DEVELOPING INDIGENOUS MACHINERY FOR CASSAVA PROCESSING AND FRUIT JUICE PRODUCTION IN NIGERIA.

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ABSTRACT
There are many emerging agro-based industries in Nigeria. Two of such industries are fruit juice production and cassava processing (into *gari*, chips, flour, starch and grit) industries. Infact, because of their increasing industrial and revenue earning potential, many Nigerians are now investing in either of fruit juice production and cassava processing business. This paper identifies the necessary machineries required for cassava processing into its major products and for fruit juice production from tropical fruits. It discusses the problems associated with the use and procurement of imported machinery, and also presents the various machineries developed by the Federal University of Technology, Akure, Nigeria for fruit juice production and cassava processing. Some of the developed machines have been installed in the factory established by the University and are being used for commercial production, while some of the machines are being fabricated and sold to farmers. Recommendations on the improvement of the machines for adoption and commercialization are proposed.

Keywords: Cassava; Fruits; Indigenous machinery; Cassava processing; Fruit juice production; Nigeria.

1. INTRODUCTION

The technology of processing, handling and packaging of agricultural products in Nigeria had been peasantry. However, efforts are now being intensified by the federal government to diversify the export potentials of the country through the exportation of processed agricultural materials such as cassava in the form of chips, pellets, gari and starch. Furthermore, significant amount of agricultural produce are lost during the peak harvesting seasons due to inadequate storage and processing technology. Such materials includes fruits

such as oranges, mango, pineapple and banana, vegetables such as amaranthus, tomato, pepper, okro and tuber crops such as cassava, yam and cocoyam to mention a few.

Many policies of successive governments of Nigeria towards self-sufficiency in food production including the Accelerated Food Production Programme (AFPP), Operation Feed the Nation (OFN), Integrated Rural Development (IRD), Green Revolution (GR), Agricultural Development Programme (ADP), Directorate of Food, Roads and Rural Infrastructure (DIFFRI) and the National Agricultural Land Development Authority (NALDA) have not succeeded because of many factors (Ogunlowo, 2003). One major factor is the indiscriminate influx of machineries and equipment into the farms resulting from the implementation of these agricultural policies. There is therefore the need to evolve our own indigenous technology to address the issue of food security in Nigeria. Many authors have reported on the need to develop indigenous technology for engineering the various aspects of our agricultural operations (Ademosun, 1997; Agbetoye, 2003a & 2004; Olukunle, 2002; Ademosun *et al*., 2003; Adewumi, 1998).

The problems militating against the development of agricultural equipment and their commercial manufacture in Nigeria have been stated (Agbetoye, 2004). Governments in Nigeria have been making concerted efforts to encourage local production of agricultural equipment but have been faced with some problems. Among these is the fact that agro-processing machinery depend largely on imported technologies and machinery. Apart from the enormous attendant cost, the issue of unavailability of spare parts for the sophisticated equipment and in some cases relevant manpower to operate and service the equipment have given rise to the need to look inward for locally fabricated equipment.

It is an established fact that economic development of any nation depends considerably on the level of its industrial development. Industrial development can only be achieved when there is a strong industrial base. The level of manufacturing activity in Nigeria can be measured by the volume of output of locally manufactured goods (Igbeka, 1996; Ige, 1987). Presently, there is an upward movement in the involvement of Nigeria in industrial processing of our natural resources. This trend has been made possible by the emergence and growth of indigenous equipment manufacturers (Igbeka, 1997).

Ogazi and Chukwujekwu (1998) attributed some of the problems of equipment production to the calibre of people that head and handle most of the existing fabrication companies in Nigeria. He pointed out that most of the fabrication companies are headed by those with limited engineering training who can copy an existing equipment or prototype but can neither draw nor interpret engineering drawing. Their knowledge of material properties is limited and therefore, they cannot make the adequate choice of material for a given job.

Nigeria is blessed with abundant land resource, well suited for mechanised agriculture. Major food crops cultivated include yam, cassava, cocoyam, maize sorghum and cowpea. Major cash crops produced include coffee, cocoa, cashew etc. Many of these crops are processed by traditional methods. Two crops that are gaining more popularity

in terms of emerging processing factories are cassava and fruits. This paper identifies relevant machinery required and also examines the efforts being made by the Federal university of Technology, Akure in Nigeria in developing indigenous machinery for cassava processing and fruit juice production.

2. CASSAVA PROCESSING IN NIGERIA

2.1 Economic importance of cassava.

Since 1990, Nigeria has surpassed Brazil as the world's leading producer of cassava with an estimated annual production of 26 million tones from an estimated area of 1.7 million hectares of land (FAO, 1991). Other major producers of Cassava are Zaire, Thailand, Indonesia, China, India, Malaysia, Malawi, Togo and Tanzania. The importance of cassava as cheap source of calories intake in human diet especially in the tropical areas of Africa, Asia and Latin America, as well as source of carbohydrates in the production of animal feed (chips and pellets) and industrial raw materials such as starch and alcohol has been reported (Odigboh, 1983: Ugwu and Okereke, 1985; Agbetoye, 1995 and 2003; Kawano, 2000; Ali and Ogbu, 2003). Cassava starch is an ingredient in the manufacture of dyes, drugs, chemicals, carpets and in coagulation of rubber latex (Odigboh, 1983). Cassava which has previously been regarded as a poor man's food is increasing in industrial and economic potential (Agbetoye, 1995). Infact, there has been a revenue generation projection of about $100 million for cassava in Nigeria by 2005 (Ali and Ogbu, 2003).

According to Professor Dupe Olatunbosun of the University of Agriculture Abeokuta in his lecture titled "Cassava Revolution- Implications for Civil Servants", world import demand for cassava in 2004 was 25 million tones, while local demand by poultry farmers in the country has reached 400,000 tones annually. Meanwhile many States and Local governments, apart from individuals, have embarked on large-scale cassava production. Among these is the Ogun State Government which on February 2005 established 12 centers for rapid multiplication of high yielding, disease and pest resistant varieties of cassava cuttings, with each center having an area of 20 ha.

Currently, there is high demand for cassava products both locally and abroad. At the local scene, there is a federal government directive that producers of flours for bread baking must include 10% cassava in their product. The Chinese and other Asian countries have also ordered for large quantities of cassava chips. There is no doubt therefore that the cost of *gari,* the most popular food derived from cassava will increase. One solution to the impending scarcity of *gari* is the development of small-scale technologies for increased *gari* production. Furthermore, for the federal government to exploit the opportunity to generate revenue from cassava and to remove over-dependency on oil revenue, urgent attention must be given to the development of machinery for mechanized production and processing of cassava. Most of the cassava produced in Nigeria still comes from peasant farmers who depend on manual tools for their field operations. Increase in production of cassava implies the mechanization of its cultivation, harvesting and processing. The demand is likely to increase because of the superior quality of Nigerian cassava (Agbetoye 2005).

2.2 The need for cassava processing

Like many other foods, such as fruits and vegetables, roots and tubers are rarely eaten raw. They normally undergo some forms of processing before consumption. Even though raw sweet cassava is occasionally eaten in the Congo region, Tanzania and West Africa, cassava is not generally consumed raw. Cassava consists of high percentage of water. Processing it into dry form will therefore reduce the moisture content and convert it into more durable and stable product. *Gari* is very popular in West Africa and is a staple food in Nigeria, Ghana, Benin and Togo. Its ability to store well and its acceptance as a "convenience food" is responsible for its increasing popularity in the urban areas of West and Central Africa (IITA, 1990 and FAO, 1990). It is often consumed as the main meal in the form of dough or a thin porridge. Both are prepared in the household by mixing dry *gari* with hot or cold water and cooking and are served with soup or stew. *Gari* is also eaten as a snack when mixed in cold water with sugar, and sometimes milk.

The processing of *gari* from cassava has been reported by many authors as a labour demanding operation and women and children are the major producers. Onwueme (1978) stated that, in traditional setting, only very simple hand equipment is employed in the production of *gari*. According to Nweke *et al*. (1994), poor processing quality of *gar*i emanates from the difficulty of processing, such as problems associated with, peeling, grating, milling, dewatering, toasting, sifting e.t.c, which are labour-intensive tasks. Francis (1984), in his study of problems involved in traditional processing of cassava into *gari* in Ibadan, highlighted several problems involved in each stage of *gari* processing and concluded that *gari* is energy, time and labour consuming operation. Likewise, Ikpi and Hahn (1989) reported that cassava processing is almost entirely performed by women at the household level or at a central location such as a village or town market place. They estimated that at least 45% of the labour requirement is accounted for by peeling and sifting.

3.3 Some locally developed cassava processing machines at FUTA, Nigeria.

The efforts of the Federal University of Technology, Nigeria in developing indigenous machines for mechanized processing of cassava are presented below.

3.*3.1 Cassava washing machine*

Washing of cassava tubers before processing is desirable to remove adhering soil particles before peeling and to remove other debris even after peeling. Proper cleaning of the tubers before and after peeling will engender good quality product. A peeling machine has been designed in the pilot plant for cassava processing in the University. It comprises rollers equipped with washing brushes that washes the tubers as they are conveyed from one end of the machine to the other. A pipe network and tank equipped with pump is provided to circulate water. Fabrication of the machine has reached an advanced stage.

3.3.2 Cassava peeling machines

Different models of cassava peeling machine have been developed in the University. These includes two models of hand-fed (single gang and double gang) and self-fed

cassava peeling machines. The self-fed model machine consists of a dual abrasive brush mounted in parallel. An auger which permits the tubers to ride through in-between the dual brush was also provided. The cassava peeler is powered by a of a 5 kW petrol engine. The machine is required in the production line of the following products: cassava grit, gari, cassava flour, cassava chips and pellets, lafun, pupuru, and starch.

3.3.3 Cassava graters

Cassava graters are common in Nigeria. They utilize grating drums made up of rough and abrasive surfaces powered by diesel engine or electric motors. An improved grating machine has been developed in the University by replacing the grating drum with grating spikes fashioned out of corrosion resistant materials.

a. Hand-fed peeling machine

b. Self-fed peeling machine

c. Motorised cassava sifter

d. Cassava washing machine

e. Cassava drying/gari frying machine

Figure 1: Cassava processing machines developed at the Federal University of Technology, Akure, Nigeria.

3.3.4 Continuous Press for cassava mash

Hydraulic and screw presses which are produced locally are plentiful in Nigeria. However, the demand for mechanized processing operations has necessitated the development of a continuous press in the University (Figure). The dewatering of the grated cassava mash is performed by series of pistons pressing small quantities of mash through eight confined cylinders arranged in a circle. The grated cassava mash is fed

continuously via an auger. The machine is powered by a 7.5 kW three-phase electric motor equipped with a speed reduction gearbox.

3.3.5. Cassava sifter

Different models of cassava sifter have been developed by the authors, including a dual powered model reported by Agbetoye and Oyedele (2005). Another motorized model has been fabricated and coupled to a new gari fryer/ chip dryer, also developed for use in the cassava processing pilot plant.

3.3.6 Gari fryer/Chip dyer

Two major operations in cassava processing that are regarded as critical are gari frying and drying of cassava chips. A lot of attempts have been made at improving the process of frying gari from the traditional methods of using open clay pots mounted on wood fire. However, this operation is still largely done by manual methods. The truth is that this method cannot cope with the emerging mechanized methods being utilized for other processing operations. Many people are advocating for flash drying of cassava chips and starch. At the Federal University of Technology, Akure, Nigeria, an electric gari fryer cum dryer for cassava chips ahs been developed. It is equipped with instrumentation for monitoring the frying and drying parameters for effective performance. It was demonstrated at the Second Nigeria Universities Research and Development Fair in Abuja in December, 2005. The machine is much cheaper to produce than the flash dryer and has shown promising performance.

4. DEVELOPMENT OF FRUIT JUICE PRODUCTION MACHINERY IN FUTA.

Fruits are plenty in the Southern and Middle Belts of Nigeria. They include oranges, Pineapples, bananas and mangoes. During the peak harvesting season, up to 50% of the harvests is lost as waste (RAIDS, 1989). Between 1997 and 1998, the then Vice-Chancellor of FUTA, Prof. L.B. Kolawole mandated a research team to develop machinery for the establishment of a fruit juice factory. The factory was commissioned for production in 1999 (Ademosun *et al.,* 2001). The machines developed for the factory include fruit washing machine; extractors, homogenizer, pasteurizer and heat exchanger (Fig. 2). Currently, the university is re-activating the factory for full-time production. Lately, a machine for removing essential oil from the orange peels in order to eliminate manual peeling during processing and a manual bottle corking machine have been developed and installed in the factory.

4.1 Fruit washing machine

The fruit washing machine (Fig. 2a) has capacity for washing up to 1400 oranges per batch. The major components of the washing machine are the frame, washing drum, water bath, washing drum adjuster and power transmission system.

4.2 Fruit juice extractor

The fruit juice extractor (Fig. 2b) was designed based on the principle of transfer of rotary motion to linear. The essential elements of the extractor include the electric motor, gear reduction box, crank wheel and pin, connecting rod, press plate, slot for

crank pin, perforated expression tray, expression base tray and frame. Power from the extractor comes from a 1420 rpm, 3-phase 4 kW electric motor. The speed reduction gear box assembly enables the motor speed to be reduced to 2 rpm required at the crank wheel. The crank pin by moving through the crank pin slots converts the rotary motion of the crank wheel to linear motion of the connecting rod. The press plate fits into the perforated expression tray containing the peeled fruits to be expressed. The expressed juice is collected using the base tray and piped into a concentrate tank located at the base of the frame.

4.3 Homogenizer, Filling tank and Manual bottle corking machine

The homogenizer fabricated from stainless steel material (Fig. 2c) is to mix the expressed juice with water and other additives. The electric motor driven machine contains a main vessel in which water is heated, a thermostat, a stirrer and a framework to support the machine. A stainless steel tank supported on metal frames and filled with pipes network, valves and taps dispenses bottled juice into 33 *cl* bottles. A manual-operated corking machine has also been fabricated locally to cork bottled juice and is being used in the factory (Fig. 2f).

4.4 Pasteurizer

A pasterurizer equipped with loading and offloading of bottled fruit juice (in crates) was produced and installed in the factory (Fig. 2d). It contains the crate containers, hot water tank with cover, heater unit, water pump, and hoist and carriage system and control unit. The pasteurizer has a length of 2.2 m and a width of 2.2 m and height of 0.87 m. The hot water tank has a heater unit, located at the base. It contains four 12 kW heaters to heat up water from ambient temperature of 25^0C to 90^0C. The centrifugal pump circulates heated water from the base to the upper portion of the tank to maintain equilibrium. The control unit at the lower end regulates the temperature and flow of water. Based on estimated pasteurization time of 15 minutes (including loading and offloading) of bottled juice, it required three batches per day to pasteurize 48 crates of 24 bottle per crate per day.

4.5 Essential oil remover from orange fruits

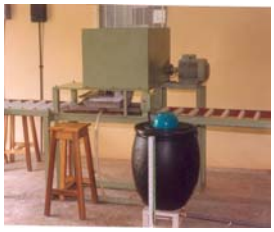
A machine for removing essential oil from orange fruits so as to eliminate manual peeling during processing has been designed, and a model of it was fabricated and installed in the factory. The picture of the machine is shown in Figure *2e*. The major components are the vibrating trays, frame, suspension springs, out-of-balance weights, water tank, water pump, pipes, belt and pulley drive system and the electric motor to drive the machine. The preliminary results indicated satisfactory performance.

5. CONCLUSIONS

Some emerging locally produced machines for the processing of cassava and for fruit juice production have been identified and discussed.

Such locally produced machines should be encouraged and supported financially especially that they are produced directly from a University of Technology. The Iron and Steel Industries in Nigeria should be revived to enhance local production of Agro-allied machinery.

a). Fruit washing machine.



(b). Fruit juice extractor

(c). Homogenizer

d).Pasteurizer (hot water Tank; carriage System and Crate containers

(e). Essential oil remover

(f) Manual corking machine

(f). Work in progress

Fig. 2: Machines in the FUTA fruit juice-processing factory (Ademosun *et al*., 2001)

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