Development Status of Production and Processing Machinery of Shea Oil from a Woody Oil Plant in Nigeria

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Abstract - This report present status of production and processing techniques of Shea oil from a woody oil plant in Nigeria. Attempt was made at presenting the geographical location and the characteristics of the climate at different ecological and geopolitical zones of the country. The land use distribution in Nigeria was also classified. History of production and processing of edible oil of plant origin in Nigeria was highlighted. Major constraints towards sustainable development of the sector were identified. Distribution of some woody oil plants in Nigeria was presented. Detailed production and processing techniques of Shea oil were presented to include traditional method, improved traditional methods, dry extraction method and processing machinery. Suggestions were presented for future development.

Keywords: Woody Oil Plants, Shea Oil, Agricultural Production, Processing Techniques, processing Machinery

1. Introduction

1.1 Agricultural Production in Nigeria

Nigeria lies between Longitudes 2° 49' E and 14° 37' E and Latitudes 4° 16' N and 13° 52' North of the Equator. The climate is tropical, characterized by high temperatures and humidity as well as marked wet and dry seasons, though there are variations between South and North. Total rainfall decreases from the coast northwards. The South (below Latitude 8°N) has an annual rainfall ranging between 1,500 and 4,000 mm and the extreme North between 500 and 1000 mm. Nigeria has total area of 923,768 sq km that is divided into land mass of 910,768 sq km and about 13,000 sq km area is covered by water. About 80 percent of Nigeria’s land is suitable for farming and grazing, while roughly 13 percent is forested and provides mahogany, iroko, ebony, and other woods. The land use distribution in Nigeria could be classified into 31.29% of arable, 2.96% of permanent crops and 65.75% of others. The irrigated land covers 2,330 sq km. Nigeria is predominantly still an agricultural society (Olaoye and Rotimi, 2001). Approximately 70 percent of the population engages in agricultural production at a subsistence level. Agriculture employs almost half of the national workforce but it accounts for only a small fraction of the country’s exports and food production has failed to keep up with the country’s rapid population growth (Olaoye, 2007). The government has attempted to stimulate agricultural production through a number of measures, including large-scale irrigation schemes and an expansion of credit to farmers.

However, the agricultural sector suffered neglect during the hey-days of the oil boom in the 1970s. Ever since then Nigeria has been witnessing extreme poverty and the insufficiency of basic food items. Historically, the roots of the crisis in the Nigerian economy lie in the neglect of agriculture and the increased dependence on a mono-cultural economy based on oil. The agricultural sector now accounts for less than 5% of Nigeria’s GDP (Olagbaju and Falola, 1996). As noted earlier, the neglect of the agricultural sector and the dependence of Nigeria on a monocultural, crude oil-based economy have not augured well for the well-being of the Nigerian economy.

1.2 History of Production and Processing of Edible Oil in Nigeria
Oil palm and ground nut oil are the first generation of vegetable oil to be produced and processed at commercial scale in Nigeria. Ground nut oil is produced from leguminous plant in the Northern part of the country and oil palm is grown in the southern part of the country. Fig.1 presents the distribution of vegetable oil production in Nigeria. There has been extensive development of ground nut and oil palm industries in many countries in the tropics. This is because of the extremely high potential productivity of the crops. The oil palm gives the highest yield of oil per unit area compared to any other crop and produces two distinct oils – palm oil and palm kernel oil. These two products are important in world trade.

Modern high-yielding varieties of oil palm were developed by breeding programs, under ideal climatic conditions and good management. The plants are capable of producing in excess of 20 tonnes of bunches/ha/yr, with palm oil in bunch content of 25 percent. This is equivalent to a yield of 5 tonnes oil/ha/yr (excluding the palm kernel oil), which far outstrips any other source of edible oil.

The export of palm kernels began in 1832 and by 1911 British West Africa alone exported 157000 tonnes of which about 75 percent came from Nigeria. Nigeria was the largest exporter until 1934 when the country was surpassed by Malaysia.

Africa led the world in production and export of palm oil throughout the first half of the 20th century, led by Nigeria and Zaire. By 1966, however, Malaysia and Indonesia had surpassed Africa’s total palm oil production. According to Oil Palm Review, published by the Tropical Development and Research Institute in the United Kingdom, over 3 million tonnes of palm oil was produced by Malaysia alone in 1983, compared with a total of about 1.3 million tonnes of African production (FAO, 2002).

The production of this important dietary component is still at declining trend in Nigeria despite the effort of the federal Government in establishing research institutes to conduct research and give appropriate advice to government in formulation of policy guide on the production, propagation and processing of the crop.

NC: North Central (Shea Plant, Cashew, Ground nut, Castor, Orange, Almond, Jatropha)
NE: North East (Ground nut, Castor, Almond, Jathropha, Cotton)
NW: North West (Cashew, Cotton, Ground nut, Castor, Jathropha)
SE: South East (Oil Palm, Cashew, Almond, Jathropha, Orange)
SW: South West (Shea Plant, Cashew, Castor, Almond, Orange, Oil Palm)

Figure 1: The distribution of vegetable oil production in Nigeria in the six geopolitical zones.

1.3 Major constraints towards the Development, Production and Processing of Edible Oil in Nigeria

The factors that may be responsible downward declining trend in oil palm industry in Nigeria and for the rise to prominence in the oil palm industry of the Far East countries are noted from the positive steps taken in the development of oil palm industry of the Far East countries, especially Malaysia. These factors are summarized as follows:

1. Solid research and development were undertaken and supported by a conscious desire to implement research findings.
2. Good foundation to introduce the large-scale plantation cultivation of palm oil was established to achieve the development of plantation culture for long cultivation and processing of latex rubber.
3. Excellent mastery of technology and rapid mechanization was adopted together with government support to the industry as a systematic and strategic industrial development policy.
4. Deliberate private sector investment in this sector was facilitated.
2. **Woody Oil Plant in Nigeria**

Woody oil plants grow predominantly in the wild. Some of these plants have been domesticated essentially for production of other products rather than oil. These include Cashew, Neem and Orange, mainly for production of fruit juice and nuts.

### 2.1 Cashew

Cashew (*Aracardium occidentale* family) is an important export crop. It is peculiar to the tropical climate with Nigeria as the major producer in West Africa (Yayock, et al, 1988). Cashew nut is edible and used in the production of cashew butter (Egburomu, 1996; Faborode and Favier, 1996). The nut contains 29.2% carbohydrate, 43.4% fat and 17.4% protein (Egburomu, 1996). All the essential amino acids for human being are present in the nut. Its protein value is equal to that of soybean and higher than that of peanut (Mrema and Nulty, 1985). Cashew oil lipid fraction contains all lipid soluble vitamins (A, D & E) among which vitamin E is 70 mg/100 g (Nagaraga, 1987). The shell of the seed yields phenol rich oil, called cashew nut shell liquid (CNSL), which is used as lubricating oil, in the manufacture of insecticides, production of plastic, preserving and water proofing after distillation, oil proof break lining, links, cement, and when polymerized, is an important ingredient for painting (Kochhar, 1981).

### 2.2 Orange

Many members of Rutaceae family of which citrus belongs produce essential oil. Orange blossom oil is obtained from the rind and flower of sour orange (*Citrus aurantium*). A matured tree may produce as much as 15 kg of flower. Orange blossom oil is useful in the manufacture of perfume, soap, shampoo and skin cream. It contains unalool, nerol, geranol and various other terpenes and orange compounds (Swamthman and Kochhar, 1989). Lemon oil contains mainly citral which is used in the manufacture of verbena type of perfumes, toilet water and soap. Fruit wastes are used for the production organic chemicals. Extracted pulp from citrus, containing about 55% of whole fruit by weight, may be dried and pectin or pelicate could be recovered from it (Godwin, 1989). As similar to Citrus both the fruit and seed of cashew have high commercial value. The fruit is edible and rich in minerals and vitamins.

### 2.3 Shea Nut

Shea butter oil is one of the important derivatives from Shea butter tree (*Vitellaria paradoxa*). Other names are Karite (French), Nku (Ghana), Emi (Yoruba), Shea butter tree and bambuk butter tree. The plant grows in the wild and widely distributed around the Savanna region of Nigeria. It thrives in savannah areas where oil palm cannot grow due to low rainfall (GTZ, 1986). The major producing countries are West African countries (Mali, Burkina fasso, Benin, Senegal, Ivory Coast, Ghana and Nigeria). Shea oil is obtained from the nut of the plant. The extraction of shea butter oil is on small-scale production level. The oil is processed by traditional method with little mechanical assistance. Shea butter oil is considered as a close substitute for oil palm in some part of Northern Nigeria. It is used for soap making, cosmetics, medicinal purpose and as a raw material for industries. According to Patterson (1989) shea nut contains about 45-55% fat. It is more saturated than cocoa butter and it is used as cocoa substitute. Shea butter has dual characteristics; a fat saturated than oil and higher than that of peanut (Mrema and Nulty, 1985). Shea nut contains about 45-55% fat. Shea butter has dual characteristics; a fat saturated than oil and higher than that of peanut (Mrema and Nulty, 1985).

Other common woody Plant oil in Nigeria include wall nut, Neem, Jathropha, Castor, Almond, among others. Some of these plants are only being used as ornamental plant or sometimes being planted as hedges to demarcate farm land boundary.

3. **PRODUCTION AND PROCESSING TECHNIQUE OF SHEA NUT OIL**

### 3.1 Traditional Method of Extraction of Shea Oil

The processing of shea butter oil in Nigeria involves traditional approach. Oil is removed from the nut through wet extraction procedure. The application of mechanical devices such as hydraulic or screw press for removal of oil is rarely carried out. The steps involved during the traditional processing of shea butter oil are presented in Fig 2. The outer pulp of the berries, the shea-fuit, is eaten at harvest time or parboiled to remove the pulp. Figures 2a to 5b presents illustration of shea plant, fruit and processed products. The nut is removed by pounding and later roasted in a large frying pot. The fried nuts are later pounded and ground in wooden mortars to a paste or milled using an attrition mill. The milled shea nut is now thoroughly stirred or mixed with water vigorously to break the emulsion and separate the fat.
By cooking the mixed paste the oil floats to the surface and is then skimmed off.

**Figure 2**: Flow Chart Showing Traditional Processing Procedure of Shea Oil

Traditional mixing takes place in a large pot, strong enough to withstand the applied force through trampling that causes mixing or stirring of the milled shea nut. According to Olaoye (1994) mixing of milled shea nut with water causes the colour of the milled shea nut to change from brownish to grayish colour and the resulting dilution enhances easy separation of oil and precipitation of the impurity and fibres during cooking. There are mechanical devices for drying and size reduction operations, but mixing of milled shea nut is yet to be mechanized.

**Figure 2a**: Shea Tree (*Vitalleria paradoxa*) preserved to be growing within crop growing area

**Figure 2b**: Shea Tree (*Vitalleria paradoxa*) preserved to be growing within built-up area (Alonge and Olaniyan, 2007)

**Figure 3c**: Distribution of Shea Plant Seen Grown in the Wild Groove in Uganda (Lovett, 2005)

**Figure 3d**: Fruit of Shea Plant Ready for Harvesting

**Figure 4a**: Harvested Fruit of Shea Nut Ready for Further Processing (Lovett, 2005)
3.2 Modified Wet Extraction Method of Shea Oil

Olaoye (1994) found that the quantity of oil obtained through the traditional method is low, the procedure is time consuming and the mixing operation is a difficult task. Mainly, women carry out the processing of shea butter with the assistance of children. Attempt at mechanizing the arduous mixing operation will ensure improvement in the oil recovery rate and make oil extraction more attractive.

The local method of extraction of shea butter oil was critically examined. Material handling during processing procedure was identified as the major cause of poor oil quality; while poor oil recovery is due to poor clarification techniques. Experimentation was carried out on the effects of dilution ratio and settling time on oil recovery in a two to power two factorial experiment. Results indicated an optimum dilution ratio of 3:1 (3 parts water to 1 part oil meal) for best oil recovery. The oil recovery for the new clarification dilution protocol showed a significant increase of 25% in oil recovery when compared with the traditional procedure.

A modified process line is suggested as shown in Figure 6. The arduous and tedious trampling mixing operation shown in Figure 1 has now been replaced by re dilution clarification protocol.

3.3 Improved Wet Extraction Method of Shea Oil

An improved wet extraction method of shea oil was developed. This employs the operation of hand operated milled shea nut mixer made from the available local materials and it was sufficiently
Olaoye and Babatunde (2001) developed a milled shea oil mixer. The capacity of the machine was 120 kg/h. The performance of the machine was evaluated at beater speed between 85rpm and 115rpm. The oil recovery ranged from 29 to 34%. Therefore, it is necessary to select a suitable mixing speed in order to optimize the performance of the machine.

The milled shea nut-mixing machine developed is a vertical feed, manually operated unit. The various components of the mixer are frame assembly, conical shaped anchored beater with three blades, mixing beater shaft, planetary gear assembly, shaft handle and the hemispherical mixing bowl that is supported with a wooden stand. The cost of mixing is less than conventional method of mixing. The improved wet extraction method of shea oil followed the processing steps in Figure 2. The arduous mixing operation was replaced by a mixer shown in Figure 7.

Also, Beck et al. (2005) developed a shea nut mixer for direct wet extraction of shea oil without clarification procedure as contained in Fig. 2. The extraction of the oil takes place at the mixing stage. The performance of the mixer was not evaluated however the mixer has capability to reduce the problem of mixing operation. The illustration of the processing procedure and the developed mixer are presented in Figures 8, 9 and 10.

Figure 7: Mechanical Milled Shea Nut Mixer

Figure 8: Modified Traditional Shea Oil Recovery without Clarification

Figure 9: Modified Shea Mixer for Shea Oil Recovery without Clarification (Beck et al., 2005)

Figure 10: Orthographic Projections of Shea Mixer for Shea Oil Recovery without Clarification (Beck et al., 2005)
3.4 Dry Expression of Oil from Shea nut

Dry expression of the shea nut was investigated by Olaniyan (2006). He examined the effects of heat treatment, application of pressure, Expression time, among other factors for effective expression of shea oil from the shea nut. The unit operations involved in the dry expression process include drying of fresh seed, sterilization, shelling, roasting of the seeds, size reduction and expression of the seeds for oil recovery. The machinery adapted for other unit operations are presented in Figures 11 to 14 (FAO, 2002).

4. Processing Constraints of Shea Oil in Nigeria

4.1 Marketing Strategies and Practices:
Traditional practices for processing shea kernels result in poorer quality kernels. The supply-chain traders, mainly the exporters who are the supply-chain’s main drivers, lack sufficient incentives, or disincentives, to improve Shea kernel quality and make the changes to their supply system that would help improve the quality of kernels.

4.2 Inconsistent in Lending Bank Rate:
The galloping increase in bank rate in the last two decades is unfavorable for industrial development. Most medium and large scale industries depend on bank funding for survival. A number of banks funding substantial number of industries equally collapsed in the recent decades and this has terrible effects on the agricultural sector.

4.3 Poor Quality of Engineering Materials:
Engineering materials is an essential component in manufacturing. Materials such as stainless steel, HSS, aluminum and some special composites are of paramount importance in the production of agricultural machines. Such materials are however very expensive and increase unit cost of production.
though very essential for the production of safe food. Many manufacturers utilize electro coated materials instead of using stainless steel, HSS, and aluminum.

Alonge and Olaniyan (2007) further identified the following as the major constraints to extraction of Shea oil in Nigeria:

4.4 Water supply:
Water is scarce during dry season when there is no supply of water. Shea butter extraction requires a lot of water most especially during the mixing of the paste.

4.5 Equipment:
Some mechanical assistance which is available in the production of shea butter can only work on small scale production. The equipment has a very low producing capacity hence makes large quantity production a difficult task. Also it is not a fully mechanical procedure but meant to assist the traditional method.

4.6 Electricity supply:
Supply of electricity in Nigeria is not steady but the operation of the available modern equipment requires the use of electricity. Hence steady supply of electricity is essential.

4.7 Maintenance skill:
Technical know-how of the processing machinery is important. The people involved in the extraction of shea butter in Nigeria are illiterate and have little or no education about maintenance of this available equipment and this leads to gradual depreciation of the equipment and eventual brake down.

4.8 Supply of lubricants:
Constant fuel scarcity and lubricant scarcity is another problem of oil extraction in Nigeria. The available equipment requires constant lubrication of the rubbing parts and hence can affect the efficiency of the equipment when not available.

4.9 Supply of spare parts:
Spare parts for the modern equipment are not readily available and even if it is available, the people involved in the extraction of Shea butter are too poor to afford the spare parts hence some of the available modern equipment are no longer functioning.

5. Conclusions
Production and processing techniques of Shea Oil one of the Woody Plant Oil in Nigeria was discussed. The processing techniques involved both wet and dry extraction process. The Traditional method of extraction, modified methods of traditional process and improved traditional methods were highlighted. The available processing machinery were also presented with their specific functions. The constraints to Shea oil extraction process in Nigeria include marketing strategies and practices, inconsistent lending bank rate, Poor Quality of Engineering Materials, water supply, equipment, electricity supply, maintenance skill, supply of spare parts and supply of lubricants. Therefore for successful development of oil extraction process solid research and development must be undertaken and supported by a conscious desire to implement research findings; excellent mastery of technology and rapid mechanization must be adopted together with government support to the industry as a systematic and strategic industrial development policy and deliberate private sector investment in this sector must be facilitated.

References


