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ORIGINAL RESEARCH ARTICLE

Overcoming the problems facing cassava processing industry in Nigeria

Lois Omolola Abiodun*, Opeyemi Adeniyi Oyelade, Yinka Segun Ademiluyi, Olusola Adetola Ogunjirin, Jelili Aremu Oyedokun

National Centre for Agricultural Mechanization (NCAM), P.M.B. 1525, Ilorin, Kwara State, Nigeria.
*** Corresponding author:** Lois Omolola Abiodun, omololamusaabiodun@yahoo.com

ABSTRACT

This paper takes a look at overcoming the problems faced by processors of cassava in Nigeria and how important the processing of cassava is to the Nigerian economy. The importance of the cassava processing industry cannot be overemphasized. Apart from providing food security, provision of employment opportunities for the ever-teeming population, it serves as a foreign exchange earner to boost the economy and provide raw materials for industries such as textile, pharmaceutical and alcohol. The roots and leaves of cassava are also source of medicine, it is also used in the production of biofuel. The paper also looked at the myriad of problems associated with the processing operations and delved into the challenges of the cassava processing industry which includes: a lack of basic infrastructural facilities, lack of access to finance the industry, excessive cost of processing equipment, poor market accessibility and limited government support. The paper proffer solutions as ways forward in taking the cassava processing industry in Nigeria to the next level.

Keywords: industry; cassava; processing; nation; problems; market

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1. Introduction

Cassava, with the botanical name (*Manihot esculenta, crantz)* is both a root tuber and a starchy crop which belong to the *Euphorbiaceae* family[1]. According to Kordylas[2], cassava is a crop that has the ability to withstand famine and grow well on any type of soil, it is also an inexpensive carbohydrate source of nutrient for both human and animal diet. Root and tuber crops with the inclusion of cassava, sweet potato, potato and yam are the most important food crops for direct human consumption in Africa. These four crops are grown in varied agro ecologies and production systems contributing to more than 240 million tons annually, covering around 23 million hectares[3]. Cassava has the potential to grow very well in areas with annual rainfall of 500–5000 mm with sun that is full but it is susceptible to cold weather and frost[4].

Nigeria and other countries like Brazil, Congo, Democratic Republic of Congo, Ghana Indonesia, Uganda and Zaire are major growers of cassava. It is grown based on their varieties which could either be sweet or bitter and also on the amount of poisonous hydrogen cyanide (HCN) found in cassava at the time of maturity. Improved varieties have been developed by the International Institute of Tropical Agriculture (IITA) which matures as early as six months after planting unlike the traditional varieties which mature in 18 months and above.

The improved varieties are more resistant to pest and diseases. high yielding, with cyanide substances as low as 3.1 mg/100g[5].

Cassava is one of the world's most important food crops, with annual global production at approximately 276 million metric tons in 2013. The top producing countries globally in 2013 were Nigeria, Thailand, Indonesia, Brazil and Democratic Republic of Congo accounting close to 19%, 11%, 9%, 8% and 6% of the total world's total production, respectively[3]. With Nigeria being the highest producer of cassava in Africa, cassava processing operations should be given serious attention. According to Quaye et al.[6], cassava in Nigeria is traditionally processed into gari, lafun, fufu and abacha. Adetunji and Quadri[7] stated that cassava is presently the most important food crop in Nigeria due to the fact that it is a foreign exchange earner, high yielding cash crop, a crop for world food security and industrialization. Resulting from this, there has been an exceptional rise in the demand for the crop and its numerous products worldwide for both industrial and domestic purposes.

In 2004, the world import demand for cassava stood at 25 million tons while that of local demand by poultry farmers alone stood at 400,000 tons. The yearly domestic demand of 180 million liters for ethanol in Nigeria was met through importation in 2005[8]. The directive given by the Federal Government which states that flour mills must substitute 10% of the wheat flour with cassava flour has given rise to the demand of 600,000 tons of processed cassava per day, apart from orders from abroad for semi-finished cassava products in the form of chips and pellets. These facts are pointers to the fact that opportunities abound in Nigeria in the area of cassava processing[6,9,10]. Cassava roots are traditionally processed using different methods into different finished products which are used in diverse ways. The call for the improvement in post-harvest processing techniques for cassava would greatly increase efficiency, increase income, increase productivity, decrease labour and improve the standard of living of our cassava farmers and processors. This will also enhance the shelf life of the cassava products and as well make their transport easy, upgrade their nutritional value and improve marketing opportunities[11].

The limited quantities of cassava-based products observed in the exportation of these products by the country is as result of failure of these processed products to meet up with the healthy foods international standards[7]. Therefore, the objective of this paper is to discuss on the problems facing cassava processing industry in Nigeria and find possible ways of overcoming these problems.

2. Importance of cassava processing to the economy of Nigeria

Cassava processing as the Nigerian economy is concerned plays an important role. This is because it is one of the country's important staple crops. In the global world, Nigeria is the largest producer of cassava accounting for about 20% of the world production. Cassava is grown in all parts of the country as it provides food and generates income for a large number of Nigerians. Discussed under subsections 2.1 to 2.6 are the major roles cassava processing plays in the Nigerian economy.

2.1. Food security

Cassava is grown primarily for its enlarged storage roots, which are consumed as food for humans in various forms[12]. It is a source of dietary energy for over 700 million people in the tropical and subtropical Africa[13]. Cassava is an important staple food especially in the rural areas where cassava is processed into different types of food such as cassava flour, fufu and gari which help to safeguard food security in the country. Traditionally, people in Nigeria purely cultivates cassava at subsistence level. Cassava has the tendency to grow in many areas on infertile and acidic soils, such characteristic makes it a more food-secure and flexible crop than many cereals. In the drought season, we experience a reduced supply of cereals. This leads to higher demand for food aid, mostly in the form of sugar, cereals and oil. During that period, cassava that is locally produced is used to mitigate hunger at the household level. The role of cassava as a food security needs to be

viewed from its direct contribution to household food security and being a cash crop serving as a raw material sold to the starch industry.

In years 2006 and 2007, the global food crisis began to manifest when the cost of food around the world has soared. This was actually the case for cereals and its based foods. Because of the high inflation witnessed in food price, some of the people living in a number of countries were unable to have access to the food they needed. This has caused social unrest, particularly in many low-income countries. To help lessen the strain experienced during food price inflation, especially in future crisis, is to diversify the crop base. This approach calls for the need to focus on locally produced, versatile and nutritious staple foods that are less disposed to the food price volatility of international markets. Cassava is a good crop for such an approach.

2.2. Provision of employment

Cassava processing serves as a means of generating employment opportunities to Nigerians especially at the level of rural areas where unemployment is on the increase. Cassava processing create jobs not only for farmers but equally for processors, marketers and others engaged in the cassava value chain. An increase in industrial activities and trade in the rural areas will translate into the creation of employment opportunities which will reduce the exodus of young people migrating to the urban areas for search for better jobs. More so, this will give room for improved rural and urban income, food security and livelihoods.

2.3. Means of generating income

The processing of cassava serves as a means of bringing in income to several Nigerians, especially the small scale farmers and processors. The sale of cassava and its finished products generate income that assists to improve the livelihood of farmers and processors thereby alleviating poverty. There is great potential seen in processed cassava for income generation. Seen more as a simple food crop in the eyes of the rural poor, it can further serve as a source of raw material for further processing into value-added products for both rural and urban consumption and as a cash for low-income farm households. The ability to process raw cassava into more shelf-stable products would help the farmers to obtain better prices than when fresh cassava is offered in their perishable state.

2.4. Foreign exchange earnings

Cassava and its products are exported to foreign countries as a means of generating foreign exchange earnings for the country. Cassava products such as gari, cassava flour and starch exported helps to diversify Nigeria's economy and reduce her dependence on oil export.

2.5. Development of industries

Cassava processing is a driving force for the creation of industries in Nigeria. The use of cassava as raw materials in industries such as food and beverage, pharmaceutical and textile industries can create more employment opportunities and boost economic growth.

2.6. Increased rural production

Processing of the cassava into different finished products give more rise to the domestic production of cassava based products. In years 2002 to 2008, something like this happened in the country when commercialization of the crop was promoted under a special initiative. Production rate of cassava increased by 25% without any significant export of its products within the 6 years period under study[14]. With higher demand for cassava, farmers in the country can be encouraged to go into the cultivation of higher-yielding varieties and make use of best processing practices.

3. Uses of processed cassava

Cassava can be used for other food products apart from the shelf-stable products like biscuits, bread, lafun, baby food, glucose, gravies, etc. or industrial products like livestock ration, ethanol, gum, etc.[15,16], syrup concentrates for soft drinks, dextrin pre-gelled starch for adhesives, hydro lysates for pharmaceuticals, drugs, and seasoning[17,18]. It can also be used as a component in the manufacture of dyes, chemicals, carpets, as binder in the textile industries and in the coagulation of rubber latex[19,20].

3.1. Source of food

Cassava is a staple food in Nigeria and many other countries. It is processed into gari, fufu, lafu (cassava flour), and tapioca. Cassava flour can be used to produce gluten free baked bread, cakes, biscuits and cookies.

3.2. Source of animal feed

Chips and pellets from cassava are used as source of energy in animal feeds such as found in pigs and livestock ration.

3.3. Source of industrial raw materials

Starch a raw material from cassava is used in industrial processes such as paper making, pharmaceutical and textile industries. Starch can also be used as a binding agent in the production of adhesives and as a thickener in the food industry.

3.4. Production of alcohol and biofuel

Fermented cassava is used to produce alcohol which is used in the production of ethanol fuel and alcoholic drinks such as beer and vodka. It can also be for the production of biofuel such as biodiesel and bioethanol.

3.5. Source of medicine

Leaves and roots from cassava contains compound with medicinal derivatives. The leaves can be used to treat diarrhea while the roots have anti-bacterial and anti-fungi properties. In general, cassava remains a multipurpose crop with several uses and benefits thereby making the crop an important food and economic resource all over the world.

4. Operations involved in cassava processing

The high perishability of cassava root requires immediate processing because it spoils within 3 to 4 days after harvest is done and that is why they are consumed immediately or being processed to other forms with better storage qualities[21]. The best form of cassava tuber preservation and the reduction of post-harvest losses has been its immediate processing into various shelf stable products such as garri, abacha, fufu, starch, flour, chips, and pellets[20,22,23]. Processing adds value to cassava and also extends its shelf life. Processing of cassava into its finished or semi-finished products often involves all or some of the following operations (peeling, washing, grating/chipping, dewatering, fermentation, pulverizing, sieving, pelletizing, and drying/frying) depending on the desired end-products[23–25]. Five distinct operations involved in producing cassava roots into gari, includes: peeling, grating, dewatering, sifting and frying.

4.1. Peeling

Peeling serves as the first processing operation performed immediately after harvesting of the roots which gives room for the removal of the cortex of the tubers. The peeling device is not yet fully developed to an acceptable stage due to factors such as irregularity in the shape of the root. However, the National Centre for Agricultural Mechanization (NCAM) developed cassava peeling tool that is made up of a U-shaped mild steel with a stainless steel “V” shaped peeling blade of 2 mm by 10 mm for uniform peeling of the tuber has a peeling rate of 45.80 kg/h, peeling efficiency of 98.80% and of minimum peeling tuber flesh loss of less than

3%. The NCAM peeling tool is easy to hold. This same peeling tool can peel various sizes of cassava tubers and it is easy to maintain by washing and drying after use. **Figure 1** shows the pictorial view of the NCAM developed cassava peeling tool.

Figure 1. NCAM developed peeling tool.

In addition to this, NCAM has also developed a rotary cassava peeler which consists of a galvanized cylindrical drum. The walls of the cylinder are lined with a rough surface that does the peeling. The bottom of the cylinder is anchored on a gear via a controlled shaft that provides rotary motion to the drum. The NCAM developed cassava peeler has 700 kg/h output capacity with over 90% peeling efficiency.

4.2. Grating

The grating of cassava is a vital unit operation in the processing of cassava root into gari and other food forms. Cassava grating is not a new activity but has been carried out locally using traditional methods. The NCAM motorized cassava grater was developed and designed to ease the problem associated with traditional method of grating which include the tedious and time consuming nature of the traditional method, the injury to the hand, the unhygienic processing and the non-uniformity of the grated particles. The grater consists of a trapezoidal shaped hopper made of stainless steel, grating unit which is made up of a cylindrical perforated galvanized sheet, outlet chute and the main frame. It is powered by a 6 hp water-cooled diesel engine. The grater has a grating efficiency of 99.08% and an output capacity of 972.7 kg/h. **Figure 2** shows the pictorial view of the NCAM developed cassava grater.

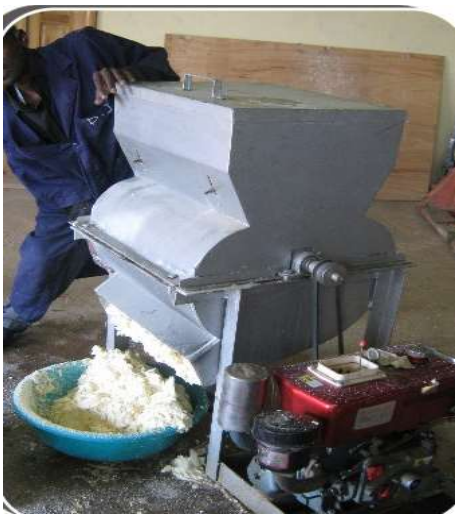

Figure 2. NCAM developed cassava grater.

4.3. Dewatering press

Dewatering of cassava mash is one of the unit operations that plays a major role in the processing of cassava roots into its various finished products. Traditionally, logs of wood and ropes are arranged with heavy stones that serve as load or pressure for removal of water from the bagged cassava mash. Presently, NCAM has developed a hydraulic cassava mash press with the capacity of dewatering up to 10 of 50 kg bags/batch. **Figure 3** shows the pictorial view of the NCAM developed hydraulic cassava mash press.

Figure 3. NCAM developed hydraulic cassava mash press.

4.4. Sifting

Sifting is the pulverization of the pressed cassava mash carried out as a necessary measure to achieve efficient heat transfer during frying. Sifting also allow for the production of different grades of gari that will be suitable to different class of consumers depending on customs and tradition. After pressing, the de-watered cassava mash which turns out to be a solid cake needs to be broken down through sifting process that accounts for the removal of large fiber and lumps so as to achieve a product with uniform particle size. Obtaining a uniform particle size is of great importance because it makes these particles to be consistent during frying operation. Smaller particles were reported to take less energy and time to roast. At the final re-sieving stage, gari products are separated into chaffy, coarse, medium and fine size fractions. This is usually done after frying operation. The consistency and texture of food products from processed cassava is of valuable consideration all over sub-Saharan Africa[26]. However, the NCAM developed cassava sifter has a sifting efficiency of 98.46% and an output capacity of 1.1 ton/h. **Figure 4** shows the pictorial view of the NCAM developed cassava sifter.

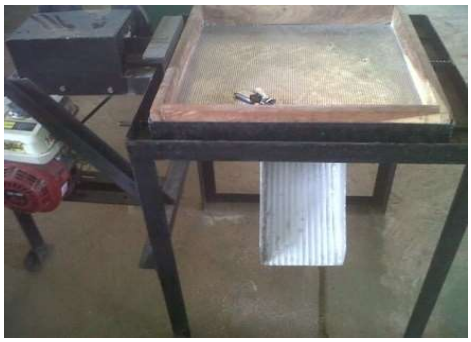

Figure 4. NCAM developed cassava sifter mass.

4.5. Frying

Frying is the final unit operation carried out during gari processing. The frying operation can be carried out using a gari fryer. NCAM was privileged to develop an automated gari fryer for this purpose. This newly developed machine save cassava processors into gari making from the drudgery and troubles that accompany

the final phase of production of this popular staple food in Nigeria. The NCAM developed mechanical fryer consists of wooden paddles which are activated by the plenary gear system. By this arrangement, the paddles rotate and revolve round the gear thereby facilitating the agitation and stirring of the sieved cassava particles being fired. It has a capacity of 50 kg/batch. **Figure 5** shows the pictorial view of the NCAM developed mechanical gari fryer.

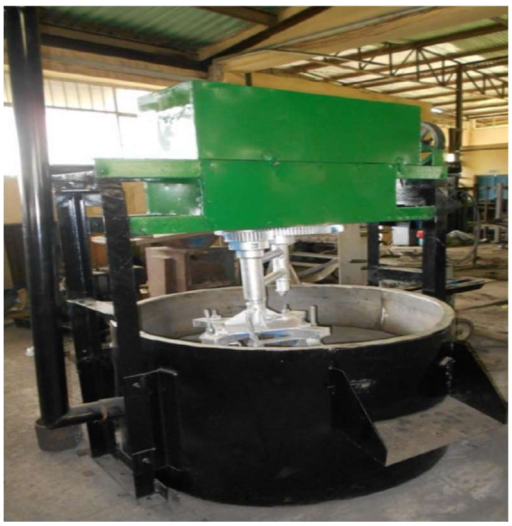

Figure 5. NCAM developed mechanical gari fryer.

Processing cassava into its finished products such as chips, flour, pellets and starch require the use of machines which NCAM have made tremendous effort over the years to develop them in order to meet the demand of the rapidly growing processing industries in Nigeria. Some of these cassava processing machines not mentioned here but which NCAM have also developed include cassava chipping machine, cassava grater cum chipper machine, semi-automatic cassava stem planter (single and double row), cassava lifter, tractor drawn cassava harvester, cassava sedimentation tank and hammer mill with and without cyclone.

5. Level of mechanization of cassava unit operation in Nigeria

The National Centre for Agricultural Mechanization (NCAM) conducted a national mechanization survey in years 2018 and 2019 in order to determine the level of mechanization involved in each unit operation of cassava processing in Nigeria. This survey exercise conducted by NCAM using a well-structured questionnaire covered 36 States and the Federal Capital Territory (FCT). The survey exercise of 2018 had a total of 27 States and FCT involved which was done in two phases while that of year 2019 covered the remaining 9 States.

Nine unit operations of cassava were considered during this study. These processing operations include peeling, washing, grating chipping, dewatering, drying, frying, milling and bagging. The outcome of the mechanization level for each of the unit operation of cassava as contained in the NNMS[27] report is discussed under this subsection. However, the NNMS[27] report also states that States like Bauchi, Borno, Jigawa, Kano, Kebbi, Sokoto, Yobe, Zamfara and FCT were not involved in cassava processing.

5.1. Peeling operation

NNMS[27] report state that a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 1884 agro-processing units representing 80.24% adopted manual method for peeling cassava, a total of 86 agro-processing units representing 3.66% reported adopting mechanical method for peeling cassava, a total of 10 agro-processing units representing 0.43% reported adopting both methods for peeling cassava while the remaining 368 agro-processing units representing 15.67% refused to provide the method used for peeling cassava. This indicates the low level of use of motorized cassava peelers to peel cassava in Nigeria.

5.2. Washing operation

According to NNMS[27], a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 1866 agro-processing units representing 79.47% adopted manual method for the washing of cassava, a total of 114 agro-processing units representing 4.86% reported adopting mechanical method for the washing of cassava, a total of 19 agro-processing units representing 0.81% reported adopting both methods for the washing of cassava while the remaining 349 agro-processing units representing 14.86% refused to provide the method used for the washing of cassava. This indicates the low level of use of motorized cassava washers to wash cassava in Nigeria.

5.3. Grating operation

NNMS[27] report revealed that a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 983 agro-processing units representing 41.86% adopted manual method for the grating of cassava, 1065 agro-processing units representing 45.36% reported adopting mechanical method for the grating of cassava, a total of 23 agro-processing units representing 0.98% reported adopting both methods for the grating of cassava while the remaining 277 agro-processing units representing 11.80% refused to provide the method used for the grating of cassava. This indicates the increase in the level of use of motorized cassava graters to grate cassava in Nigeria.

5.4. Chipping operation

NNMS[27] report revealed that a total of 2337 agro-processing units that are into cassava processing operations were visited in 28 States. It was noted in the NNMS[27] report that Rivers State which involved the 11 agro-processing units visited had no entry for chipping operation which may likely be an indication that they are not into the chipping operation of cassava. It is good to note that out of these 2337 agro-processing units visited, a total of 1528 agro-processing units representing 65.38% adopted manual method for the chipping of cassava, a total of 221 agro-processing units representing 9.46% reported adopting mechanical method for the chipping of cassava, a total of 19 agro-processing units representing 0.81% reported adopting both methods for the chipping of cassava while the remaining 569 agro-processing units representing 24.35% refused to provide the method used for the chipping of cassava. This indicates the low level of use of motorized cassava chippers to chip cassava in Nigeria.

5.5. Dewatering operation

According to NNMS[27] report, a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 1229 agro-processing units representing 52.34% adopted manual method for the dewatering of cassava mash, 901 agro-processing units representing 38.37% reported adopting mechanical method for the dewatering of cassava mash, a total of 22 agro-processing units representing 0.94% reported adopting both methods for the dewatering of cassava mash while the remaining 196 agro-processing units representing 8.35% refused to provide the method used for the dewatering of cassava mash. This indicates the gradual increase in the level of use of dewatering press in dewatering cassava mash in Nigeria.

5.6. Drying operation

NNMS[27] report revealed that a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 1605 agro-processing units representing 68.36% adopted manual method for drying cassava, a total of 291 agro-processing units representing 12.39% reported adopting mechanical method for drying cassava, a total of 19 agro-processing units representing 0.81% reported adopting both methods for drying cassava while the

remaining 433 agro-processing units representing 18.44% refused to provide the method used for drying cassava. This indicates the low level of use of mechanical dryers for drying cassava in Nigeria.

5.7. Frying operation

According to NNMS[27] report, a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 1564 agro-processing units representing 66.61% adopted manual method for the frying of sifted dewatered cassava mash, a total of 277 agro-processing units representing 11.80% reported adopting mechanical method for the frying of sifted dewatered cassava mash, a total of 18 agro-processing units representing 0.77% reported adopting both methods for the frying of sifted dewatered cassava mash while the remaining 489 agro-processing units representing 20.82% refused to provide the method used for the frying of sifted dewatered cassava mash. This indicates the low level of using mechanical means such as gari fryer for the frying of sifted dewatered cassava mash in Nigeria.

5.8. Milling operation

NNMS[27] report revealed that a total of 2342 agro-processing units that are into cassava processing operations were visited in 28 States. It was noted in the NNMS[27] report that Taraba State which involved the 6 agro-processing units visited had no entry for milling operation which may likely be an indication that they are not into the milling operation of cassava. It is good to note that out of these 2342 agro-processing units visited, a total of 1038 agro-processing units representing 44.32% adopted manual method for the milling of cassava, 961 agro-processing units representing 41.03% reported adopting mechanical method for the milling of cassava, a total of 21 agro-processing units representing 0.90% reported adopting both methods for the milling of cassava while the remaining 322 agro-processing units representing 13.75% refused to provide the method used for the milling of cassava. This indicates the increase in the level of use of motorized hammer mills for the milling of cassava in Nigeria.

5.9. Bagging operation

According to NNMS[27] report, a total of 2348 agro-processing units that are into cassava processing operations were visited in 28 States. Out of these 2348 agro-processing units visited, a total of 1884 agro-processing units representing 80.24% adopted manual method for the bagging operation of cassava, a total of 130 agro-processing units representing 5.54% reported adopting mechanical method for the bagging operation of cassava, a total of 17 agro-processing units representing 0.72% reported adopting both methods for the bagging operation of cassava while the remaining 317 agro-processing units representing 13.50% refused to provide the method used for the bagging operation of cassava. This indicates the low level of using mechanical means for the bagging process of cassava products in Nigeria.

6. Problems militating against cassava processing operations in Nigeria

The major constraints of cassava processing include lack of machines, tools, efficient equipment and appropriate processing technologies. These processing machines are not easily affordable and at times not readily available at the farm. The processing machines that are presently available today were those that were merely fabricated without putting into use adequate engineering research. Other problems militating against cassava processing operations in Nigeria are discussed under these subsections.

6.1. Problems associated with peeling of cassava

Peeling of cassava is usually carried out by holding the root in one hand while peeling is carried out with the other hand using knife. This method is slow, burdensome, cumbersome and labour intensive. In order to tackle this problem, the NCAM peeling tool was developed. Peeling remains a major setback in cassava processing. Attempts in mechanizing cassava peeling operation have been acknowledged but the development

of such machines have not yet been fully successful[25] as no efficient cassava peeler is presently in the market in Nigeria[9,10,19,23,28]. This is due to the irregularity found in the shape of the tubers, variations in tuber size, weight and thickness of the peel across different varieties of the crop[19,29]. Also, the environmental factors such as relative humidity, temperature, rainfall, soil type, soil moisture, soil acidity, soil fertility, and vegetation of the farm may affect the tuber characteristics that have effect on their peeling[30]. The problems encountered during the peeling of cassava tubers is as a result of cassava tubers exhibiting noticeable differences in shape, size and weight. Cassava peels show some differences in their properties which varies in texture, thickness and strength of adhesion to the tuber flesh[31,32]. According to Ohwovoriole et al.[28], an effective cassava peeler should, among other things, be efficient in removing the cortex of the tubers without substantial loss in tuber flesh. By developing a functional peeling machine will further improve the mechanization of cassava processing.

6.2. Problems associated with grating of cassava

The problems associated with the traditional means of grating cassava include injury to the hand, unhygienic processing and non-uniformity of the grated particles. More so, the traditional method of grating of cassava has been characterized as a tedious and time-consuming operation.

6.3. Problems associated with dewatering of cassava mash

Dewatering of cassava mash is one of the unit operations that play a major role in the processing of cassava roots into its various products. The traditional method of dewatering involves the use of logs of wood and stones which are placed on top of the bagged cassava mash to drain out water from the cassava mash for long hours and sometimes days. This crude and cumbersome method is burdensome and unhygienic.

6.4. Problems associated with sifting of cassava

The problems encountered during the sifting of dewatered cassava mash include high labour, expenses associated with manual sifting, time wastage, tedious nature of the operation, injury to the hand or palm as one rubs it against the raffia sieve continuously, backache caused by prolonged sitting in one position during manual sifting, low productivity, and the hygienically unsafe nature of manual sifting as products are exposed to germs.

7. Challenges encountered during cassava processing operations in Nigeria

Cassava processing operations in Nigeria is faced with myriad of challenges. These challenges are discussed under the following subsections.

7.1. Lack of basic infrastructure

Lack of infrastructural facilities such as good roads, electricity, water supply and high transportation cost, affects the processing operations of cassava. Processors are not given adequate support such as purchasing these cassava processing equipment at a reduced cost. The cost of these machines are on the high side thereby making them to be out of reach to most of these cassava processors. Lack of adequate training and failure of government agricultural agencies to inculcate a maintenance culture leading to incessant breakdown affects the performance of cassava processing equipment which invariably affects the production process.

7.2. Lack of access to loan facility

Most small and medium scale industries that engage in the processing of cassava find it difficult to access loan that could be used to finance their cassava processing business thereby reducing their capability to expand their business and invest in modern equipment and technologies.

7.3. Excessive cost of processing equipment

The cost of producing the various finished products of cassava through its processing operation is on the high side which hinders both small and medium scale industries to get modern processing technologies that can help boost production which at the long run will increase their profit margin.

7.4. Low quality raw material

Most cassava supplied to processing centres have high moisture content and impurities which have a negative effect on the finished product. Farmers are not given access to high yielding and pest resistance cassava stem for planting thereby leading to the low quality of processed products found in the Nigerian market.

7.5. Insufficient skilled manpower

Cassava processing industry in Nigeria is faced with shortage of skilled manpower which reduces the embracement of modern processing technologies thereby hindering the development of new value-added products.

7.6. Poor market accessibility

Products access to local and international markets are limited and this have a knock-on effect on the demand for cassava and the profitability of cassava processing operations in Nigeria.

7.7. Insufficient government support

The government support for cassava processing is on a limited scale which is not encouraging and this hinders the development and competitiveness of Nigeria cassava products in the world market.

8. Way forward and conclusion

8.1. Way forward

The processing of cassava in Nigeria is faced with several challenges, however, the following solutions are proffered to move the industry forward. These solutions are presented under the following subsections.

8.1.1. Improvement of basic infrastructure

Both the government and private sectors should invest heavily in improving basic infrastructures such as roads, electricity and water supply to facilitate the transportation and storage of cassava and also support the operation of the processing plants.

8.1.2. Ease of accessing loan

Government should give directive to financial institutions in the country to grant unlimited access to finance through loan facility in which the small and medium scale cassava processing enterprises in Nigeria can use for the smooth running of their operations so as to enable them expand their businesses and invest in new technologies and equipment.

8.1.3. Modern methods and innovations

The industry should embrace new methods and innovations by adopting modern technologies as this will improve their processing methods and as well enhance the development of new value-added products. Modern method of processing cassava should be introduced to processors. Aside from this, high yielding and pest resistance cassava stem should be given to farmers who are responsible for the cultivation of the crop.

8.1.4. Quality control

The quality of cassava supplied to the processing plant should be improved in terms of better farming practices, use of improved cassava varieties, improved post-harvest handling and storage practices.

8.1.5. Development of skilled manpower

Both the government and private sector should invest in training and capacity building programmes for cassava processing industry workers in order to improve their skills and knowledge of modern processing technologies. Special attention should be given to small-scale farmers who accounts for the greater amount of cassava being processed.

8.1.6. Market accessibility

Both the government and private sector should create an avenue to access the local and international market for cassava products. i.e., organizing trade fair that will give room for foreign investors to invest deeply in our cassava processing industries. This will hereby promote cassava products which by so doing will give room for better investment in the marketing infrastructure of the finished products of cassava.

8.1.7. Government support

The government should support the operation of the cassava processing industry through the formulation of viable policies and initiatives that will cater for investment and as well as providing funds for research works that deals with the mechanization of cassava processing operation. These include tax incentives, subsidy and targeted funding programme. Educational institutions, government establishments and research institutes should also be allowed through the support of international donors to develop machines for cassava processing.

8.1.8. Promoting the use of agro-processing machines in speeding up the rate of cassava processing operations in Nigeria

The use of agro-processing machines in speeding up the rate of cassava processing operations in Nigeria is very important at a time like this when the nation's economy needs to be diversified into agriculture. There is the urgent need to draw the attention of the three tiers of government to this in order to help boost the nation's economy. However, one of the outcomes coming out from the cassava processing industry in Nigeria as contained in the NNMS[27] report is that the unit operations dealing with the peeling, washing, chipping, drying, frying and bagging of cassava have higher involvement of manual methods among the agro-processing units visited. For this reason, the three tiers of government in Nigeria needs to do a lot to increase the mechanization level for these listed processes involved in cassava processing operation.

8.1.9. Empowering NCAM to popularize proven technologies developed for cassava processing in Nigeria

NCAM is a federal government parastatal given the mandate to promote the practice of agricultural mechanization in Nigeria. In view of this, there is need for the federal government of Nigeria to provide more funds to the Centre for use in popularizing all her proven technologies developed for cassava processing in the 36 States and FCT of the federation. This increase in fund will also give room for NCAM extension agents to reach out to more agro-processing units that are in dire need of NCAM cassava processing machines.

8.2. Conclusion

The importance of cassava tuber to the nation's economy and food security drive cannot be overemphasized. Apart from providing a source of food for the nation's ever-teeming population, raw materials for her industries and a foreign exchange earner, it can also provide jobs for rural dwellers and halt the rural urban population drift if the necessary attention and support by the government is given. The government should fund research works on cassava processing and encourage local investors to invest in the cassava processing business by granting reduced-interest loans to those who are willing to invest into cassava processing business. Improved high yielding cassava variety should be introduced to local farmers in assisting the processing industries in producing high quality cassava products.

Concerted effort should be made to introduce mechanized processing equipment to reduce the longtime associated with the processing of cassava tuber. Tedious, menial and exhausting work in post-harvest processing of cassava into utilization products can be reduced or completely eradicated if adequate mechanized processing is embraced. In addition, adequate investments and extensive research into the designs and development of these processing machines will ensure competitiveness in the processing of the products. Enhanced processing, storage and packaging technologies will go a long way in extending the shelf life, maintaining global food security and contributing to the increase in availability and reliability of cassava root thereby allowing for export to countries where food is unavailable and hunger is severe.

Author contributions

Conceptualization, LOA and OAO (Opeyemi Adeniyi Oyelade); methodology, LOA and OAO (Opeyemi Adeniyi Oyelade); software, OAO (Olusola Adetola Ogunjirin); validation, LOA, OAO (Opeyemi Adeniyi Oyelade) and OAO (Olusola Adetola Ogunjirin); formal analysis, LOA, OAO (Opeyemi Adeniyi Oyelade) and JAO; investigation, LOA, OAO (Opeyemi Adeniyi Oyelade) and JAO; resources, LOA, OAO (Opeyemi Adeniyi Oyelade) and JAO; data curation, LOA, OAO (Opeyemi Adeniyi Oyelade) and JAO; writing—original draft preparation, LOA and OAO (Opeyemi Adeniyi Oyelade); writing—review and editing, OAO (Opeyemi Adeniyi Oyelade) and YSA; visualization, LOA, OAO (Opeyemi Adeniyi Oyelade) and JAO; supervision, YSA and OAO (Olusola Adetola Ogunjirin); project administration, YSA; funding acquisition, YSA. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors of this paper declare no conflict of interest.

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