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Review of Gari Processing Technologies: The Challenges and Prospects

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Abstract:- Gari is the most populous carbohydrate meal eaten by approximately 148 million people across the country, which is about 74% of the people of different tribes of Nigeria. Currently, the demands outstrip the local production thereby resulting in the price inflation and scarcity of the product in the market. This can be attributed to significant increase in population with little or no increase in various production centres within the country. The shortage is one of the risk factors imposing a great threat to food security in the Nation. Also, it has been proven that the recent lack is due to tediousness and drudgery associated with the manual methods of processing the roots – as most of the operations in production of gari is manually executed. Although, some operations involved in processing of cassava roots into gari have been improved, mechanized and automated in this country except peeling and frying. Studies have shown that the challenges in making gari in Nigeria are not in sourcing of the cassava roots or other unit operations in the production line but on the techniques and machines involved in the processing operation. Efforts have been made in producing and upgrading the traditional types to improved technologies by several researchers, all these have not met the need of the farmers and industrial processors economically. Therefore, this study is aimed at reviewing the different types of gari processing machines in the country with the view to improve the design of the indigenous processing equipment/machines by our researchers and local fabricators for large-scale production of gari in Nigeria.

Keywords:- *Gari, Production, Manual, Mechanical Fryer, Automated Fryer, Technology.*

I. INTRODUCTION

Nigeria is the world largest producer of cassava crop (FAO, 2013). There is also a high utilization of cassava roots in the region – the reason for the vast production. Significantly, this expresses the viability and huge prospects of cassava business in agribusiness sector of the country's economy. In this country, the preponderance of cassava roots produced are used for human consumption (IITA, 2010; Onyenwoke and Simonyan, 2014). This is processed into products such as fufu, gari, flour, lafun, abacha, tapioca, chips, tidbits, pellets, chin-chin, bread, and other confectioneries, while animal feed, starch, glue, ethanol and biogas for industries are the minor use of the crop. All these have been possible due to rapid development of technologies in agro-sector of the economy both in pre- and postharvest units. According to Sanchez et al (2010), the machines will reduce postharvest by 50% and labour by 75%.

Among all the above-mentioned products of cassava, gari is the most common and forms the main meal of the day for majority of people in most of the West African countries, while Nigeria and Brazil taking the lead. The production technology and tools are now high developed in cassava processing industry. Gari is a pre-gelatinized grit with particle size ranging from below 10µm to over 2000µm, fine and coarse respectively (Nwankpa, 2010). Gari flying is a simultaneous cooking and dehydrating operation; the product is first cooked with the moisture in it and then dehydrated. The moisture content of dewatered and sieved cassava mash is between 50 to 65 percent that has to be reduced to about 12% after the frying (Samuel and Adetifa, 2012). The heat concentration during frying operation affects the quality of the final product. In the village technique, the initial frying temperature is relatively low to avoid the formation of many lumps or caking. Most of the small lumps developed, as the moisture content gradually becomes and these lumps are broken down by constant pressing and agitation, then the temperature is increased to further roast and dehydrate the product (Olagoke *et al.*, 2014).

Traditionally, women are largely involved in all cassava processing (Kehinde and Subuola, 2015) and shallow earthenware of cast-iron pans (agbada) are usually used to fry gari over a wood fire and the smoke which discomforts and levies health disorders to the operator (Fasoyiro, 2012). Consequently, this brought about the need for innovations and improvements to alleviate the problems encountered by these women (RMRDC, 2004). Subsequently, several models were staunchly designed to stimulate the village manual frying operations. Yet none of these technologies has met the present day need of the commercial processors especially the women (Kehinde and Subuola, 2015). Therefore, the study is aimed at evaluating the various existing gari processing facilities in Nigeria with the view of finding their challenges and proffering solutions to increase the production capacity.

II. PROCESSING TECHNIQUES OF CASSAVA ROOTS INTO GARI

The objectives of processing of cassava roots into gari are to reduce postharvest losses of the fresh roots, eliminate or the cyanide content, improve the flavour of cassava products, provide resources for small-scale cassava based urban and rural areas. Processing bridges the demand and supply gab that exist between in the seasonal production of the crop.

Cassava roots have a shelf life that is generally accepted to be of the order of 24 to 48 hrs after harvest (Andrew, 2002). Therefore, shortly after harvest as the matter of fact, cassava roots are being processed into durable forms to storage of the products, facilitate transportation and marketing, reduce cyanide content and improve palatability. Statistics available also shows that the nutritional status of cassava can also be improved through fortification with other protein-rich crops. According to Onyenwoke and Simonyan (2014), processing cassava can affect the nutritional value of cassava roots through modification and losses in nutrients of high. He further argued that although raw cassava root contains significant vitamin C, yet, it is very sensitive to heat and easily leaches into water. Thus, it can be concluded that almost all the processing techniques of cassava roots have the ability affect its nutrient content. Fresh cassava roots cannot be stored for long because they deteriorate within 48 hrs of harvest. They are bulky with about 70% moisture content (Onyenwoke and Simonyan, 2014). The processing techniques include peeling, boiling, steaming, slicing, grating, soaking, grinding, fermenting, pounding, roasting, pressing, drying, and milling.

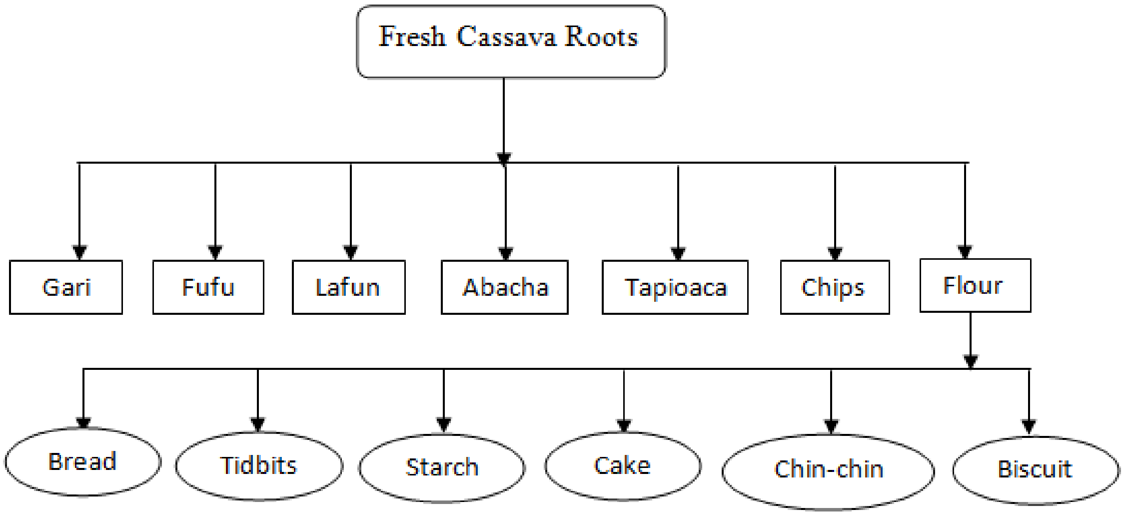

Fig 1:- The Major Products of Cassava Roots in Nigerian Communities

- *Gari Production Steps and Consumption Rate*

The production of gari involves the following component operations such as peeling which is the first operation and it is done immediately or 2 to 3 days maximum when the roots are received by the processor (Onyenwoke and Simonyan, 2014). This operation is carried out to remove the inedible thin and thick layers of the roots. The next operation is the washing of the roots to remove the dirt usually in form of sand particles on the body of the peeled roots. Follow by the grating which is done to crush the fresh roots into pulpy form called mash for easy dewatering. The grated cassava roots which is dewatered or dried to about 10% moisture content and the starch is probably partially dextrinized (Osho and Dashiell, 2002). Next to this is fermentation which is an act reducing the cyanide content of the starchy food.

Dewatering accompanies the fermentation process to remove the excess water and cyanide in the food substance. Immediately after this operation is the pulverization, a unit process which aims at breaking the lump that occurred in the last process. After this, is the sieving operation which removes the uncrushed and hard fibres of the roots that were not broken down during the grating operation. Then, follow by the frying which converts the mash into gari by moisture content reduction process through the application of heat. The cooling and storage is a process that allows the gari to air cooled and bagged. The moisture content of gari for safe storage is belong 12.7% (Osunde and Fadeyibi, 2011), when temperature and relative humidity are above 27°C and 70% respectively, gari goes bad (Onyenwoke and Simonyan, 2014).

In Africa about 600 million people are dependent on cassava for their food (IFAD, 2013), of which gari is the major cassava product eaten by them on a daily basis. It is fine or coarse granular flour prepared from the roots. Only in Nigeria, gari is consumed by almost 148 million people (Fig. 2) according to the research questionnaires issued out in one of our reviews. It is usually eaten as a cooking in the form of dough or flat soup or porridge. They are prepared indoors by mixing dry gari with hot or cold water and cooking and using soup or stew. With a share of 70% of all cassava fresh roots harvested, gari will continue to dominate the cassava sector in the short term (Cassava Master Plan, 2006). The growth rate of gari has been put at least 4 to 6% per annum, primarily due to population growth and increasing urbanization, and export to the regional West African market (Okafor and Ejiofor, 1990). It has already provided up to five million farmers and producer (usually women living in poor communities) in Nigeria, as well as a large number of equipment manufacturers, retailers and suppliers. In addition, small-scale gari processing business planning has been the primary source of employment in many countries. The steps to making gari are described in the figures 3 below.

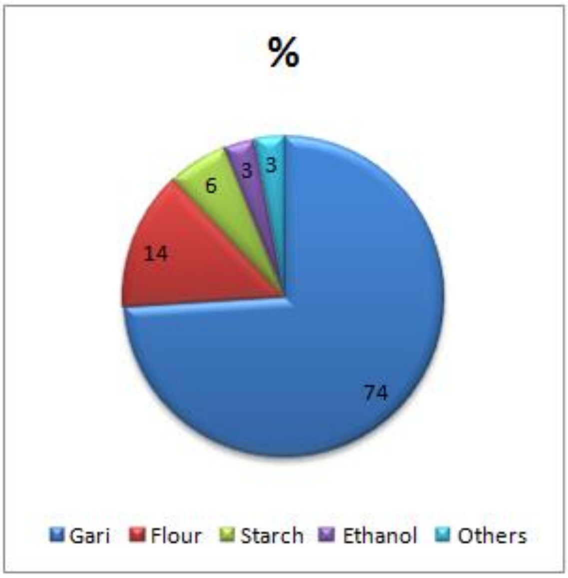

Fig 2:- Percentage of Gari Production by SME

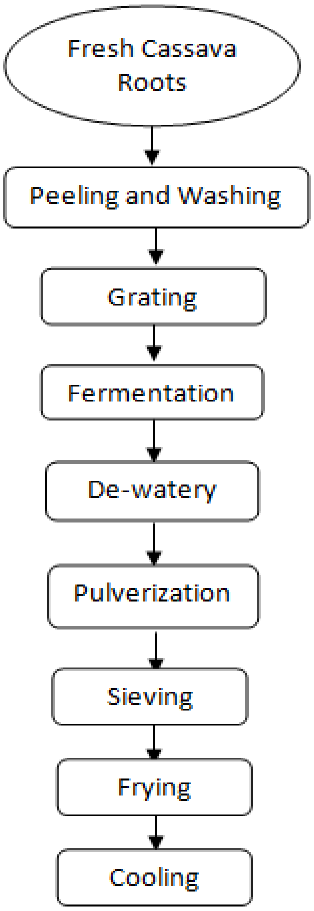

Fig. 3: The Steps Involves in Gari Production

III. CHALLENGES FACING GARI PRODUCTION

According to the statistics, the major problem fresh cassava roots have is a very little post-harvest storage life, and needs to be processed into durable and resilient forms soon after harvest. The most critical unit of operation while processing cassava into gari is the frying which occurs as a result of the simultaneous cooking and dehydrating the moisture content present by the application of heat (Akinnuli *et al.*, 2015). Traditionally, gari is fried by women in shallow earthenware of cast-iron pans (agbada) over a wood fire. The operator sits sideways by the fireplace while frying, and this brings discomfort and various health disorders owing to heat of frying equipment and the operator's sitting arrangement. Thus, this necessitated the need for advancement and upgrading to solve these issues usually experienced by the operators. Then, Odigbo model from University of Nigeria, Nsukka was designed to stanchly stimulate the traditional manual frying operations and few years after, Igbeka from University of Ibadan improved the gari fryer which was made of a fireplace oven with a chimney and a flying pan (Gbasouzor and Maduabum, 2012).

Further improvements continued as the researchers were only able to solve manually oriented problems; Brazilian model, Newell Dunford model and Niji Lukas model ranging from charcoal, wood, gas to diesel burner firing fryer respectively have assisted the frying operation significantly. Although the diesel burner fryer by Niji Lukas which is one of the best among the present frying available technologies within the country. Following our review, it was discovered that these problems are associated Niji Lukas model;

- ➢ High cost of purchasing a diesel burner which is a factor contributing to high cost of the fryer;
- ➢ Frequent breakdown of the burner during any slight power surge;
- ➢ Regular replacement of key components parts of the burner like transformer. electronic module, fuel pump, fuel pump solenoid, etc.;
- ➢ Regular maintenance and servicing cost of the burner;
- ➢ Increase in operational down time (i.e often loss of production time)
- ➢ High cost of diesel fuel in the market.
- ➢ Quantity fried per batch is small hence low production efficiency.
- ➢ It takes longer time to fry the production to dryness.

In view of this, the researchers decided to carry an extensive review on all the available technologies involved in gari frying in order to proffer long lasting solutions that would lead to further improvements on them.

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IV. PROSPECTS: GARI PROCESSING TECHNOLOGIES

➢ *Peeling and Washing Machine*

This is the technology used for removal the uneatable outer parts of the roots comprising of the corky periderm and the cortex. These are toxic cyanogenic glucosides not good for human health. Hence, for a root composed of 15% peel with a total cyanide content of 950 mg/kg (fresh weight basis) and 35 mg/kg in the flesh, 83% of the total cyanide is removed by peeling operation (Bencini, 1991). Traditionally, peeling is usually done manually with the knives. Crude method or manual peeling is time consuming and labour intensive, but its yields are still the best results. The output of one person is about 25 kg/hour of peeled roots with a loss of 25 – 30% of weight in the peels. New technologies of peelers are invoke now which reduces drudgery and tediousness involved in the peeling with higher capacities more than that reported by Olukunle and jimoh (2012). See the fig. 4 below.

Fig 4a:- Peeling and Washing Machine (Wikipedia, 2017)

Fig 4b:- Electrical Peeling Machine (3000 kg/hr)

➢ *Grating Machine*

This technology is used for crushing of cassava roots into pastry form called mash. Before the arrival of grating technologies, grating operation was being carried manually. Crude method of grating is always measured the most tiresome and throbbing operation of the whole exercise. To adopt a traditional means of grating 1000 kg of fresh peeled cassava roots will normally need 10 – 15 women for 2 about day. The grater's manual is usually a galvanized sheet or even a flattened piece of tin, punched with about 3mm diameter nails leaving a raised sharp flange on the bottom. It is not possible to completely grate a whole cassava piece a using manual method, 3% to 5% of the cassava must be left un-grated (Bencini, 1991). A skillful person can produce rarely grate about 30 kg/hr. Improved mechanized graters have been developed and tested as new technologies to reduce drudgery in grating (Kehinde and Subuola, 2015). The capacities of up to 4000 kg/hr are available in the market now (figure 5).

Fig. 5a: Grating Machine (4000 kg/hr)

Fig. 5b: Grating Machine (1000 kg/hr)

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➢ *Fermentation*

At the village level, fermentation and de-watering are performed in a single function. The grated mash is packed inside baskets, jute bags or perforated plastic sacks and left to ferment for 1 - 4 days. The method of the operation affects the colour, taste, texture and quality of the gari obtained at last. This service time can be reduced by seeding the freshly grated mash with previously fermented liquor as a starter, provided that it can be mixed properly. Fermentation process either by solid or sub-merged fermentation reduces the cyanide content of cassava (Imeh and Odibo, 2013). Fermentation involves a series of microorganisms and the prevailing conditions determine which organisms will dominate hence the need to control or monitor the process closely (Kehinde and Subuola, 2015).

➢ *Dewatering Machine*

In the processing of dewatering soluble cyanide and organic acid are removed with the press liquor, containing some quantity of starch which is gathered by permitting the liquor to settle and decanting off the liquid. In larger scale operations, the ideal method the wet mash is left to ferment between one to four days in its container before passing through the dewatering process. Pressing is done using a number of designs of screw or hydraulic jack in which the pulps filled in a bag is placed between two parallel boards to apply pressure to the bag using jacking or screw handles. This operations are usually done by men (Taiwo *et al*., 2001) This idea has been extended to a several designs ranging hydraulic pumps to electrical machine with capacity of about 3000 kg/hr (figure 6).

Fig. 6a: Hydraulic Jack (500 kg/hr)

Fig. 6b: Electrical Dewatering Machine (2000kg/hr)

➢ *Sieving Machine*

After pressing operation, the de-watered cassava mash is usually in a form of solid cakes called lumps which are broken down and sieved to remove the stalks and fibres (from the central vascular strands) and to obtain a homogenous mixture of a product. Standardized particle size is important because it makes products to come fine during roasting or frying operation, smaller particles taking less time and less energy in roasting. Without the achieving uniform particle size during sieving causes large lumps formation. Traditionally, sieving is done manually using sieves made from palm leaves, bamboo or raffia cane. Advancement technology has led to design of a mechanical sieve with high capacities up to 5000 kg/hr.

Fig. 7a: Electrical Sieving Machine (5000 kg/hr)

Fig. 7b: Traditional Sieve (300 kg/hr)

➢ *Frying Machine*

A traditional fireplace consists of three large stones supporting the frying pan (fig. 8a). This results in a lot of health of issues to the user owing to great heat and smoke exposure from the fire and steam from the wet cassava mash. There is no doubt that this system and method is very inefficient, even to its use of fuel, energy consumption per unit of dried gari is very high. Available statistics have proven that enclosing the fire on three sides will improve fuel consumption and reduce the smoke blowing into the faces of the operator. The inefficiency of frying and firewood consumption is the most important problems in traditional gari production that need to be addressed most urgently (Fasoyiro, 2012)

Fig. 8a: Traditional Gari Fryer (1st Generation)

Fig. 8b: Improved Gari Fryer (2nd Generation)

➢ *Improved and Mechanized Method*

In the recent years, several researches have been carried out to improve some aspects of the operations in gari production, which include peeling and washing of the roots, grating, de-watering, fermentation, sieving, frying and cooling (Akinnuli *et al.,* 2015). The most significant process in gari production that determines the quality of the final product is the flying or roasting operation. It has been quite difficult to mechanize this operation correctly and rightly because the operation was probably not well understood by many designers and manufacturers or the technological know-how was never invoke.

Several studies have demonstrated mechanized processing for production of gari. Ajayi et al (2014) developed and evaluated the performance of a mechanized gari fryer. The machine showed an optimum speed of 20 rpm and initial mash moisture content of 41.2% and gari of 12.6% final moisture content was obtained at the 21st min of frying using 5kg charcoal as source of heat energy. The gari had a good texture and was fit for consumption but the system was never effective for commercial business in terms of capacity and heat source.

In this review several fryers were examined and investigated in South West, South East and South-South of Nigeria, following the historic design of gari frying equipment/machines started with these researchers: UNIBADAN fryer, IITA fryer, RAIDS fryer, Newell Dunford, Brazilian, Fabrico, UNN model, and Niji Lukas (Ajewole and Adeosun, 2018). It was found that these mechanized systems ranges from the use of charcoal, firewood, diesel to gas burner as the heat source have one deficit or other.

Fig. 9a: Diesel Burner Mechanized Fryer (Wikipedia, 2017)

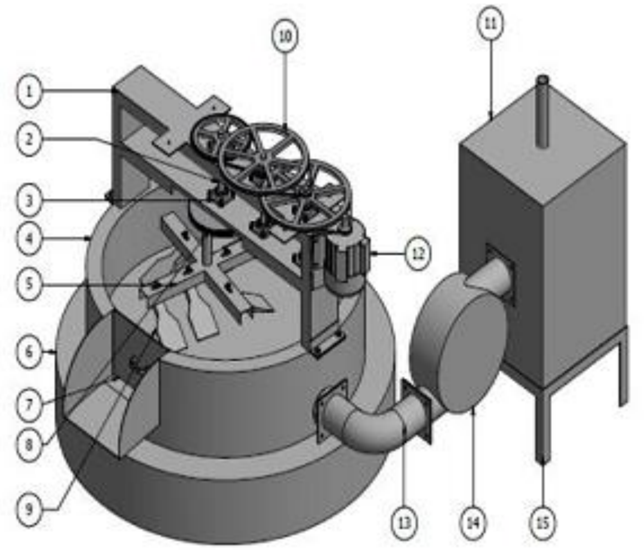

Fig 9b:- Charcoal Mechanized Fryer (Ajewole and Adeosun, 2018)

- *Storage Techniques*

Based on the microbiological safety as well as sensory aspects, it has been recommended that gari should not be stored for more than 3 months. The storage should be done in proper packaging materials. A study showed that, out of different types of packing bags (polyester, polypropylene and hessian), polyester and polypropylene are the most acceptable from the microbiological and sensorial point of view, whereas hessian bags are unacceptable (Adejumo and Raji, 2012).

V. CONCLUSION

The recent hike of gari in Nigerian markets at this period of Covid-19 issues necessitated this research to see the possibility of improving its production. The result found shows that gari is an important staple food in this country, and insufficiency of it could lead to serious food insecurity. Statistics proved that millions of people of various tribes depend on it daily for survival. This is simply because not only that product is cheap and affordable to a low-income earner but also the crop thrives well in all the regions of the country. In the eastern part of the country, almost every household has a cassava farm for family consumption. Thus, it is the reason behind Nigeria being the largest producer in the world. However, the result of this study shows that the technological expertise of the country's local fabricators and the engineers must be broadened especially in the area of frying to achieve an increase in production efficiency. This study revealed that improved frying technologies are needed to bridge the huge gap between the demand and supply of the food product. Any operation that will make frying less tedious and drudgery free will certainly attract the employable youth and investors into the agribusiness which in turn would create the chances of providing food security in the country.

RECOMMENDATIONS

Since all the gari unit processing technologies have been improved significantly except frying technologies, therefore, automated systems should be adopted to achieve the expected results in frying operation. These are the improved technology – perfect tools that are capable of tripling the production efficiency of the mechanical fryers within a short space of time. Although, the industrial components of this technology maybe a little bit expensive to acquire by the local processors but the government, public and private sectors of the economy can intervene by subsidizing price of these machines to support, encourage and motivate the processors in their efforts to produce sufficient food for the populace at all time and an affordable price.

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