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AN OVERVIEW OF BIOETHANOL PRODUCTION FROM CASSAVA FEEDSTOCK IN NIGERIA

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ABSTRACT
The production of bioethanol from cassava feedstock may hold great promises for the fact that cassava is easily accessible, abundant, and has relatively low cost of production. However the high output of cassava in the country is in fact due to government policies in providing improved varieties and enhanced production practices. Currently Nigeria being the leading cassava producer in the world, has decided to participate in the production of bioethanol mainly from Cassava (*Manihot esculenta* Crantz) feedstock. However, there is need for the government to review both short and long term strategies for cassava production, in order to meet the extra demand for bioethanol production. Since Nigeria government has embarked on an ambitious program to promote the use of bioethanol as transportation fuel. Therefore it is concluded that due to large availability of cassava in Nigeria gives a great potential for biofuels production. The study offers suggestions, to serve as contributions for the bioethanol programme these include excise tax exemption for the biofuels production and income tax waiver for both local and foreign investors; introduce loans and subsidies for biofuel production etc.

INTRODUCTION

Perspectives on Cassava Production

Cassava (*Manihot esculenta* Crantz) is one of the staple food crops, in terms of its production it is ranked as the sixth most important world food crop (El-Sharkawy, 2004). The production takes place in the tropical part of the world, it is grown and cultivated throughout the year in humid regions of the world which include Northern Eastern Brasil, Nigeria, Ghana, the Pacific Ocean and certain islands in Indonesia (Stupaka *et al,* 2006; Olsen and Schaal, 2007). Nigeria is ranked as the topmost cassava producing country in the world (see

Table 1 Below) (FAO, 2004; Oyekanmi and Okeleye, 2007; Ingledew *et al,* 2009; Abila, 2010). Cassava plays a major role in providing the dietary calories for approximately 40% of the rural population in Africa and considered to be the next crop after maize with regard to calorific values (Jekayinfa and Olajide, 2007).

Table 1: Showing Nigeria Position in World Feedstock Production

Crop	2008 Average Yield (MT)	Nigeria's Nominal Production Rank (Global)	Nigeria's Yield Land Productivity Rank (Global)	Nigeria's Cultivated Area (Ha) Rank
Sesame	110,000	7th	13th	6th
Palm fruits	8500,000	4th	20th	3rd
Ground Nut	3900,000	3rd	6th	3rd
Soybean	591,000	13th	20th	10th
Coconut	234,000	19th	10th	17th
Cotton Seed	492,000	12th	18th	9th
Cassava	44,582,000	1st	13th	1st
Maize	7525,000	14th	17th	7th
Green Maize	5709,000	3rd	17th	2nd

Source: Abila (2012)

Cassava crop is a rich source of carbohydrate consumed by more than 500 million people around the world, the crop is also used in industries as a raw material in making animal feeds, processing of starch etc. cassava leaves has lots of vitamins and protein value of 5.1-6.9% (Stupaka *et al,* 2006; Oyekanmi and Okeleye, 2007; Ian *et al,* 2010; Bull *et al,* 2011). But the roots lack essential nutrients however the crop has only a total of 1-3% dry matter of protein with less quantities of some vital elements. However despite the commercial value of cassava, unlike other crops, cassava is a perishable crop quickly degenerate between 2-7 days after harvest (Stupaka *et al,* 2006; Ian *et al,* 2010). Cassava can successfully thrive even with little application of farm inputs, and it can grow productively in diverse agro ecological conditions (Nguyen *et al,* 2007).

However cassava is prepared using various procedures into assorted nutritional foodstuff and other industrial products. In Nigeria animal, feeds prepared as chips from the cassava tubers take up sixteen percent (16%) of the cassava output; five percent (5%) of the tubers are used in producing molasses for further treatment to produce soft drinks. While dextrin, confectionaries, pharmaceutics, alcohols, gums, starch, and flavours consume below one percent (1%) of the cassava tubers, in addition biogas is produced from accumulated cassava waste via anaerobic digestion. Similarly, combine heat and power (CHP) can be accessed from the use of cassava peels, the cassava tubers are processed into flour or starch which are further prepared into gari, fufu, akpu, tapioca cakes and snacks etc (Jekayinfa and Olajide, 2007; Oyekanmi and Okeleye, 2007; Echebiri and Edaba, 2008; Agboola and Agboola, 2011). The likelihoods for Nigeria to succeed in its bioethanol production programme may be high because about ninety four (94%) percent of its population are producing food crop and sixty eight (68%) are livestock farmer respectively. Moreover the issue of land further increased its chances, because the country has an estimated land area of 92.4 million hectares and 79.4 million hectares is the land mass and the total area of land under agricultural activities is 71.9 million hectares (see table 2 below) (Jekayinfa and Olajide, 2007; Agboola and Agboola, 2011).

Table 2: The Land Area of Nigeria and Areas under Agricultural Use

Nigeria	Percentage (%)	Quantity (Million Ha)
a. **Size**		
Total area	100.0	92.4
Land area	85.9	79.4
Water bodies	14.1	13.0
b. Land Use		
Agricultural Land	77.8	71.9
Arable cropland	30.5	28.2
Permanent cropland	2.7	2.5
Pasture land	30.6	28.3
Forest and woodland	11.6	10.9
Fadama	2.2	2.0
Other land	8.1	7.5

Source: Agboola and Agboola (2011)

The aim of this paper is to investigate Nigeria's plan of using cassava as one of the principal feedstock for bioethanol production, the information resulting from this study will serve as a base for more detailed research.

CASSAVA BIOETHANOL PRODUCTION STRATEGY IN NIGERIA

In spite of the abundant crude oil reserve available in the country, Nigeria intends to join other biofuel producing nations. The federal government of Nigeria make this known in August 2005 following an official mandate to the Nigerian National Petroleum Corporation (NNPC) to fashion out modalities for the biofuel production business in the country (NNPC, 2007).

About 5.14 billion litres per annum of biofuel is the required quantity specified by the Nigerian government, this quantity is expected to alleviate the suffering the country has been experiencing for over decades of purchasing refined oil from overseas. Moreover the private sector have showed positive interest in participating towards realizing this objective, with this development it is estimated that there is a capital spending of more than $3.86 billion for building nineteen processing plants, and a farm dedicated for producing the raw materials. In addition there are also ten thousand divisions of small refineries which are capable of producing more than 2.66 billion litres of ethanol per annum. Likewise more projects are believed to emerge in foreseeable future, as an agrarian country, Nigeria is blessed with vast fertile arable land making agriculture the foremost occupation. The vast majority of the population are engaged in the production of different types of crops in the rural areas of the country. Therefore the biofuel programme may benefit from easily accessing the ample raw materials of agricultural goods produced in the country. In addition, the government also intend to utilise this avenue to restore the lost glory of the country's agriculture production (Ohimain, 2010).

Farinell *et al,* (2009) mentioned that Nigeria procured about one hundred and twenty three million litres of ethanol from Brazil in 2007 this translate to only about 2% of the total ethanol requirement of the country. Besides since the government announced that it would start biofuel production in 2005, still the country is not producing enough quantities that is required to meet the target of more than 5 billion litres annually. In fact most of the producing facilities are yet to start working, but the few functional bioethanol producing plant include Allied Atlantic Distilleries Ltd (AADL) among the most recent bioethanol plant that started production in 1999 with an output of about 30,000litres per day of ethanol. However AADL is also the single factory that is utilizing the cassava produced by the rural farmers for the production of bioethanol. Another emerging bioethanol factory is the Dura Clean production Plant which has not yet resume production, moreover an approximately 118.6 million litres which translate to almost ninety percent (see table 3 below) of the combine bioethanol output of the country is produced by UNIKEM, Alcon/Nosak and Intercontinental Distilleries. Unlike AADL this ethanol producing factories deny Nigerian farmers from getting the contracts of supplying feedstock but rather these industries procure their feedstock from Brazil (Ohimain, 2010).

Table 3: The Present Quantities of Biofuel Produced in Nigeria

Name of Company	Plant Location	Feedstock	Installed Capacity (Mill L/yr.)
Alconi/Nosak	Lagos	Crude ethanol (imported)	43.8
UNIKEM	Lagos	Crude ethanol (imported)	65.7
Intercontinental Distilleries	Ota-Idiroko	Crude ethanol (imported)	9.1
Dura clean (Formerly NIYAMCO)	Bacita	Molasses/cassava	4.4
Allied Atlantic Distilleries Ltd. (AADL)	Sango-Ota	Cassava	10.9
Total			**133.9**

Source: NNPC (2007b)

Among other plans of the Nigerian biofuel initiatives is to launch a six Automotive Bioethanol Schemes across the country with four sites in the northern zone and two in the southern agro ecological zones of the country respectively. The plan is to establish bio-refineries and acquire land for cultivating the raw materials that will supply the refineries in these areas. Two of the cassava bioethanol factories is expected to give an average output of fifty million litres of bioethanol and it is likely to generate combine heat and power (CHP), biogas, provide energy output of 8.53MW annually, produce feeds for animals, as well as produce starch by utilizing the feedstock harvested from the fifteen thousand hectares of cassava plantations in the southern part of the country. On the other hand the government has also declared sixteen thousand hectares for sugar cane plantation, from a total of sixty thousand hectares of acquired land. Each plantation will have twenty thousand hectares of land. However the three ethanol plants is projected to produces a combine output of seventy five million litres per annum of ethanol and about 116, 810 metric tonnes of sugar cane is believed to possibly turn out 59MW of power in the northern part of the country. Furthermore in a bid to further reduce the use of fossil energy, the federal government plan to replace the widely used kerosene cooking fuel with ethanol base cooking fuel from cassava tagged as cassakero, from cultivated eight million tonnes of improved variety of cassava feedstock. The plan is to acquire a farm area of about four hundred thousand hectares of land, which would yield an average of twenty tonnes per hectares. This output is expected to meet the demand of a population of about four million families. Moreover the government also intend to erect additional ten thousand small scale mini-refineries all over the country within a period of four years (2009-2013) (Ohimain, 2010).

The Nigerian National Petroleum Corporation (NNPC) is in charge of blending the bioethanol at its various designated depots. The federal government has decided to replace gasoline by authorising the use of blending 10% ethanol and 20% bio-diesel respectively; this ratio therefore necessitated the need for 5.14

billion litres annually. So far, in line with the seedling policy of achieving the production of a blend of E10 bioethanol by the first quarter of 2008, a lot has been achieved in major reconstruction and restructuring of many NNPC subsidiary equipment's such as the PPMC equipment's at Mosimi and Atlas Cove where the blending of E10 bioethanol procured from overseas will take place for further supply to the market in Nigeria (NBPI, 2007; Felix, 2008; Ohimain, 2010).

CASSAVA – ETHANOL BIOCONVERSION PROCESS

At the moment bioethanol is produced in large quantities using different types of feedstocks globally (Ogbonna and Okolib, 2010). For example United States ranked as the world largest producer of bioethanol mainly used corn as a feedstock, Brazil the second largest producer chiefly used sugar cane as the main raw material for bioethanol production and while wheat, sugar beet etc are used in Europe to produce bioethanol (William 2007; Shanavas *et al,* 2011; Tushar *et al,* 2011).

According to Nadir *et al* (2009) in order to obtain bioethanol, fermentation has to take place, and the principal feedstocks used in the production of bioethanol includes the followings; sugars, starches and cellulose. The cellulose is hydrolysed by alkali or acids to sugars which enable the microbes to act on the sugars for fermentation to take place in order to yield ethanol. Whereas the sugars are feedstocks that can be freely fermented and transformed to ethanol by the microorganisms. The starch feedstock is first hydrolysed before its subsequent conversion process of producing ethanol (Shanavas *et al,* 2011). But the hydrolysis of starch is by enzymes of malt or moulds. Basically the starch has two types of polysaccharides viz, the amylose which is a linear molecule and amylopectin, a highly branched molecule (Nadir *et al,* 2009).

According to Ingledew *et al* (2009) the moisture contents of cassava is lowered to about 10 – 15 wt% by sun drying in order to properly store the dried chip for subsequent use in ethanol production, unlike other feedstocks cassava feedstock can either be used for ethanol production when the fresh root is harvested, the fresh root contains (moisture concentration 70 – 80 w%) or when the roots are chipped and sun dried which has only about 10 – 15 w% moisture concentration (Ogbonna and Okolib, 2010). There are four tasks to be carried out when preparing the fresh roots of cassava before the kick-off of the conversion process. These are washing of the fresh roots in order to extract and free the roots from all sorts of impurities (Ayoola *et al,* 2012).

This also ensures the elimination of large matters such as trailing plant, soils etc. Peel removal decreases the linamarin quantities which produce cyanide, in addition the procedure ensure total extraction of sand from the roots this process reduce the risk of soils that can potentially cause harm to the industrial machines during ethanol production. Rasping is a process used in extracting starch from fibrous cell walls; subsequently water is applied to enable the discharge of starch materials. Centrifugal separation is a process which produces slurry that is of compacted and solid mixture of starch granules that can be used for the conversion. The efficiency of fermentation by S. cerevisiea depends on the availability of nutrients in the starch slurry, however the starch slurry has very low concentrations of nutrients, in order to obtain good fermentation, nutrients has to be supplied into the starch slurry. On the other hand the method of ethanol production from dried cassava chips is carried out by starting with scrubbing the chips in order to extract the impurities such as sands, then crushing the chips by pounding it into powdered form (Fig. 9b) followed by applying water to make slurry mixture in preparation for ethanol production (Ingledew et *al,* 2009).

However, there are three common phases deployed in the production of bioethanol from cassava these are liquefaction, saccharification and fermentation. Liquefaction and saccharification processes are carried out by α-amylase and glucoamylase these enzymes are valuable in performing hydrolysis to produce glucose syrup. Hai-Juan *et al,* (2010) mentioned that to acquire sugar for subsequent fermentation process, amylolytic enzymes is a suitable enzyme for the hydrolysis of starch. The fermentation is carried out by microbes such as yeast, (Saccharomyces cerevisiea), bacteria and fungi (Ogbonna and Okolib, 2010; Shanavas *et al,* 2011). To obtain cassava flour for the conversion process, the fresh cassava is peeled and allowed to stay in water for one day (Fig. 9a), then the tubers is prepared into chips, in order to achieve a low water concentration, the cassava is exposed to sun heating and then a low moisture of as low as 10% is obtained, the cassava is then crushed into powdered for subsequent utilization (Nadir *et al,* 2009; Hai-Juan *et al,* 2010; Ogbonna and Okolib, 2010). Generally during the start of conversion process a temperature of about 90 ^{0}C is used for cooking the starch with α-amylase. However this process is referred to as the hydrolysis.

Nadir *et al* (2009) point out that under temperature of 90 ^{0}C in a B-Braun bioreactors about 300g of cassava, 900mL of distilled water, as well as the enzyme α-amylase 0.1% (v/w) are poured into the bioreactor then the mixing was done at 500 rpm for one hour. Afterwards the temperature of the mixture was allowed to cool falling to 50 ^{0}C; another enzyme glucoamylase of the same amount 0.1% (v/w) was further poured into the mixture. But this time at 250 rpm the mixture is allowed for two hours after which some solids were extracted, and the temperature of the solution was left to drop down to 35^{0} C then the solution was attuned to pH 5. However the energy cost can be reduced if the techniques of simultaneous saccharification and fermentation (SSF) would be applied in the production of the bioethanol (Shanavas *et al,* 2010; Yingling *et al,* 2010).

Because there is no separation of hydrolysis and fermentation phases in the process of ethanol production. The Simultaneous Saccharification and Fermentation (SSF) process has the advantage of producing large quantities of ethanol, the procedure is time efficient and it utilised less energy during the process of ethanol production. Moreover the SSF process is now improved as it is yielding high volumetric output and the process is now more economical to operate as presently the technique of very high gravity (VHG) is practiced by the large scale ethanol producers because of its numerous benefits such as less threats of infection by bacteria, low energy cost, high ethanol yield and less water utilisation (Yingling *et al,* 2010). Since cassava starch is devoid of nutrients, nutrients such as urea 0.5% (w/w) & NPK 0.05% (w/w) was poured into the bioreactor, followed by the microbes essentially yeast (Saccharomyces cerevisiea) was also added ten minutes after. The mixing was carried out for only five minutes afterward the mixture was allowed for eight hours to settle, then at 50 rpm the mixture was incubated for seventy two hours.

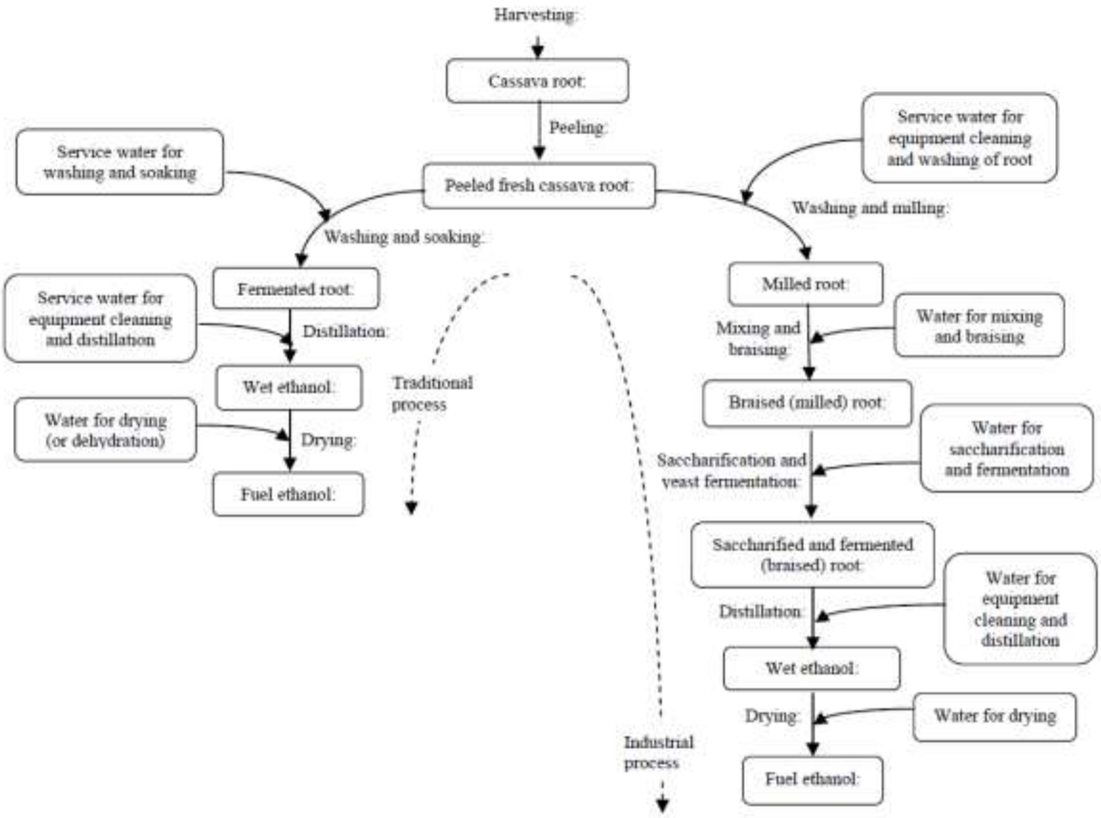

Fig. 3a: The Process of Ethanol Production from Fresh Cassava Root
Source: Adeoti

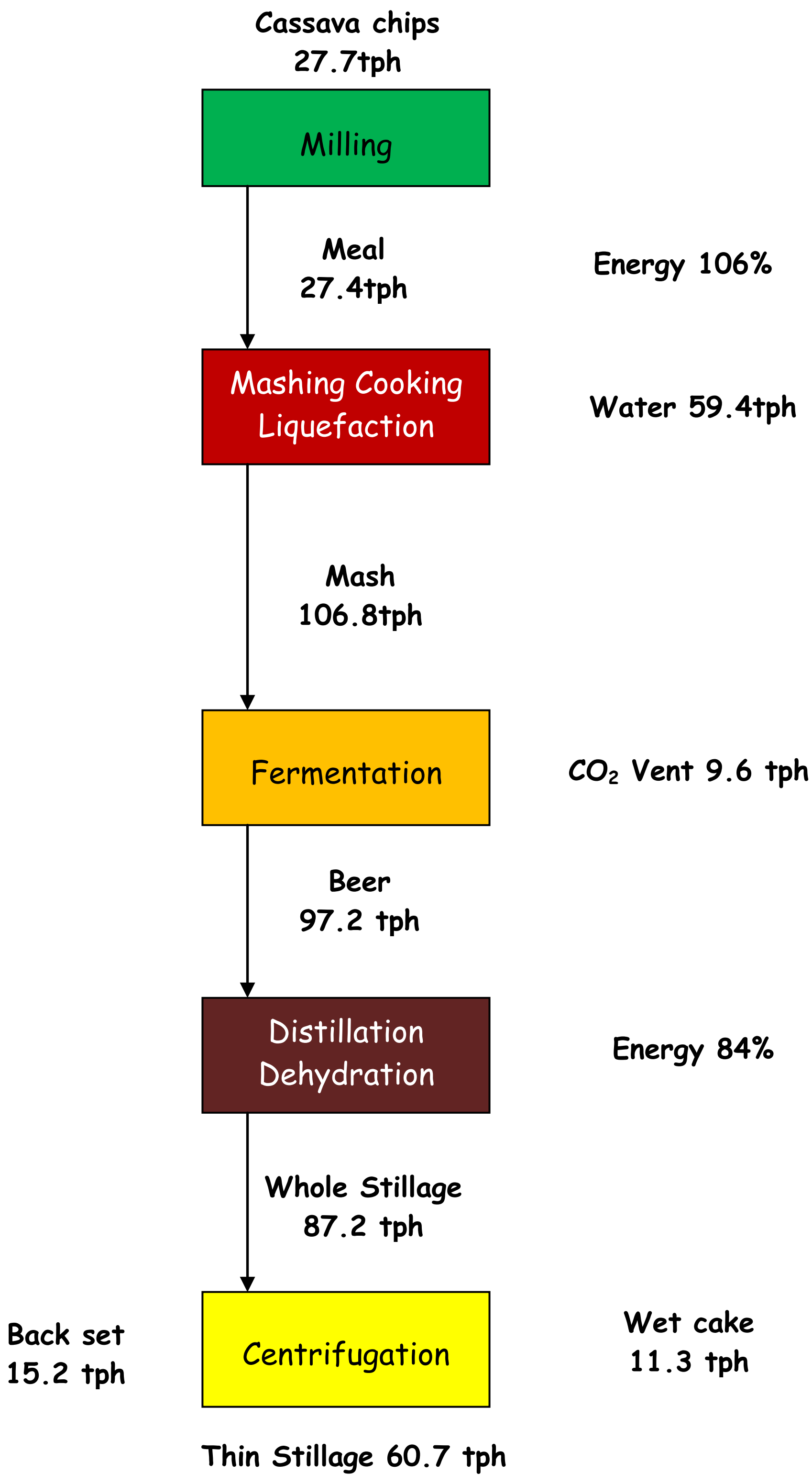

Fig. 3b Ethanol Production from Dry Cassava Chip
Source: Ingledew *et al,* 2009.

CONCLUSION AND RECOMMENDATIONS

The production of bioethanol from cassava feedstock may hold great promises for the fact that cassava is easily accessible, abundant, and has relatively low cost of production in Nigeria. However, even though the bioconversion processes are technically feasible and cost-effective; cassava as one of the most important crop in this country is used as food. Since Nigeria government has embarked on an ambitious program to promote the use of bioethanol for transportation fuel. Thus the study concludes with few suggestions which may serve as useful inputs for the government bioethanol policies these include:

- Excise tax exemption for the biofuels production
- Income tax waiver for both local and foreign investors
- Introduce loans and subsidies for biofuel production etc.

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