Processing and Packaging of Secondary Products of Root-Tuber Crops for Industrial and Domestic Consumption: A Step towards Recovery from Economic Recession in Nigeria.

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Abstract
This paper focused on the processing and packaging of secondary products of root-tuber crops for industrial and domestic consumption. The value of starchy crops (such as cassava, yam and sweet potato), cassava as raw materials for various types of industries, derivatives and their uses; cassava bread as part of the indigenous people's traditional diet, cassava flour as good substitute for gluten free and wheat free flour, livestock feeds for animals, ethanol produced by fermenting and distilling of cassava roots. Starch extraction from cassava fresh root which are used by food industries; cassava noodles, canned fruits, jam and preservatives, steps of extraction, production of mono sodium glutamate by fermentation, canned leaves and stem extraction. Sweet potato processing and utilization, canned sweet potato juice, yam processing; Food uses-fresh, frozen, dehydrated, non food uses-Glue, animal feed, fuel-grade ethanol and importance to the world ecosystem and feed, steps toward, recovery from economic recession in Nigeria, conclusion and recommendations. This work recommended among other things that the private sector should commit itself to working with cassava as an industrial input and improving upon it so that it can effectively compete with alternative input sources.

Key Words: Processing, Packaging, Secondary Products, Root - tubers.

Introduction

The value of yam, cassava and sweet potato exceed all other African staple crops, and are much higher than the value of cereal crops. There are many compelling reasons for encouraging the production of root and tuber crops for sustainable food production in Africa. They are versatile staples to address food and nutrition security for millions of people and produce more food per unit area of land. Potato and sweet potato are short cycle crops with three to four months cropping cycle. They are well suited to the double cropping seasons, particularly in rain-fed systems and have significant advantage over grain crops which require longer time to harvest. Their short growing cycle allows for flexible planting and harvesting times and also permits quick production of foods to augment "hunger months" that is, a period of several months between sowing and harvest, when people do not have food to satisfy their food requirements to meet their basic caloric and nutritional needs.

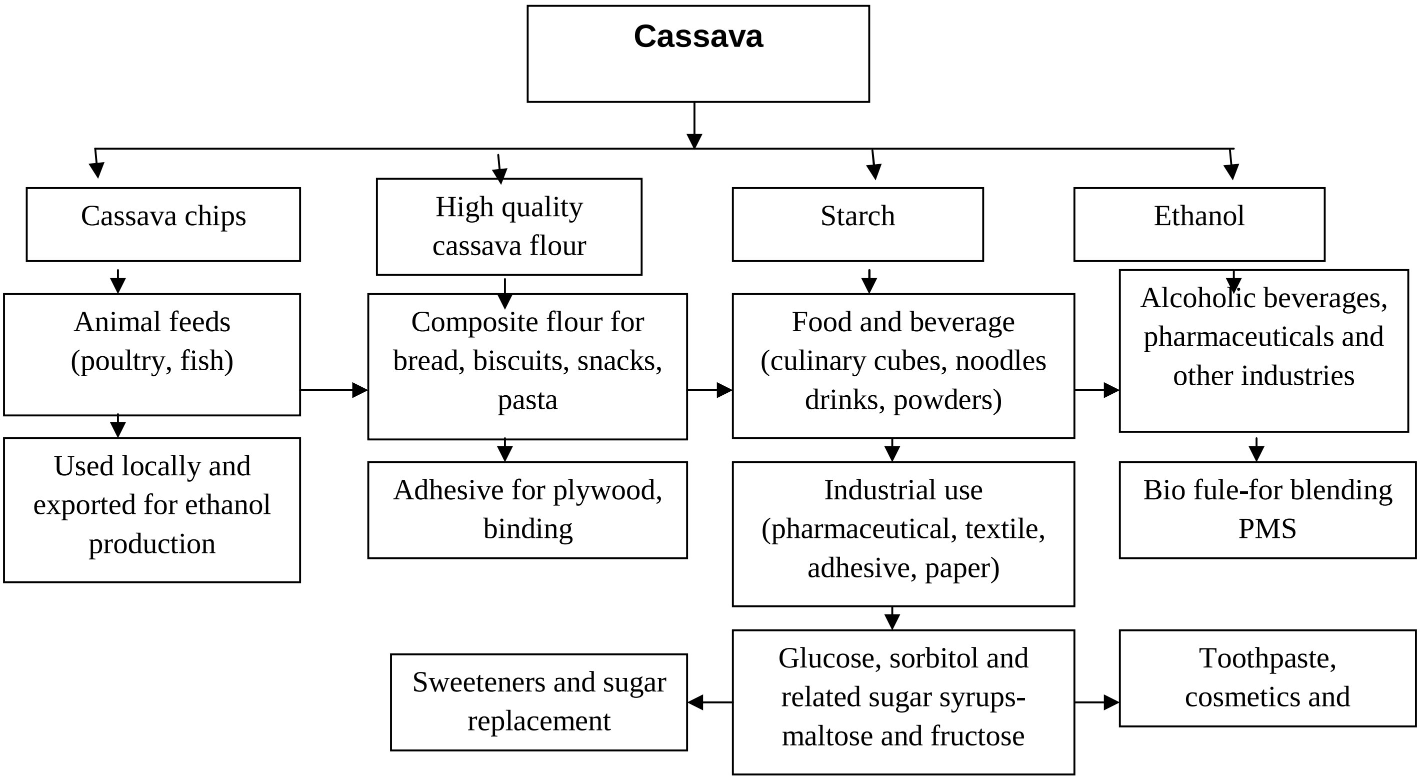
Yam and cassava, though with longer cropping cycles, are vital for annual cycle of food availability. Their broader agro-economical adaptation including the marginal environments, diverse maturity period and in-ground storage capability permit flexible harvesting periods which aids sustained food availability. These crops are also capable of efficiently converting natural resources into a more usable product, caloric energy in the growing season, which is the most productive of all major arable crops. Yam, cassava, potato and sweet potato are cheap but nutritionally rich staple foods that contribute to carbohydrates, protein, vitamin c, vitamin A; zinc and iron towards the dietary demands of regions, fast growing towns and cities. These crops are largely traded locally and nationally, (Munshi & Mondy 2006).

Processing and packaging are the coordinated system of preparing food for transportation, distribution, storage, retailing and end-use to satisfy the ultimate needs of consumers with optimal cost (Eds, Cole, McDoowell & Kirwan, 2003). Processing and packaging are essential part of modern agricultural practices. Commercially processed food could not be handled and distributed safely and efficiently without packaging. The world packaging organization stated that more than 25% of food is wasted because of poor packaging (Berger and Gainesville, 2005). Thus it is clear that optimal processing and packaging can reduce the large amount of food waste. Moreover, the current consumer demand for convenient and high-quality food products had increased the impact of food packaging. This paper is focusing on the processing and package of secondary products of root-tuber crops in relation to domestic and industrial consumption.

Cassava

In several African countries, cassava is perceived, not only as a food security crop, but also as a raw material for various types of industries. Virtually all cassava (90%) produced in Africa are used as staple food for human consumption. In some countries, there are concerted efforts being initiated, sometime with strong political support to make cassava an engine of economic growth. Cassava can be converted into a large number of products, livestock feed, ethanol, starch and numerous other derivatives (Kormawa & Akoroda, 2008). In recent years, a substantial trade has developed in dehydrated cassava chips and pullets which are exported to Europe as low cost animal feed ingredient (Fetuga & Tewe 1985).

Cassava Derivatives and their Use



Kormawa & Akoroda, (2008)

Cassava Bread

Cassava bread is an important part of indigenous people's traditional diet. It is said to keep away new world diseases like diabetes, heart disease, high blood pressure and obesity. Cassava, also known as manioc or yucca in the American continents is widely used all over the world as a staple (Katz & Weaver 2003). Traditional cassava bread of indigenous people should not be confused with western style bread made from cassava flour. Following the recipe of indigenous peoples of South America, no salt, sugar, oil, butter, baking powder or yeast is added. When dried properly the bread can last for days, weeks or even months. The bread is used as a basic staple. Its plain taste can be delightfully flavored and enhanced by eating with dishes of other flavors. The bread is filtered because it smells with the addition of digestive juice. To be enjoyed, it has to be properly dried to biscuit type dryness or consumed within a day after baking (Cock 1985).

Cassava Flour

The cassava flour traditionally is made for the indigenous people purely from the cassava root and processed until it is a soft coarse meal, similar to moist corn meal. Properly processed cassava flour in whatever state is healthy and can be a great substitute for gluten-free and wheat-free flour. The bread made from the flour can be used as a substitute for those who suffer celiac disease since it is gluten-free and wheat-free flour (Onyango, 2011).

Cassava Bread/Flour Steps of Processing

Cassava roots are peeled, washed and sliced thinly with knife. The shed-ded cassava was washed with enough water to remove part of the starch and the water allowed to drain. Spread thinly on a clean concrete surface on a straw mat in the sun for about 11 hours until it becomes brittle. Grind through a corn mill grinder and passed through a 120 mesh sieve to produce cassava flour. The flour is packaged and sold locally or exported. Cassava bread are baked using the processed flour through adding ingredient like yeast, salt, sugar and baking fat in the right proportion to have rich and brown bread package and commercialize locally and exportation. Therefore, it would enhance recovery from recession by Nigerians if adopted.

Ethanol

Ethanol is produced by fermenting and distilling cassava roots. Ethanol has various industrial uses as stated by (Atthasampunna, 1987) as follows:

1. It can be mixed with petrol or used on its own as a transport fuel.
2. It can also be used as a base for alcoholic beverages.
3. Ethanol can be utilized as industrial alcohol which is important in the pharmaceutical and cosmetic industries.

Ethanol is generally produced by the fermentation of sugar, cellulose or converted starch.

Ethanol processing Steps

Harvested cassava is washed, reduced into cassava chips and mixed with water, converted to cassava starch molecules and sugar and are allowed to ferment. In fermentation process sugar and starch molecules are broken down by yeast to produce ethanol. During distillation process water will evaporate thereby increase the purity of ethanol.

Therefore, Nigerians can package the product for marketing to local consumer and even export the product since it can be used as fuel for cars, drinking alcohol and in alcoholic beverages. This could enhance recovery from recession.

Cassava Flour: Cassava Processing To Ethanol

Cassava flour
Water and alpha-amylase enzyme
↓
Liquification
90 & 95 c, Ph 4-4.5) 400rpm
↓
Saccharification
(55-65 c, Ph 4-4.5)Glycosidase enzymes
↓
Cooling
(30-33c)
↓
Fermenter
(Yeast added) (Carbon doxide out)
↓
Distillation
Feed recovery
↓
Ethanol

Equipment required
Peeler
Grater
Jet cooler
Fermentor
Distiller
Steam boiler
Generator
Efficient treatment plant

Atthasampunna, Somchai, Euraree & Artjarrjasripering, (1987)

Cassava Starc

Cassava starch can be extracted from cassava roots to form starch which are used by food industry, but are also used by the paper and textile industries, as well as adhesive in glass, mineral, wool and clay (Wurzburg, 1987).

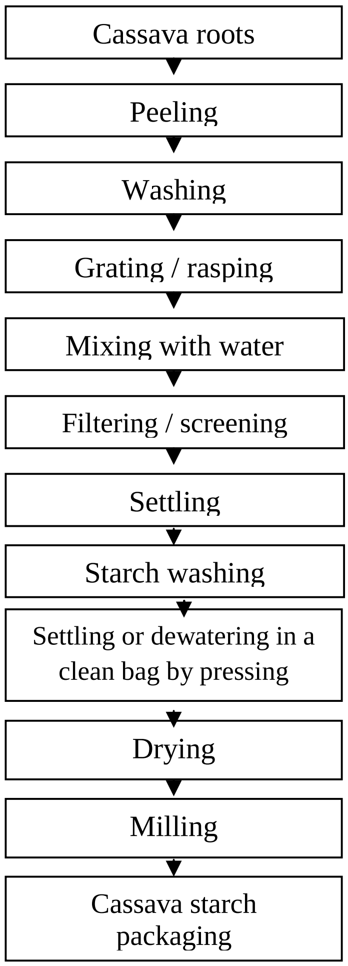
Cassava is also used in making of glucose and alcohol which are essential commodities in many pharmaceuticals and food canning industries.

1. Cassava product is also very useful in the confectionaries for the making of large varieties of food items including ice cream, jelly beans, jams, sweets and gums.
2. Recently, many fruit juice manufacturers are now beginning to replace sucrose with dextrose, which is a product of cassava. Dextrose is preferred to the sucrose due to the absence of dangerous sulfur dioxide and because it helps to preserve the original flavor of the fruit and reduces the tendency of it becoming crystallized into sugar.
3. Cassava product is also used to produce *caramel* which is used as a coloring agent in food, confectionaries and liquor because it is cheaper than other alternatives and provides greater coloration.

Cassava Starch Processing Steps

Cassava root are peeled, washed, grated, mixed with water vigorously stired and screened or filtered and allowed for about 11 hours to settle. Dewatered in a clean bag by pressing to drying, thereafter the cassava starch is packaged for marketing and exportation for local and foreign consumers respectively. This enhances the recovery from economic recession by Nigerians if embraced.

Cassava Starch Extraction Procedures Diagram



Udoh & Nsa Field Work (2017)

Cassava Noodles

Dough extrusion: Extrusion of starchy food results in gelatinization, partial or complete destruction of the crytalline structure and molecular fragmentation of starch polymers, as well as protein denaturation and formation of complexes between starch and lipids and between protein and lipids (Colonna, Mercier & Tayeb, 1983).

Pre-gelling - cassava starch is an acidic polysaccharide consisting in its powdered form of 77% carbohydrate, 21% lipid and 2% protein (Dabai & Muhammad, 2005) The most important characteristics of cassava starch are adourless, paste clarity, stickiness and low impurities like proteins and lipids. Cassava flour at 8% provides optimum gelling and quality can be improved by mixing cassava flour with some ager.

Cooling and packaging – Noodles and sachets are packed by two flowrapper pillow – pack machines producing a total of up to 640 heat sealed, Packs per minute. Guaranteeing optimal cooling in a minimum of space, the gondolas are located in a cooling tunnel with guarding located on the right, left and over and under the gondolas (Rahul, Annapure, 2017). The next machine is the sachet feeder a multiplication unit featuring smart handling that ensures correct positioning of the sachets. The major raw materials for cassava based noodles are cassava flour.

Food Industry

The food industries are the largest consumers of starch and starch products. In addition, large quantities of starch are also sold in the open markets for household cooking's laundry services.

Unmodified starch, modified starch and glucose are used in food industries for one or more of the following purposes (Onyango, 2011).

Unmodified Starch

- Starch is used as thickeners, stabilizers, emulsifiers, ingredients for the production of salt expanded biscuits and cheese rolls.
- It can be used as a carbohydrate source in animals feed and also as a raw material in the manufacture of processed food, animals feed and industrial products.

Modified Starch

Modified starch also called starch derivatives, are prepared by physical, enzymatically or chemically treating native starch to change its properties. Modified starches are used in physical agent, stabilizer or emulsifier. In pharmaceuticals as a disintegrant, as binders in coated paper (Maurer, 2001).

- Starch is modified to enhance their performance in different applications.

- Starch are modified to increase their stability against excessive heat, aid, shear, time, cooling or freezing to change their texture, to decrease or increase their viscosity, to lengthen or shorten gelatinization time or to increase their viscosity.
- To thicken instant desserts, allowing the food to thicken with the addition of cold water or milk.

Similarly, cheese source granules (such as in macaroni and cheese or lasagna) or graving granules may be thickened with baling water without the product going lumpy (Jenny Ridgwell, 2001).

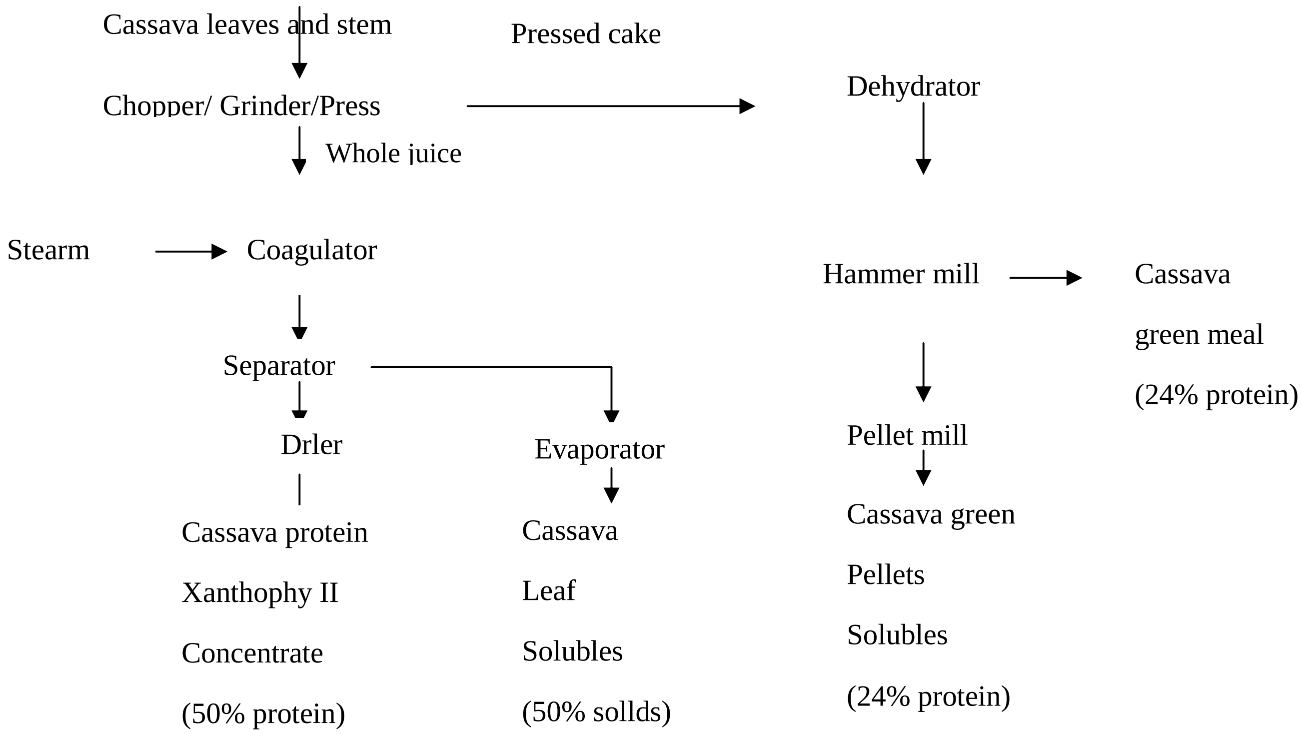
- Modified starch is used as a fat substitute for low-fat versions of traditionally fatty foods example industrial milk-based deserts like yogurt or reduced-fat hard salami having about 1/3 the usual fat content.
- Modified starch is added to frozen products to prevent them from dripping when defrosted.
- Modified starch, bonded with phosphate, allows the starch to absorb more water and keeps the ingredients together (Jenny Ridgwell, 2001).

Glucose Syrup

- Glucose syrup is a concentrated aqueous solution of glucose, maltose and other nutritive saccharine from edible starch. Glucose syrup is used in large quantities in fruits, liquors, dry sterilized fruit, bakery products, pharmaceuticals and brewery products.
- Glucose syrup production from cassava can be subdivided into the following process areas of liquefaction, saccharification and purification.

1. Directly as cooked starch food, custard and other forms
2. Thickened products using the paste properties of starch (soups, baby food, sauces and gravies etc)
3. Filler contributing to the solid content of soups, pills and tablets and other pharmaceutical products, face-cream, etc.
4. Binder to consolidate the mass and prevent it from drying out during cooking (sausages and processed meats).
5. Stabilizer, owing to large water-holding capacity of starch, e.g. in face cream Baranowska, Rezler, Poliszko,. Dolata, Piotrowska, & Piatek (2004).

Young tender leaves are good source of dietary proteins and vitamin K. Vitamin K has a potential role in bone mass building by promoting osteothropic activity in the bones (Berkner,& Runge, 2004).



(Thangavel, K. 2006)

Sweet Potato Processing and Utilization

Sweet potato roots and other plants are used as human food, animal feed and by processing industries for industrial processing. Starch, sugars and natural colorants are the major intermediate products that can be used in food and nonfoods processing industries.

Sweet potato roots are processed into dehydrated forms such as dried chips, cues, granules, flakes and flour for storage and use in food preparation including soups, bakery products, vermicelli, needles, extruded snack food. Processing methods vary in sophistication from simple slicing and field sun-drying of roots as practiced at the village levels in many tropical countries to large-scale, multistage production of dehydrated products by large food companies (Bencini, 1991).

Canned Products of Sweet Potato

Canned sweet potatoes are widely consumed among the sweet potato products available to consumers in the United States. Sweet potatoes can be canned whole, halved, or cut into chunks, either in syrup or water; it can also be canned as a solid pack (Roberto Verzo, 2014).The use of sweet potato in the food industry often involves processing of the roots into purees that can be subsequently frozen, canned or packaged in a septic condition to produce self-stable products for year round availability (Woolfe, 1992).

There are many small and medium factories in Asia producing about 26%of starch production (Bovel-Benjamin, 2007). The process for manufacturing sweet potato starch is basically similar to the starch extraction from other sources. The roots are ground in lime water (PH 8.6-9.2) to prevent browning due to binary chemical compound of oxygen to dissolve pigments and to flocculate the impurities. The extracted starch is separated from the pulp by thoroughly washing over a series of screens, bleaching with sodium hypochlorite, then setting by gravity or centrifugation (Ertrela & Barbin, 2002). Centrifugation and mechanical drying such as flash drier are commonly used for medium scale factories. Sweet potato starch is used in the product of traditional noodles, vermicelli, thickening agent, or converted into sugar syrups which are used in many processed food products. The sweet potato starch and sugars are also utilized in the production of fuel alcohol, monosodium glutamate, microbial enzymes, citric and other chemicals (Kotecha, Kadam & padmaja 2009). In Japan the orange and purple-fleshed sweet potatoes have been used in commercial production of natural beta-carotene and anthocyanin pigments in beverages and other food products. It can also be processed into other food products such as clips, starch, puff-puff, buns, bread, jam, crisps (Carnizales, 1991). Sweet potato is also used in bread Spices, pone and chips. Sweet potato fries are now available in fast food restaurants as a substitute for white potato fries. Secondary processing are bread, cake, cookies, extruded snack, thickener. Flour is processed into potential bakery products and fabricated snacks (Carnizales, 1991).

Sweet Potato Processing and Uses

Potatoes are used for a variety of ways and not only as a vegetable for cooking at home. In fact, it is likely that less than 50% of potatoes grown worldwide are consumed fresh. The rest are processed into potato food products and food ingredients, fed to cattle, pigs and chicken, processed into starch for industry and unused tubers are preserved for growing in the next season's cropping.

Fresh potatoes are baked, boiled, or fried and used in staggering range of recipes, mashed potatoes, potato pancakes, potato dumplings, twice-baked potatoes, potato soup, potato salad and potatoes gratin, to name a few but global consumption of potato as food is shifting from fresh potatoes to added value in processed food products, one of the main items in that category is frozen potatoes, which include most of the fresh fries (chips in the UK) served in restaurants and fast-food chain worldwide. Another processed product, the potato crisp (Chips in the US) is the long-standing king of snack in many developed countries.

Dehydrated potato flakes are used in retail mashed potato products, as ingredients in snacks, and even food aid. Potato flour, another dehydrated product is used by the food industry to bind meat mixtures and thicken gravies and soups. A fine, tasteless powder with "excellent mouth feel", potato starch provides higher viscosity than wheat and maize starches, and delivers a tastier product. It is used as a thickener for sauces and stews, and as a binding agent in cake mixes, dough, biscuits, and ice creams.

In Eastern Europe and Scandinavia, crushed potatoes are heated to convert their starch to fermentable sugars that are used in the distillation of alcoholic beverages, such as vodka and akvavit (Woolfe, 1987).

Steps towards Recovery from Economic Recession in Nigeria

1. Adoption of efficient and effective development approach in various root-tuber value chains to increase the productivity of the entire crop value chains can drive down the prices of crops to rural and urban consumers. Various root crops should be developed by the federal government by investing in root-tuber farms and financial empowerment of rural and urban farmers for effective and efficient productivity of the entire crop value claim and price control.
2. Agricultural competitiveness must be addressed through:
   (a) Large investments in industries using cassava as raw material (e.g. food, feed, ethanol and starch) to foster demand for cassava (public-private partnerships). Large industries using cassava as raw materials should partner with government and individual farmers right from planning stage by empowering them for effective production and arousing the interest of many into farming.
   (b) Small and medium scale investment by entrepreneurs to enhance production, processing and delivery of high quality and quantity of cassava products to the larger industries. Entrepreneurial production, processing and delivery of cassava should be such that it meet the standard required by large industries, and by adoption of contract farming approach to agricultural development.
   (c) Adoption of labor savaging devices in root-tuber production and processing to ensure more efficient field productions, better services to field production, more attention to post harvest systems (pre and post harvest mechanization). Mechanization should be efficient to savage labor for better service production.
   (d) Improvement in the quality and quantity of crops products for diversified uses to attract urban consumers and industries, create demand for the crop, stimulate increased production and provide more income to producers, processors and traders. Cassava should be used in diverse ways e.g. cassava bread, flour etc. to attract the public to demand for the produce.
   (e) Networking, partnership and cooperation to strengthen national organization (public and private extension). All government sectors, cooperate bodies and individual farmers should have common ways of communication, training and developing information to update themselves for current innovations and efficient production.

(f) Policy regulation by government and procedural change to innovative financing, market linkages and access by youth and gender inclusiveness should be made a provision in governments empowerment programmes. Government policy should recognize agricultural organizations and empower them through their cooperatives.

Conclusion

Root and tuber crops including cassava, yam, potato and sweet potato are the most important food crops for direct and indirect human consumption in Africa. They are grown in varied agro-ecologies and production systems contributing to more than 240 000,000 tons annually. The aggregate value of yam, cassava, Potato and sweet potato exceeds all other African staples, including cereal crops.

There are many compelling reasons for encouraging root and tuber crops production for sustainable food supply in Africa:

1. They are versatile staples to address food and nutritional security and they produce more food per unit area of land, compared to many other crops.
2. Potato and sweet potato are short cycle crops (3 to 4 month) and thus well suited to the double cropping seasons, particularly in rain-fed system.
3. Yam and cassava, though longer in their cropping cycle, are vital in the annual cycle of food availability.
4. They are cheap but nutritionally rich staple food that contributes carbohydrates protein, vitamin c, vitamin a, zinc and iron to meeting the dietary demands of the regions fast-growing towns and cities.

In today's society, processing and packaging are pertinent and essential. It covers, enhances and protects the produce or goods we buy, from processing and manufacturing, from handling and storage, to the final consumer. Without processing and packaging, material would be messy, inefficient and costly exercise and modern consumer marketing would be virtually difficult.

Recommendations

1) There should be alternative to the laws enforcing domestic industries to use cassava for bread making. A memorandum of understanding could be sought between all shareholders of the Nigeria cassava supply chain. For example, the government could commit to relieving market imperfections and improving infrastructural facilities such as transportation, communication and electricity.
2) The private sector should commit itself to working with cassava farmers as an industrial input improving upon it so that it can effectively compete with alternative input sources. This could be achieved through contract farming system.

3) Non-governmental organizations should commit themselves to supporting the effort of both government and the private sector in supporting he farmers in root/tuber crops production.

4) Farm processing and cottage type processing that include storage and packaging facilities should also be provided by government at all levels to assist farmers.

5) The typical requirements of a cassava processing facilities include chipping machines (manual and motorized), a drying platform and tray dryers, a grinder/milling (harmer/plate mills) a starch collection vat and sift (mechanical and manual), the concept of mobile processing facilities should also be promoted amongst processors and also be empowered by government to able to adopt them.

6) Lastly, an industrial commodity organization could be formed that would raise consumers and industrial awareness of cassava's attributes and use to ensure a maximum level of investment in the production of root-tuber crops to sustain the industries that process and package these products. This would go a long way to drive out the Nigerian economy from recession.

References

Amey, E. & Sauti A. (1987). An over view of traditional processing and utilization of cassava in Africa. *International Institute of Tropical Agriculture*. Ibadan, Nigeria

Atthasampunna, P., Somchai, P. Euraree, A.& Artjariyasripong, F. (1987). Production of fuel ethanol from cassava. *World Journal of Microbiology and Biotechnology*. 3(2): 135- 145.

Ayuk, E. (2004). Effects of sweet potato meal on the growth rate of boilers livestock Res. Rural Dev. Vol. 16. No. 9.

Baranowska, H. Rezler, R. Poliszko, S. Dolata, W. Piotrowska, E. & Piatek, M. (2004). *Starch as a functional addition in meat batters. Starch from starch containing sources to isolation of starches and their applications*. New York: Nova Publishers.

Bencini, M. (1991). Post-Harvest and processing technologies of African staple foods: A technical compendium, agriculture service bulletin No 8FAO, Rome.

Berger K.&Gainesville, F. (2005). *Agricultural and Biological Engineering Department. Florida cooperative Extension Service Institute of Food and Agricultural Science*. University of Florida.

Bovel, A. & Benjamin, I. (2007). Factories in Asia producing about 26% of starch production.

Carnizales, P. (1991). *Flurs, potential bakery products and fabricated snacks*. The AVI Publishing Company, Inc. Westport, Connecticut.

Colonna, P. Tayels, J. & Mercier, C. (1989). *Extrusion cooking of starch and starchy products.*St. Paul, MN: American Association of Cereal Chemists. Inc.

Cook, J. (1985). *Cassava: New potential for a neglected crops*. West view press, Boldr: Colorado, USA.

Eds, R., Cole, D., McDowell & Kirwan, K. (2003). Processing and packaging, coordinated system of preparing food for transportation, distribution, storage, retailing and end-use to satisfy the ultimate consumer with optimal coat.

Estrala C. & Barbin E. (2002). Mechanism of action of sodium hypochlorite. *Brazilian Dental Journal*, 13(1): 113-117).

FAO, (2004). Percentage production of yam in West African Countries.

Febuga, B. & Tewe, O. (1985). Potentials of agroindustrial by products and crop residences as animals feeds. *Nigerian Food Journal,* 3((1): 136-142.

Jenny, Ridgwell (2001). Modified starch, Ridgwell Press, BISBN 978-1-901151-07-7.

Katz, G. & Weaver E. (2003). Cassava as manioc or yucca in the Americas, widely used all over the world as a staple.

Ketecha, B. Kadam, U. & Padmaya, N. (2009). The sweet potato starch and sugar, utilized in the production of fuel alcohol.

KL, Berkner, & K.W. Runge (2004).*Journal of Thrombosis and Haemostasis.* Wiley online library.

Kormawa, P. Akoroda, M. (2003). Cassava supply chain arrangement for industrial utilization in Nigeria. Ibadan: ITTA.

Manurung, F. (1974). *Technology of cassava clips and Rellets processing in Indonesia, Malaysin and Thailand*. Pages 89-112 in cassava processing and storage.

Maurer, H. (2001). *Starch and starch products in surface sizing and paper coating*. Tappi Press, Atlanta.

Munshi E. & Mand A. (2006). Tuber crops are largely traded locally and nationally.

Nakanura, J. (2007). Mutations of the corynebacterun glutamicun NCg11221 gene, encoding a mechano sensitive channel homolog, induce L. glunanic acid production. Appl Environ microbial, vol. 73 no. 144491-4498.

Nwachukwu, E. (1987). An overview of traditional processing and utilization of cassava in Africa.

Og, E.& Mouritsen, R (2012). *The manufacture of MSQ in for East and Latin* American Countries.

Onyango, A. (2011). Cassava bread, gluten-free and wheat free flour.

Rahul, P. Rathod, U. & Annapine, S. (2017). Physiochemical properties, protein and starch digestibility of lentil based noodle prepared.

Roberto, V. (20014). Sweet potato canned, vacuum park, NDB11512, U.S. Department of Agriculture, Agricultural Research Service.

Thangavel, K. (2006). Young tender leaves are good source of dietary proteins and vitamin k

Udoh, U. O & Nsa, S. O. (2017). Cassava starch extraction in press.

Woolfe, J. (1987). The potatoes in the human diet Cambridge University Press, Cambridge. UK, 19-54.

Woolfe, J. (1992). *Sweet potato*: An untapped food resource, P. 389. Cambridge, UK: CambridgeUniversity Press.

Wurzburg, O. (1987). *Modified starches*: Properties and uses, CRC Press.