October 21-25, 2007, Tsukuba, Ibaraki, Japan. Pp. 284-287.

Schneider, K., 1997. Waldbau mit *Gmelina arborea* im Regenwaldgebiet Ghanas. AFZ/DerWald 4, pp 185-188.

Smyth, A.J. and Montgomerry, R.F., 1962. Soils and Land Use in Central Western Nigeria. Govt. Printer, Ibadan, Nigeria, 265 pp.

Soil Survey Staff, 2003, Keys to soil taxonomy, 9th ed.: United States Department of Agriculture, Natural Resources Conservation Service, USA, 332 pp

Stefan, T., 2007: “Shrubs supply Biofuel” in Deutschland forum for politics, culture and business magazine. “The Creative Economy”. Pp 36 – 37.