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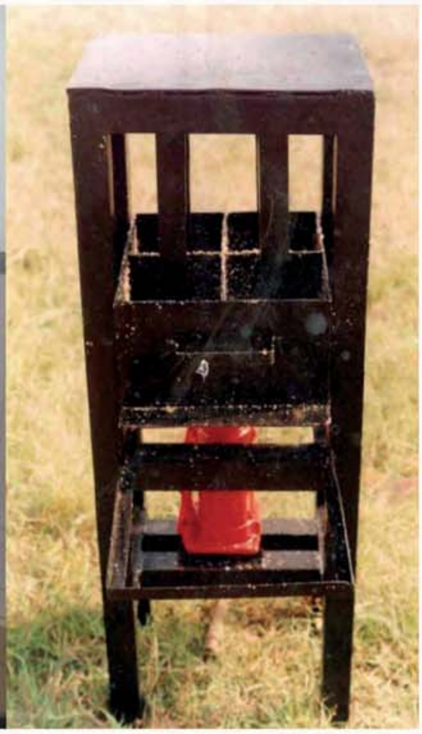

Edited by:

Professor Simeon O. Jekayinfa

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Alexander von Humboldt Foundaiton,
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DEDICATION

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

FROM THE EDITOR

Agricultural residues are the excesses of production that have not been utilized and currently constituting environmental problems. Finding practical and economic uses for the residues will create an opportunity for building a bioeconomy that can deliver sustainable economic growth. This may lead to job creation and social cohesion. Creating such a bioeconomy involves the substitution of fossil materials with renewable carbon. As a consequence of increasing the use of renewable resources for industrial feedstocks and for energy, the bioeconomy will bring benefits in a number of areas. These areas may include: Reduced dependence on imported fossil oil, Reductions in greenhouse gas emissions, , A bio-industry that is globally competitive, The development of processes that use biotechnology to reduce energy consumption and the use of non-renewable materials, Job and wealth creation, The development of new, renewable materials, New markets for the agriculture and forestry sectors, including access to high-value markets, Underpinning a sustainable rural economy and infrastructure., Sustainable development along the supply chain from feedstocks to products and their end-of-life disposal.

The articles contained in this book are a collection of research findings on value-added products from agricultural residues. These fields of science and technology cut across several disciplines which include agricultural engineering, chemical engineering, civil and construction engineering, microbiology, animal science & production, agronomy, agricultural economics & extension, rural sociology, food science and engineering, pharmacology and pharmaceuticals and all other allied disciplines.

Professor Simeon O. Jekayinfa

Dedication

From the Editor

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

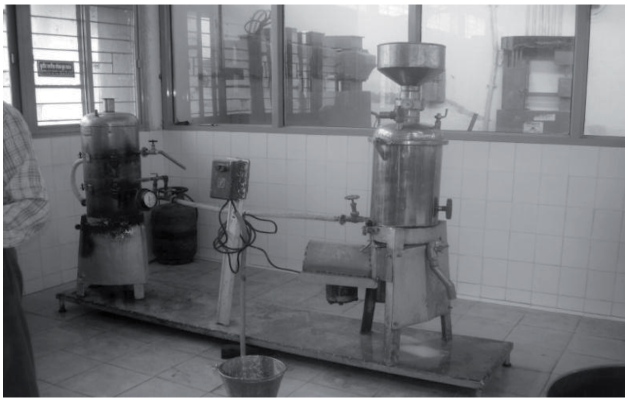

Fig. 9: Soy Milk, Cake and Cheese Machine

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

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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	Absorbance at 540nm		Concentration (8 ml)	
(years)	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.

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BIOFUEL TECHNOLOGY AND ITS SUSTAINABLE DEVELOPMENT IN NIGERIA

Adebayo, S.E.[1] and Ewemoje, O.E.[2]

[1]Agricultural Engineering Department,
Federal University of Technology, Minna.
E-mail: oluvictor4life@yahoo.com
[2]Agricultural and Environmental Engineering Department,
University of Ibadan, Ibadan.
E-mail: seyiajayi2@yahoo.com
Corresponding author e-mail: seyiajayi2@yahoo.com

Abstract

The article reviews establishment of a thriving Biofuel industry utilizing agricultural products as a means of improving the quality of automotive fossil-based Fuels in Nigeria. The paper further highlights the current status of the use and possible application of Biofuel in Nigeria through the introduction of Jatropha plant for Biodiesel production. Rapid Research and Development investments flowing into Jatropha cultivation, processing and conversion into Biodiesel through the adoption of modern techniques which could lead to Biomass increase and food yields was also discussed. Primary issues favouring Jatropha over other crops which are its non food nature, reported ability to grow on marginal lands and the special ability to grow with limited rainfall was reported. The drivers behind the rush to Biofuels production and its sustainability were also enumerated in the paper. Detailed explanation of the potential benefits of Biofuel was given in relation to improved energy security, economic gains, rural development, greater energy efficiency, reduced Green House Gases (GHG) emissions compared to standard Fuels, the expansion of the agricultural frontier and deforestation to mention a few. Negative impacts of Bio-Fuels in terms of food security, higher economic costs compared to conventional Fuels as a result of large scale development of Biofuel technology, spread of genetically modified organism resulting in contamination of local crop varieties with its attendant destruction of biodiversity. The study concludes by pointing out that Biofuels could help mitigate climate change and reduce dependence on oil. Furthermore, the exploitable bio-energy potential of the Sub-Saharan African region is reported to be significant despite concerns over food security and land ownership in crop production. Finally, Biofuels production represents an opportunity for the African region to increase energy supply security and to give a boost to rural economies by opening markets for agricultural surpluses, creating jobs and reducing carbon emissions. But on the negative note, the recent increases in food prices have been attributed worldwide to increases in Biofuel production as farmers have switched to crops for Biofuel, which have threatened food security in the region and worldwide generally.

INTRODUCTION

Biofuels are products that can be processed into liquid Fuels for either transport or heating purposes. Global production of Biofuels has doubled in the last five years and will likely double again in the next four years, according to the UN framework (Any Reference(s)?). Burgeoning demand for Biodiesel derived from plant oils has grown significantly over the last decade (Chand et. al. 2008). The advantages of Biodiesel compared to fossil diesel Fuel include: biodegradability, it is biorenewable, has low sulfur content and toxicity, its low volatility/flammability, and storage properties and salutary atmospheric CO2 balance for production (Srivastava and Prasad, 2004).

Among the countries that have enacted new pro-Biofuel policies in recent years are Argentina, Australia, Canada, China, Colombia, Ecuador, India, Indonesia, Malawi, Malaysia, Mexico, Mozambique, the Philippines, Senegal, South Africa, Thailand, Zambia Zimbabwe and Nigeria (Annie Dufey, 2006). Biofuels production represents an opportunity for the African region to increase energy supply security and to give a boost to rural economies by opening markets for agricultural surpluses, creating jobs and reducing carbon emissions. On negative note, the recent increases in food prices have been attributed to increases in Biofuel production as farmers have switched to crops for Biofuel, which have threatened food security in the region and worldwide (Annie Dufey, 2006).

CURRENT STATUS OF THE BIOFUEL INDUSTRY IN NIGERIA

At this time, Nigeria is establishing an Ethanol industry, using Cassava and sugarcane as Biomass. The introduction of the Jatropha plant for Biodiesel and the adoption of modern techniques could increase Biomass and food yields. As well, they could also reclaim land lost to desertification and improve the standard of living. Among all the oil bearing crops, Jatropha has emerged all over the world as the focal point for the Biofuel industry with rapid Research and Development (R & D) investments flowing into its cultivation, processing and conversion into Biodiesel. With the growing emphasis on the sustainability of the Biofuels production, there have been pressures on regulators and governments to set in place sustainable models for Jatropha cultivation and use as a Biofuel feedstock (KnowGenix, 2008).

While petroleum prices are increasing exponentially across the world, it is the African people who are being affected the most, with prices reaching #200/litre in some nations. This is the case in Senegal, where high gas prices have caused daily blackouts because their electric companies can not afford Fuel. There is a similar story in Nigeria. Despite its vast petroleum supplies and per capita income of less than $1,500, there are long queues at gas stations (Reference(s)?). With oil prices rising, the cost to produce and transport crops increases. In an impoverished nation, this can have huge consequences on the well being of the population. The integration of a Biofuel economy would help alleviate the inflated Fuel prices in Nigeria by providing a steady income to their people so that the purchasing of these expensive fossil Fuels becomes bearable. It is of the utmost importance that Nigeria and other countries in Africa start implementing Biofuels into their economy before this opportunity to industrialize passes.

Cassava is a tree like plant that is the staple food for Nigeria and much of the surrounding region. Nigeria is the world's largest producer of Cassava, with 30 million tons produced annually (Osterkorn, 2000).

Recent researches have shown that Cassava can be refined to create Ethanol. This discovery has already been well received by China and Thailand where Cassava is already being used to produce Ethanol; coincidentally the Cassava being used in these nations is being imported from Nigeria. The Nigerian government has already made an agreement with the Brazilian Fuel company, Petrobras, in which Brazil will supply the Nigerian national oil company with the technology to build and sustain an Ethanol industry in exchange for a Nigerian market for Brazilian Ethanol (The New Scramble for Africa). This is a tremendous step in the right direction because the Nigerian people will be creating their own industry instead of selling their resources and labor to foreign companies. This was initially what happened with the oil resources. Nigeria did not have the technological resources to develop a petroleum industry nor did they have the capital to start such an endeavor. With poverty on the rise and no solution on the horizon, the Nigerian government was forced to allow foreign companies to start and monopolize the petroleum industry. The result is that Nigerian oil is not making its way to the Nigerian people and none of the money from the profits is beneficial to the people. With this new deal with Brazil, the average farmer will personally profit from the sales of his crops. We must not forget about the hunger issues in Nigeria. Cassava is the main staple of this region.

If Cassava is being diverted for Ethanol production, then more people will starve. Fortunately this disaster is easily avoidable. In fact, the Nigerian National Petroleum Corporation (NNPC) has proposed agreements with the International Institute of Tropical Agriculture (IITA) that will focus on the low yield problems with Cassava. Once the agreements are made, researchers will study various Cassava varieties that could create higher yields (Osterkorn, year?). These higher yields will nullify the negative effect that Ethanol production would have on the food supply. Of course, this will not be enough. The Nigerian government will have to make sure that land is not sold in large expanse to Fuel companies. The best path for Nigeria is one in which the expansion of land dedicated to industrial Cassava farming is limited, while coupled with a set percentage of land dedicated to industrial and consumer use. The duty of a government is to provide for its people. If the land is sold to Fuel companies, then the people can not grow enough food to eat. This is why research into higher yield Cassava is so important.

THE DRIVERS BEHIND THE RUSH TO BIOFUELS

The current rush to Biofuels is due to a confluence of factors, many of them politically potent and economically appealing. One of the factors relates to Fuel security through a diversified energy portfolio. The volatility of world oil prices, uneven global distribution of oil supplies, uncompetitive structures governing the oil supply (i.e. the Organization of Petroleum Exporting Countries (OPEC) cartel) and a heavy dependence on imported Fuels are all factors that leave many countries vulnerable to disruption of supply. The need to address the growing volume of greenhouse gasses which in turn negatively influences the global weather patterns, as been internationally agreed to through the Kyoto Protocol is also another valued driver.

BIOFUELS AND THE SUSTAINABLE DEVELOPMENT DEBATE

Links between Biofuels and sustainable development are varied and complex. On one hand, Biofuels may imply improved energy security, economic gains, rural development, greater energy efficiency and reduced Green House Gases (GHG) emissions compared to standard Fuels. On the other hand, production of energy crops could result in the expansion of the agricultural frontier, deforestation, monocropping, water pollution, food security problems, poor labour conditions and unfair distribution of the benefits along the value chain. The positive impacts and trade-offs involved vary depending on the type of energy crop, cultivation method, conversion technology and country or region under consideration.

POTENTIAL BENEFITS OF BIOFUELS

The perceived benefits of Biofuels are reflected in the increasing number of countries introducing or planning to introduce policies to increase the proportion of Biofuels within their energy portfolio. If this is to be achieved, significant increases in production are required to rapidly satisfy greater global demand. The following are some of the potential benefits of Biofuels production.

PRODUCTION DIVERSIFICATION AND VALUE-ADDED

Biofuels generate a new demand for agricultural products that goes beyond traditional food, feed and fibre uses. This may reduce the problem of commodity surpluses. In addition it provides an opportunity for more value addition to agricultural output. All of these aspects are needed to support poverty reduction, especially in developing countries. Nigeria is likely to benefit because she can now add value to her sugar instead of exporting it in the raw form and this is likely to lessen her dependence on European Union (EU) where she has been coerced to enter into agreements in order to access the EU market when exporting sugar.

GREEN HOUSE GAS (GHG) EMISSIONS

One of the greatest advantages associated with Biofuels and one of the main driving forces behind worldwide Biofuel uptake are their alleged reduced GHG emissions, and hence their potential to help minimise climate change. However, there is considerable variation in GHG savings, ranging from negative to more than 100%. Estimates vary according to the type of feedstock, cultivation methods and conversion technologies. A recent evaluation of six studies on GHG reduction of corn-based bioEthanol found a variation from a 33% decrease to a 20% increase, averaging a 13% reduction in GHG emissions compared to petrol (Koonin, 2006). Estimates for wheat-based bioEthanol point to reductions ranging from 19 to 47%, while for sugar cane based bio-Ethanol estimates were around 92% in Brazil (IEA 2004). One estimate for rape based bio-Ethanol in Brazil showed a 95% reduction compared to standard Fuel (IEA, 2004). Figure 1 shows estimates of GHG reduction for different types of Biofuels.

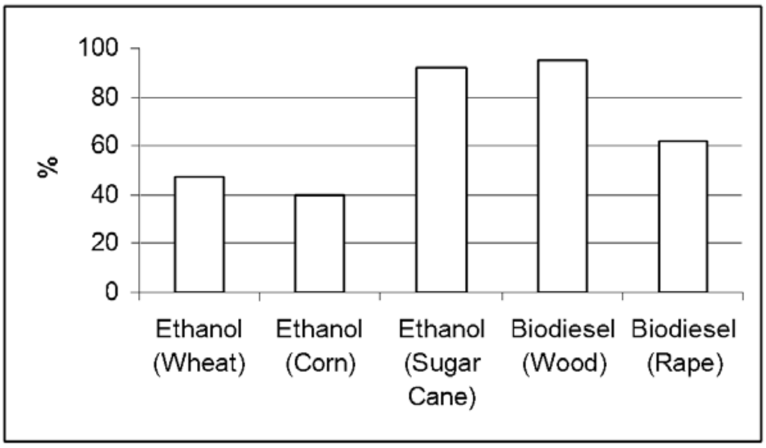

Fig. 2: GHG reductions for different Biofuels
Source: E4 Tech, et al 2005

The variation in levels of GHG emissions for different types and sources of Biofuels make it difficult to predict the achievement of GHG reduction targets for policy makers in countries that rely on various sources of Biofuels. This highlights the need to identify Biofuels with lower GHG emissions and create incentives for their production. At the same time it is important to bear in mind that Biofuels are not deemed to provide a final solution to global warming but they form an important component of an integrated approach to tackling the issue (Macedo *et al.*, 2004).

EMPLOYMENT CREATION AND QUALITY

In addition to the environmental benefits of Biofuels, a primary motivation for the promotion of Biofuels in Nigeria is rural economic development (MEPD, 2007). Biofuel production can have a positive impact on agricultural employment and livelihoods, especially when the cultivation of jatropha involves small-scale farmers and the conversion facilities are located near the crop sources in rural areas. Sugarcane plantation in Nigeria for instance, employs a lot of workers and the number is expected to grow if Ethanol production is fully entered into. BioEthanol related jobs involve low skilled and poor workers in rural areas.

IMPROVED LIVELIHOODS

In addition, Biofuel production offers opportunities for better livelihoods. As its production requires many crops as inputs, policymakers see the promotion of Biofuels as a viable option

to change the composition of agricultural output from surplus food commodities to Fuels that can be consumed domestically. This increased demand for agricultural commodities could significantly increase the price of agricultural commodities, and therefore farmers' incomes. A problem that has been highlighted in this respect relates to the potential trade-offs that might arise in terms of food security in the poorest countries.
Primary issues favouring Jatropha over other crops are its non food nature, reported ability to grow on marginal lands and the need for limited rainfall. There are also claims of Jatropha assisting in preventing deforestation and desertification, and improving soil fertility. However, experiences across the developing world have been quite varied reflecting complexities in local practices, soil, water and climatic factors (KnowGenix, 2008). Livelihoods could also improve because of the positive impacts on land restoration associated with crops such as jatropha. Becker and Francis (2005) argue that once the jatropha trees establish themselves and fertilize the soil, their shade can be used for intercropping shade-loving vegetables such as red and green peppers, tomatoes, etc, which would provide additional income for the farmers.

NEGATIVE IMPACTS OF BIO-FUELS

Most of the negative sentiments around bio-fuels, especially bio-Ethanol, are derived from concerns in the market around energy balances and the ability of the agricultural industry to produce sufficient raw material cost effectively.

FOOD SECURITY

The debate of crops for food versus crops for Biofuels remains one of the major problems yet to be resolved. There is the worry that an increase in the use of food crops such as maize, cassava and sorghum is likely to increase the food price of most staple foods in Nigeria. It has been argued in one of the articles that grain to fill a 4x4 car could feed a person for a year. Price rise will depend on whether or not oil crops are planted on arable land that could otherwise be used for growing food crops, and whether water is diverted from food crops to irrigate the Biofuel plantations. It has also been argued that increasing Biofuel development is likely to affect food aid. The United States for example, provides food aid from its surplus crops. But if the surplus is used for US Biofuels, the US will use the surplus food crops for Biofuels instead of donating it to Africa. At a consultative workshop hosted by AIPAD, it was agreed that food security is non negotiable and therefore food production should not compete with Biofuels.

HIGHER COSTS THAN CONVENTIONAL FUELS

One of the biggest barriers to large-scale development of Biofuels remains their higher economic costs compared to conventional Fuels. Some estimates show Biofuels to be twice as costly as conventional Fuels. (Petroleum Economist, 2005). Economic costs, however, tend to differ depending on the type of Biofuel, the country of provenance and the technology used.

EXPANSION OF THE AGRICULTURAL FRONTIER AND FOREST CONVERSION

Another concern associated with increased Biofuel production is the impact on the agricultural frontier. Biofuels are expected to contribute to around 20 to 30% of global energy demand by 2030. This is very likely to exacerbate the already intense competition for land between agriculture, forests and urban uses. Sugarcane production has been linked to the clearing of some of the most unique and biodiverse regions on the planet. Likewise, if the increased Biofuel demand were met by soya-based Biodiesel, this would imply further environmental pressure.

SPREAD OF GENETICALLY MODIFIED ORGANISMS (GMOS)

There is considerable concern that Biofuel development will lead to a wider spread of GMOs because of the need to improve both the economic efficiency and the energy efficiency of Biofuels. The use of GMOs will contaminate local varieties and destroy biodiversity. The main arguments against genetically modified GM technologies relate to food safety concerns, and their impacts on biodiversity and on farmers' livelihoods.

TRADE IN BIOFUEL

Currently, very little Biofuel enters international markets since the bulk of it is consumed in domestic markets. Trade in Biodiesel is at a less developed stage than trade in bioEthanol. However, it is expected that trade in Biodiesel will develop in a similar way to that of bioEthanol. There is already some evidence of increasing trade flows. The EU, for instance, currently imports about 3.5 million tonnes of refined and crude palm oil a year, mainly from Malaysia and Indonesia. In Nigeria, there is no trade in Biofuels because currently, production in most African countries is still at its infancy.

At present there is no comprehensive trade regime specifically applicable to Biofuels. Biofuels are categorised as "other Fuels" or as alcohol (in the case of Ethanol) and are subject to general international trade rules under the World Trade Organization (WTO). Energy crops are covered by the WTO Agreement on Agriculture.

FUTURE PROSPECTS OF BIOFUELS PRODUCTION IN NIGERIA

All things considered, it appears that Biofuels are indeed high on Nigeria's agenda as in all other countries, industrialised and developing are implementing or planning to implement directives to promote greater use of Biofuels. However, uncertainty still surrounds Biofuels' potential in Nigeria because climate change, energy shortages, food security, land availability and sustainability all have to be taken into consideration. The most important criteria in the long-term sustainability of Biofuels is not whether they produce enough reward, but whether the Biofuels industry is able to sustain a market. If a market cannot be sustained, supply cannot satisfy demand, and viability will then become questionable.

The potential of Biofuels production in Nigeria seems unlikely to be realized due to the concerns over food prices and environmental degradation caused by growing of Biofuels. The unfavourable economics of Biofuels also suggests that the potential of Biofuels is unlikely to be realised. Although there is hope for production costs for Biofuel feed stocks to decline as a result of improvements in yields, it is not clear that such improvements will be enough to compensate for rising prices due to production factors and the combined pressures on prices of rising demand for food, feed and Biofuels. Increasing competition with Biomass feed stocks, woody material as well as agricultural products is actually pushing feedstock prices and production costs up. Higher oil prices will have the effect of increasing Biofuel production costs while simultaneously making fossil Fuel alternatives increasingly competitive.

CONCLUSIONS AND RECOMMENDATIONS

This study pointed out that Biofuels could help mitigate climate change and reduce dependence on oil in the transport sector. They can also have a positive impact on the limited foreign exchange reserves of many African countries. When well managed, they also offer large new markets for higher priced products for agricultural producers that could stimulate rural growth and farm incomes. Biofuel production could be especially beneficial to poor producers, particularly in remote areas that are far from the consumption centres, where inputs are more expensive and prices lower, making food production, by and large, noncompetitive. Farmers in these areas could plant crops that do not compete with production of food crops such as jatropha.

The exploitable bio-energy potential of the Sub-Saharan African region is significant despite concerns over food security and land ownership. One area of bio-energy development that offers some opportunities both for domestic markets and international markets is bio-Ethanol. The region has a fairly strong industrial base in the sugar industry. Expansion of sugar production is unlikely to be rewarding, given decisions in recent years to reduce the preferential market access to Agricultural Common Policy (ACP) countries.

Biofuels production must take into account social issues: accessibility, affordability and acceptability. Given the existence of important potential benefits associated with Biofuels, there is need for investment in research and development on Biofuels in order to assess the negative impacts against the potential benefits. The international community can also help by providing evidence on the costs and benefits of Biofuels; evidence on the impacts of different policy tools; and the development of global market incentives and financial resources for market development in the poorest countries.

In general, Biofuels that use food sources are costly to the poor and raise prices on the basic foods that already represent a large share of poor people's household spending. It should also be noted that crop subsidies that encourage the production of Biofuels from certain food sources have a welfare burden on the poor. In certain cases, the benefit to society at large of reducing carbon emissions might justify some level of producer support and price policy towards Biofuels, since simple market forces do not recognize such benefits, and fail to reflect them in market prices. If this were so, then the cost of fossil-based Fuels would be much higher, as a reflection of their true impact on the environment.

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THE POTENTIALS OF BIODIESEL PRODUCTION AS A FUEL FOR DIESEL ENGINES IN NIGERIA.

Bamgboye A.I. [1] **and Oniya O.O.**[2].

1. Department of Agricultural Engineering,
University of Ibadan, Ibadan.
2. Department of Agricultural Engineering,
Ladoke Akintola University of Technology,Ogbomoso.
Coresponding Author: O.O. Oniya. E-mail; toyinprayer@yahoo.com

Abstract
Current increase in petroleum prices together with increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum Fuels for engines. Biodiesel is one of such non-petroleum Fuels with positive environmental benefit of reducing the dangerous exhaust emissions in diesel engines. Biodiesel is made from vegetable oils and animal fats and is presently produced and marketed in many developed countries for Fuelling diesel engines. It is relatively unknown as a Fuel in Nigeria, although there is an obvious need to conserve and/or supplement the available petroleum resources with renewable Fuels. This paper examines the methods of Biodiesel production and reviews the potential problems and prospects of its production in Nigeria.

Keywords: Biodiesel, vegetable oils, renewable Fuels.

INTRODUCTION
Energy is the essence of life on earth and is one of the most basic of human needs, not as an end in itself but as a means to numerous ends. Energy is needed to sustain technological development and the quality of life in any society. This energy comes from natural resources as fossil Fuels, such as coal and oil, living resources, such as Biomass, nuclear Fuel such as uranium, or renewable resources such as flowing water and wind and the power of the sun.
In the last century, there was concern that fossil Fuels would run out, plunging the world into an energy crisis. Today the fear is that their continued use might be wrecking the global climate by emitting carbon dioxide (CO2) as we burn carbon- containing Fuels. This anxiety has generated an intense international interest in developing alternative non-petroleum Fuels for engines. Vegetable oils have attracted attention as a potential renewable resource for the production of an alternative for petroleum based diesel Fuel. Various Biofuels derived from vegetable oils have been proposed as an alternative Fuel for diesel engines, including neat vegetable oils, mixtures of vegetable oil with petroleum diesel and alcohol esters of vegetable oil (Ma, et al., 1999). Alcohol ester known more generically as Biodiesel is the most commonly used method and appears to be the most promising alternative (Krawczyk, 1996 and Conceicaco et al., 2005).
In its most general sense, Biodiesel is any Biomass derived diesel Fuel substitute (Sheehan, et al., 1998). Most commonly, it refers to various ester-based oxygenated Fuels composed from vegetable oils or animal fats (Hobbs, 2003). Biodiesel can be used in it's pure form to Fuel any existing diesel engine, and it can be blended with petroleum diesel.

There are unfavourable cold weather flow properties of the Biodiesel Fuel leading to operatability problem of the engine in cold climate and temperate regions (Shresta, et. al., 2005). This is the reason that Rakopoulos et. al. (2006) reported that blends of not more than 10-20% Biodiesel with petroleum diesel should be used in existing diesel engine without modification. They noted that higher percentage of blends can limit the durability of engine components leading to engine malfunctioning. This problem of unfavourable cold weather flow properties of the Biodiesel Fuel is not an issue in the tropics. Therefore the Fuel is more suitable for use in the tropics. Krawczyk (1996) identified Biodiesel as a possible replacement to fossil's Fuels as the world's primary energy source.

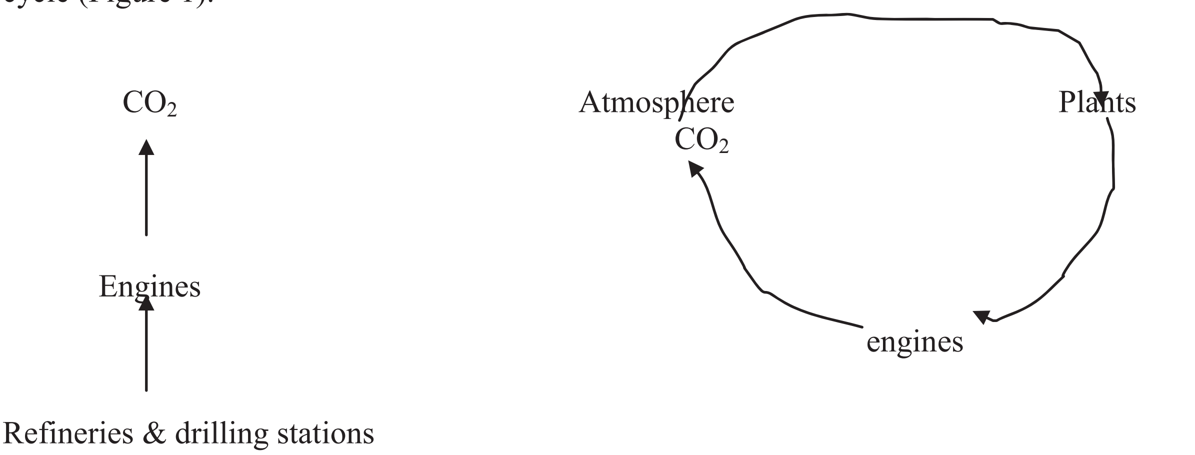
PERFORMANCE OF BIODIESEL IN COMPRESSION IGNITION ENGINES

Biodiesel has become more attractive recently as an alternative Fuel for compression ignition engines because of its numerous advantages. Hobbs (2003); Faupel and Kurki (2002); Elsebeth and Bialkowski (2003) have given a number of distinct advantages of using Biodiesel over fossil Fuel. They are stated as follows:

1. It is renewable and has positive environmental benefits. It burns up to 75% cleaner than conventional diesel Fuel made from fossils Fuels.
2. It substantially reduces unburned hydrocarbons, carbon monoxide and particulate matter in exhaust fumes.
3. It is plant based and adds no CO_2 to the atmosphere. Instead of releasing stored carbon in to the atmosphere, there is occurrence of basically cycling carbon.
4. The Fuel economy is the same as conventional diesel Fuel.
5. Sulphur dioxide emission are eliminated (Biodiesel contains no sulphur).
6. Increased Nitrous Oxide (NO_x) emissions can be reduced to below conventional diesel Fuel level by retarding engine timing.
7. It is a much better lubricant than conventional diesel Fuel and extends engine life.
8. It has a high cetane rating, which improves engine performance and efficiency.
9. Biodiesel increases safety in storage and transport because the Fuel is non-toxic. It is neither harmful nor toxic to humans, animals, soil or water.
10. It has high calorific value and high energy density.
11. It is biodegradable.
12. Increased value for our farm products, especially the vegetable oils.

One of the biggest advantages of Biodiesel compared to many other alternative transport Fuels is that it can be used in existing diesel engines without modification (Shresta, et. al., 2005 and Briggs, 2004).

It is worth mentioning that while our current energy system can be represented by an irreversible, open cycle, an energy system based on natural vegetable oil constitutes a closed cycle (Figure 1).



Natural closed cycle based natural vegetable oil
current open cycle based on petro diesel

Fig 1: Energy system based on petro-diesel and natural vegetable oil

It has been reported that petroleum diesel exhaust causes cancer and other human health problems (Faupel and Kurki, 2002). However, the use of Biodiesel in diesel engines has been found to reduce significantly the emissions (e.g carbon monoxide, carbon dioxide, hydrocarbons, etc.) which cause cancer. (Hobbs 2003; Faupel and Kurki 2002; Elsebeth and Bialkowski, 2003).

Another advantage of the use of Biodiesel is that with care and practice, Biodiesel can be produced on – farm using a variety of oils as feedstock. Farmers can produce their own Fuel for tractors and other farm equipment from their own oil seeds or from Waste fryer oil collected in neighbouring communities.

BIODIESEL – THE BEST ALTERNATIVE TO PETROLEUM BASED DIESEL FUEL

The greatest driving force for the use of Biodiesel is the need to have a Fuel that fulfills all of the environmental and energy security needs required which does not sacrifice operating performance. One of the largest roadblocks to the use of alternative Fuels is the change of performance noticed by users.

The most noted attribute of Biodiesel is the similar operating performance to conventional diesel Fuel and the lack of major changes required in facilities and maintenance procedures. (Shresta, et. al., 2005; Rakopoulos et. al., 2006).

Rakopoulos, et. al., 2006; Faupel and Kurki, 2002; Mohammed et. al., 2002 gave a number of disadvantages encountered when using Biodiesel in compression – ignition engine. They are stated as follows:

1. Biodiesel Fuels have higher viscosity, higher pour point, lower heating value and lower volatility than petroleum diesel Fuel.
2. The oxidation stability of Biodiesel Fuels is lower, and they are hygroscopic.
3. As solvents they cause corrosion of component, attacking some plastic materials used for seals, hoses, paints and coatings.
4. They showed increased dilution and polymerization of engine sump oil, thus requiring more frequent oil changes.
5. The use of vegetable oil for Fuel causes competition with the use of vegetable oil for food.
6. There is the possible concern with engine warranties.
7. Special measures must be taken to use Biodiesel, particularly B100 (i.e pure Biodiesel) in cold climates.
8. Higher per gallon cost than petroleum diesel in the current market.
9. Limited commercial availability of the Fuel, if you are not going to process it yourself.

BIODIESEL PRODUCTION TECHNOLOGIES

There are four primary ways to make Biodiesel. (Ma et. al., 1999; Rakopoulos, et. al., 2006). They are direct use and/or blending; micro emulsion, thermal cracking (pyrolysis) and transesterification.

In direct use, pure vegetable oil is used to Fuel the diesel engine, while in blending, a blend of vegetable oil and diesel Fuel is used. The main problem with the direct use of vegetable oils as Biodiesel Fuel is high viscosities (Rakopoulos, et. al., 2006). Other problems associated with the direct use of vegetable oils as Fuels were oil deterioration and incomplete combustion (Peterson, et. al., 1983; Frame, et. al., 1997). The incomplete combustion resulted in carbon deposits and lubricating oil thickening. (Ma, et. al., 1999). The purpose of blending vegetable oil with diesel Fuel is to lower the viscosity to make it thinner, so that it flows more freely through the Fuel system into the combustion chamber. (Ma, et al 1999). It is note worthy that direct use of vegetable oils and\or the use of blends of the oils has generally been considered to be not satisfactory and impractical for both direct and indirect diesel engines because of the obvious problems associated with it as discussed earlier (Elsbett and Biakowki, 2003). However, the Elsebett engine has been developed for successful direct use of vegetable oils. (Elsbett and Biakowki, 2003).

In micro-emulsion, a colloidal equilibrium dispersion is formed by mixing vegetable oils with solvents such as mEthanol (Schwab et al., 1987). Though the performance of such micro emulsions has been reported to be as good as that of diesel Fuel (Goering et al., 1984), the problem of heavy carbon deposits, incomplete combustion and an increase of lubricating oil viscosity have been reported (Ziejewski et. al., 1984).

Thermal cracking (pyrolysis) involves heating vegetable oils or animal fats in the absence of air to produce a variety of Biofuels (Sonntag, 1979). The initial product of the pyrolysis of vegetable oils or animal fats is a crude oil (Ma, et al., 1998). The crude oil can be refined to produce diesel Fuel and small amounts of gasoline and kerosene (Ma, et al., 1998). The major problems associated with this method include the fact that the equipment for thermal cracking is expensive for modest throughput.

In addition, while the products are chemically similar to petroleum derived gasoline and diesel Fuel, the removal of oxygen during the thermal processing also remove any environmental benefits of using an oxygenated Fuel (Ma et al., 1998).

Transesterification involves the reaction of fat or oil with an alcohol to form esters and glycerol (Watt et al., 1997). Chemically, it is defined as the reaction of triglyceride molecule of vegetable oil or animal fat with a simple alcohol such as mEthanol, Ethanol, butanol or iso-propanol to form esters and glycerol. (Watts, et. al., 1997). In simpler terms transesterification is the conversion of heavy oils or fats into a less viscous fluid that is suitable for combustion in a conventional diesel engine (figure 2). The esters are used as Biodiesel Fuel. This method is generally the preferred and most probably the best option to making Biodiesel.

Biodiesel can be used in pure form, or blended with petroleum diesel for use in compression ignition engines. The physical and chemical properties of Biodiesel Fuel are similar to petroleum diesel Fuel.

similar to petroleum diesel Fuel.

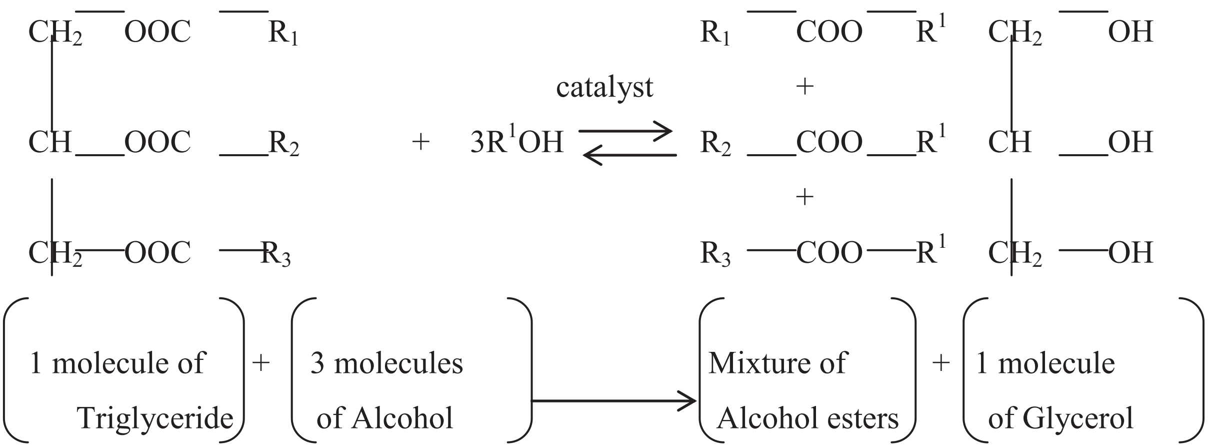


Fig 2: - Transesterification of Triglycerides (or plant oils) with alcohol (Ma et al., 1999)

COMMON FEEDSTOCKS FOR PRODUCTION OF BIODIESEL

The common feedstocks for production of **Biodiesel** are:

(a) Virgin oil feedstock such as palm oil, soybeans oil, sunflower oil, coconut oil, rapeseed oil, tung oil, mustard oil, corn oil etc. (Faupel and Kurki, 2003, Elsebeltt and Bialkowski, 2003).

(b) Animal fats including tallow, lard, yellow grease and fish oil. (Elsebett and Biaskwoski, 2003)

(c) Waste vegetable oils and restaurant grease.

Biodiesel Production in Nigeria

A number of problems in the refining and distribution sectors of the petroleum industry had led to persistent soaring of prices of the locally refined and imported products, despite the fact that there are abundant oil reserves in Nigeria which make the country a potent petroleum oil producer in the world. These price increases have become too frequent in the recent past and there is need to think of other alternatives or supplements such as Biodiesel that can be produced and used in the country. Plants with oilseeds abound in the country and the oils can be used as feedstock for Biodiesel production.

POTENTIAL PROBLEMS OF PRODUCTION OF BIODIESEL IN NIGERIA

The production of Biodiesel in Nigeria can only be possible after addressing the following problems.

A. Lack of Adequate Feedstock for Sustainable Production

Vegetable oils are mainly produced from groundnuts, cottonseed, palm kernels and sheanuts, although several oil-bearing crops exist in the country. The predominant small-scale agriculture practiced in the country had prevented self-sufficiency in edible oil production from being achieved; hence there is importation to meet demand for domestic and industrial use. Animal fats and spent or Waste frying oils, which are claimed to be unhealthy for human and animal consumption because they contain trans fatty acids are cheaper feedstock used elsewhere. However, the low income and cooking habits of most Nigerians are such that animal fats and oils used in frying are used completely leaving no Waste. Hence, this category of feedstock cannot become available for Biodiesel production in the near future.

B. Vegetable Oils are more Expensive Than Petrodiesel

The vegetable oils obtained in the local markets have average prices in the range of ₦155 - ₦250 per litre, and are more expensive than petrodiesel (Table 1). The cost of producing Biodiesel from available vegetable oils, assuming adequate feedstock supply would not be attractive at all compared to petrodiesel since production cost include cost of the feedstock. Therefore it is not economical presently to use the available vegetable oils for producing Biodiesel.

Table 1: Market prices of vegetable oils and petrodiesel in Ogbomoso in April, 2010

S/N	Commodity	Average price (₦/litre)
1	Groundnut oil	180.00
2	Palm oil	160.00
3	Cotton seed oil	155.00
4	Imported oil (Turkey brand)	250.00
5	Petrodiesel	90.00-110.00

C. **Little or no Incentive from Government for Farmers**
Farmers have little or no incentive from the government to purchase costly agricultural services and inputs such as fertilizer and other chemicals to improve local production of vegetable oils to accommodate its use for the production of Biodiesel.

D. **Abundant Petroleum Resources**.
Nigeria has abundant petroleum reserves which make petrodiesel cheaper than many alternative Fuels including Biodiesel. This will hinder the country from taking the production of Biodiesel seriously.

E. **Lack of Equipment and Facilities for Research and Development**
The essential equipment and laboratory facilities needed for the production of Biodiesel are not available in higher institutions and research centers in the country.

PROSPECTS FOR BIODIESEL PRODUCTION IN NIGERIA

The problems listed above notwithstanding, there are prospects for Biodiesel production in Nigeria listed below.

A. **Use of Non - Edible Feedstocs**
There are non-edible oils such as those of loofah and neem seeds which can be harnessed for the production of Biodiesel since they do not compete as food items. Others are castor and pumpking seed oils.

B. **Technical Feasibility**
The technology involved in the production of Biodiesel simple. There are adequate engineers and technicians in Nigeria to produce the Fuel.

C. **Conservation of Petroleum Resources**
The production and use of Biodiesel the country would conserve the available petroleum resources and provide more crude oil for export.

CONCLUSION

From a technological stand point, producing Biodiesel will help Fuel the transition to a more sustainable transportation system. Most of the current challenges facing the use of Biodiesel globally is its production cost, as the cost of Biodiesel is still higher than it's petro-diesel counterpart. This opens a golden opportunity for the use of Waste seeds such as loofah, neem, pumpking and castor seed oils as its production feedstock.

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