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REVIEW PAPER

Cassava as Potential Crop for the Food and Fermentation Industry: A review

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Abstract

Cassava (*Manihot esculenta* crantz), a perennial shrub is cultivated mainly by resource-limited small farmers for its starchy roots. It is used as a human food either fresh when low in cyanogens or in many processed products, mostly starch, flour and for animal feed. Because of its inherent tolerance to stressful environments, where other food crops fail, it is often considered as a food-security source against famine, requiring minimal care. Cassava flour and starch may act as potential valuable substitutes of maize, rice and wheat crops. The benefits ranged from being a human staple food, constituent of animal feeds, raw material in food processing, edible coatings, paper making industry, indigenous alcoholic beverages to ethanol production. The vast production of cassava under marginal soil conditions can be explored in order to maximize its potential as an industrial crop for interested entrepreneurs. All these aspects have been reviewed here especially with respect to food and fermentation industry.

Keywords: Cassava, starch, flour, edible coating, adhesive, baked products, biofuel

Cassava (*Manihot esculenta* crantz) is a perennial, sub-tropical crop which is valued for its underground starchy tubers (roots). It is a starchy root crop grown mostly in the hotter low land tropics, is a dicotyledonous perennial plant belonging to the family *Euphorbiaceae*. It is an important source of energy as a staple food for more than 500 million people in Africa, Latin America and Asia (Maziya-Dixon *et al.,* 2007). Tuber of cassava is also used as raw materials in the garment, bakery, food and pharmaceutical industries. It is a hardy crop that produces under marginal conditions e.g. draught or depleted soils (Lyer *et al.,* 2010). Though described as inferior source of nutrients because of its low protein content, poor protein quality, and because of its cynogenicglucoside content most of the total world production of cassava is processed for human consumption directly as a food or indirectly as feed for livestock. It is a crop which does not fail and whose food quality is generally improved through processing (Falade and Akingbala, 2010). Global annual production of cassava is estimated to be more than 2,60,000 millions of tons with Africa alone contributing about 54%, followed by Asia and then South America (FAO, 2013). The crop fluids a lot of application in food, fermentation, paper industry, pharmaceutical industry, (Essess *et al.,* 1994; Bose *et al.,* 1987; Singh and Nath, 2012; Srirotha, 1999) but focus has been made on food and fermentation industry here.

COMPOSITION OF CASSAVA

Cassava flour has been promoted as a composite flour for use in food industry (Shittu *et al.,* 2008; Nwabueze and Anoruoh 2009). Cassava flour is recommended in the diet of celiac patients who are strictly adhered to gluten-free food products (Briani *et al.,* 2008; Niewinski 2008). Cassava root comprises of peel and bulky storage root with a heavy concentration of carbohydrates of about 80% and only 2-4% crude proteins on dry weight basis. Proximate composition of cassava is summarized in Table 1. The protein of cassava tuber is rich in arginine, but low in essential amino acids (Omodamiro *et al.*, 2007). In developing countries, cassava root is a valuable food and energy source and optimum post-harvest handling, processing and storage techniques alleviate some concerns of food insecurity (Uchechukwa-Agua *et al.*, 2015). Cassava tuber is the main source of starch and minerals, its flour (10-30%) in combination with wheat flour is used in bread industry to reduce pressure on wheat. Therefore, cassava flour as mixture with wheat flour can be used to make nutritious food and food products. Its tuberous root contains 30-40% dry matter and 25-30% starch. Nutritionally, cassava contains potassium, iron, calcium, vitamin A, folic acid, sodium, vitamin C, vitamin B-6 and protein (Montagnac *et al.*, 2009). Its nutritional component especially protein can be added in composite flours in cassava-soya, cassava-peanut bread.

Table 1: Proximate composition of cassava

Chemical constituents	(%) of Fresh cassava tuber
Moisture	65-70
Starch	21.5
Protein	0.7-1.1
Fats	0.42
Ash	0.54
Dry matter	35-38

Source: IITA, 1990

There is much variation in the nutrient quality of the cassava root (Chaves *et al.*, 2005). In the tropical regions, cassava is the most important root crop and, as a source of energy, the calorific value of cassava is high, compared to most starchy crops. The starch content of the fresh cassava root is about 30% and gives the highest yield of starch per unit area of any crop known. The protein content of cassava is extremely low, however, and ranges between 1-3% but contains significant amounts of iron, phosphorus and calcium and is relatively rich in vitamin C (Enidiok *et al.*, 2008). Further it is a principal source of carbohydrates for the consumers. Because of its good nutritive value, the cassava can be converted into more utilizable products. Efforts in this regard are gradually developing. Recent developments on the utilization of cassava for industrial applications have been reviewed with respect to food and fermentation industry.

TOXIC COMPONENTS OF CASSAVA

It is well established that cassava is not edible raw due to the presence of toxic compounds. Cassava contains two cyanogenic glucosides, namely linamarin and lotaustralin, present in all parts of the plant with the highest concentration in the root peel (Falade and Omojola 2010). Structure of some common cyanogenic glucosides is shown in Fig 1. Normal levels of cyanoglucosides range from 31 to 630 ppm calculated as mg HCN/kg of fresh cassava root, although the content varies considerably depending upon variety, climate and environmental conditions. Sweet cassava varieties have often lower levels of cyanide than bitter varieties but there is no established correlation between the taste and the toxicity (Falade and Akingbala 2010). Hydrolyzing enzymes present in the plant, such as linamarase, degrade the cyanoglucosides to hydrogen cyanide (HCN) as soon as the plant tissue is wounded. If the root is ingested without previous processing, acute poisoning occurs due to the release of HCN in the body. Cyanide affects tissue respiration in mitochondria's, as it is a potent inhibitor of oxidase and other important enzymes in the respiratory chain (Balagopalan *et al.*, 1988). Chronic exposure of inadequately processed cassava can lead to diseases such as tropical ataxic neuropathy, goiter and cretinism.

The toxicity can however be reduced to safer levels during traditional processing (Falade and Akingbala 2010). Processing of cassava eliminates or reduces the level of toxic cyanogenic glucosides that result in production of more acceptable hygienic quality products and improves root palatability which enhance the shelf-life and facilitate transportation and marketing of products (Haggblade *et al.*, 2012).

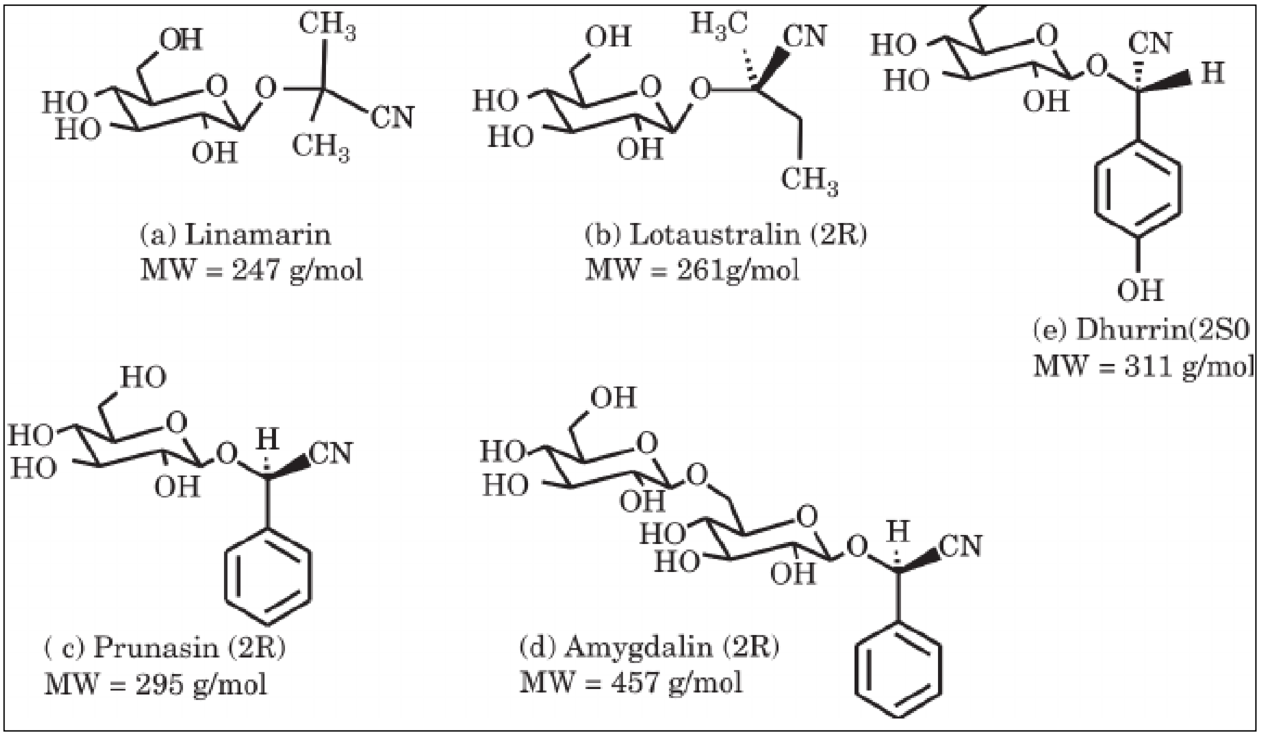

Fig. 1: Structure of common cyanogenicglucosides (Source: Halkier *et al.,* 1988)

All parts of the cassava plant contain cyanogens that are hydrolyzed to hydrocyanic acid (HCN) that escapes into the air during harvesting and processing (Bokanga *et al.,* 1994).

CASSAVA FLOUR PRODUCTION

The processing of cassava roots into cassava flour is depicted in Fig. 2. Healthy cassava roots with no bruises and cracking should be harvested 10-12 months after planting and processed within 24 hours. Grating, is generally, carried out by a motorized cassava grater that disintegrates cassava tissue, which facilitates later steps such as pressing and drying due to an increased surface area. De-watering or pressing is the removal of internal liquid from the roots by means of a screw press and is important to reduce toxicity.

The cassava mash is packed into a clean jute sack that allows the excess water to pour out until it is crumbly. Off colour and odour from fermentation is avoided by keeping the pressing time short (less than one hour). Disintegration reduces the particle size of the cassava crumbles. Drying can be carried out by a hot air mechanical dryer or a solar dryer. The dried cassava mash is milled into flour by a hammer or disc-attrition mill. The flour is sieved by means of a motorized flour sifter fitted with a 250 μm screen in order to obtain smooth flour with a uniform particle size. Finally, the flour is packaged in polypropylene sacks to avoid moisture uptake of the flour during storage (Shittu *et al.,* 2008; Nwabueze and Anoruoh 2009).

Another fast method involves harvesting and sorting of good roots, peeling and washing manually, grating (usually done with a motorized cassava grater), dewatering (with screw or hydraulic press), pulverizing, drying (solar or oven drying), fine milling, sifting the milled flour with a motorized flour sifter having 250 μm sieve size and then, packaging (Jekayinfa and Olajide 2007). Cassava flour is used for making bread and other products like chips, jam, jelly and chutneys. Flour extraction from cassava tuber depends on reduction of moisture. Cassava drying aims at reducing its water content to less than

15% (Shittu *et al.,* 2008). Factors that influence the drying of cassava are temperature, airflow, humidity and tumbling frequency.

Harvesting tuber

↓

Cleaning/Washing

↓

Peeling

↓

Slicing/grating

↓

Pressing

↓

Disintegration

↓

Drying in hot air oven

↓

Milling/Grinding

↓

Sieving

↓

Cassava Flour

Fig. 2: Cassava flour preparation

UTILIZATION OF CASSAVA FLOUR

Cassava flour in bread

The major raw material used in the bakery product is wheat flour, which can be replaced upto some extent with other flours to increase the nutritive value. The use of cassava flour as a raw material for the bakery and pastry industries is fast growing and gaining recognition as reliable partial substitute for wheat. Cassava flour is highly recommended in the diet of celiac patients who require strictly gluten free food products (Briani *et al.,* 2008). Cassava flour is suitable since it has no fat content which is an important factor for storage life. Other possible advantages include its bland taste offering no foreign odour or flavour. Mechanical leavening rather than bulk fermentation for the ripening of the dough and a blend of 60% wheat flour, 30% cassava starch, and 10% soybean flour, produced a bread of good quality almost equal to the normal wheat flour bread in volume, appearance and eaten quality (Taiwo *et al.,* 2002). Different wheat flours have been diluted with various proportions of cassava starch and flour (Shittu *et al.*, 2007; Shittu *et al.*, 2008). Khalil *et al.* (2000) reported that inclusion of cassava flour into wheat flour up to about 30% could still give an acceptable fresh loaf depending on the source of the flour. Bread containing 20% fresh minced cassava showed higher sensory evaluation rating (Crabtree *et al.,* 1978). Federal Institute of Industrial Research Oshodi (FIIRO) Nigeria, has developed cassava bread with 20% high quality cassava flour substituted with 80% wheat flour, which gives similar characteristics of bread produced with 100% wheat flour both in sensory and nutritional properties (Niewinski 2008).

Cassava flour in biscuits

Cassava flour of high quality can be effectively substituted for wheat flour in biscuits can substitute for up to 30% of wheat flour in sweet dough biscuit and 40% in hard dough biscuit, without consumers being able to detect any adverse change in colour, taste or texture as compared to 100% wheat flour control. At higher levels (>40%) of substitution, the flour texture was found to be too light. This could be overcome by incorporating additional margarine, but this result in an unacceptable increase in production cost (Taiwo 2006). Consumers found biscuit containing >40% cassava flour to be less crispy, bland in flavour and susceptible to crumbling. Biscuits containing a minimum of 40% cassava flour had a very low microbial counts and cyanogens levels that are below the limits of detection after baking (Falade and Akingbala 2010). Obadina *et al.* (2014) used improving agents such as ascorbic acid, sodium metabisulphite, sorbic acid and soyflour for the production of whole cassava biscuits. The result showed that, there was a slight decrease in mixing time, extrusion time, length and width of the biscuits samples Amylograph reflected an improvement in flour stability and low retrogadation tendency, most especially flour with inclusion of ascorbic acid. Crude protein and fat increased with sample contained soyflour. Sensory evaluation result indicated no significant difference among the samples except the texture of the biscuits prepared with improvers. However, there was a considerable increase in biscuits thickness. Kamaljit *et al.* (2016) prepared different blends of cassava flour with wheat flour and soy flour for the preparation of cookies. The blend with wheat flour, soy flour and cassava flour in the ratio of 85:5:10 was found to be the best regarding baking and sensory quality.

Cassava flour in noodles

Menon *et al.* (2016) developed gluten-free starch noodles from sweet potato with enhanced protein content through fortification with whey protein concentrate (WPC) and studied the effect of protein fortification and blending Sweet potato (SPS) with banana (BS), cassava (CS) and digestibility. The study showed that protein and/or BS fortification with sweet potato starch (SPS) could enhance the acceptability as well as functional value of SPS noodles mung bean (MBS) starches and annealed cassava starch (ACS) in reducing the starch. The use of cassava in composite flour for production of fast food reduced the cost and enhanced the production of noodles, breakfast cereals and pastries (Falade and Akingbala 2009). Instead of industries, bakers, caterers and individuals also produce and purchase cassava flour for home scale use. Inclusion of cassava flour at 10% in wheat flour has also been made for producing acceptable noodles (Falade and Akingbala 2008).

EXTRACTION OF STARCH FROM CASSAVA

Extraction of starch can be done by using wet method described earlier by Benesi *et al.* (2004) as shown in Fig. 3. Fresh tubers were washed, peeled, chopped into approximately 1 cm cubes and then, pulverized in a high speed blender for 5 min. The pulp was suspended in ten times its volume of water, stirred for 5 minutes and filtered using double fold cotton cloth. The filtrate was allowed to stand for 2 hr for the starch to settle and the top liquid was decanted and discarded. Water was added to the sediment and the mixture was stirred again for 5 minutes. Filtration was repeated as before and the starch from filtrate was allowed to settle. After decanting the top liquid, the sediment (starch) was sun dried for 24 hr and stored. Both modified and unmodified cassava starch are used as raw material in food industries, either directly as starch food in the form of custard or as a thickener in baby foods and gravies and as a binder for products during cooking to prevent drying out (Taiwo 2006). Cassava starch is a very good raw material in the food industry, has low gelatinization temperature, high water-binding capacity and high viscosity and it however, does not retrograde easily (Jekayinfa and Olajide 2007). Both modified and non-modified starches are used as a raw material in food industries, either directly as a starch food in the form of custard or in the form of thickener in gravies and as a binder in food products to prevent drying out (Taiwo 2006).

Cassava roots
↓
Peeling
↓
Washing
↓
Grating/Grinding
↓
Mixing with water
↓
Filtering/screening
↓
Settling
↓
Starch washing
↓
Settling/dewatering
↓
Drying
↓
Milling
↓
Cassava starch

Fig. 3: Extraction of starch from cassava

Starch from cassava tuber can be extracted in two simple, wet and sundry methods. In the wet method, fresh tubers are blended with adequate water and the filtrate is decanted to starch. The starch obtained is then, dried in the sun and is ready for use. In wet method fresh tubers are certainly be used for flour production immediately after harvest, within 72 hrs, since fresh roots deteriorates quickly. In sundry methods, fresh tubers are chopped into small pieces and are sun dried until desirable moisture content is achieved. The dried cubes are milled into flour. The methods of extraction of flour influence the degree of detoxification (Nwabueze and Anoruoh 2009).

CASSAVA STARCH IN CONFECTIONERY

Cassava starch can be converted to maltotriose and maltose and to other modified sugars and organic acids (Tan *et al.,* 1984). Starch is mostly used as an input for producing sugar syrups in a process known as controlled enzymatic hydrolysis, which involves the use of either acid or α-amylase enzyme. Cutting the starch chain using acid will produce a mixture of dextrin, maltose and glucose. Simple methods produce several maltodextrin divisible products of starch, maltose and glucose. Starch from cassava can be used to make fructose syrup (Vuilleumier 1993) and formulate gelatin capsules (Nduele *et al.,* 1993). By controlling the processing greatly, cassava starch can almost be broken down to form glucose syrup. Enzymatic isomerization of glucose syrup is used for the preparation of high fructose syrup. Glucose syrup made from cassava starch can be utilized for the production of candy, soft drinks, traditional medicines and biscuits.

The amylose content of cassava starch is lower than that of arrowroot, but the productivity of cassava roots is much higher than that of arrowroots. Cassava starch can also be used to produce gums, pastes and other types of candies; it can be used to make moulds or to dust sweets for not to stick together. Dextrose does not allow boiled sweets to crystallize and also reduce shydroscopicity in the finished products (Sriroth *et al.*, 2000).

PRODUCTION OF CASSAVA STARCH BASED ADHESIVE

The main raw material used in glue and adhesive industries is starch. The necessary things for an adhesive to be effective are ease of application, reasonable setting time, resistance to moisture, aging, heat and fungal attack, non-staining and gap filling. By virtue of its good adhesive qualities, cassava starch is an important raw material in adhesive industries. The adhesive had been prepared from cassava starch (Fig. 4) by taking measured quantity of dried starch in a beaker and known volume of 0.01 molar concentration of HCl was added and stirred continuously while heating in a heating mantle maintained at a specified temperature.

Dried cassava starch
↓
Add gelatinization enhancer (NaOH/HCl)
↓
Stirr continuously
↓
Heat in a heating mantle at desired temperature
↓
Add viscosity enhancer (Borax)
↓
Stir continuously until mixture becomes sticky
↓
Allow Adhesive to cool

Fig. 4: Preparation of adhesive from cassava starch

Known mass of viscosity enhancer (borax) was added in meal and stirred continuously until the mixture became sticky. Product was then, allowed to cool.

CASSAVA STARCH IN EDIBLE COATING

Edible coatings are fine layers of digestible material added to a food product. It is known that, during the drying process, the application of these coatings may reduce the loss of aroma, color and nutrients by reducing oxygen diffusion into the food, minimizing solute incorporation and maintaining the product's physical integrity (Zhao & Chang 1995). Lago Vanzela *et al.* (2013) evaluated the effect of edible coating pre-treatments on the retention of provitamin A during pumpkin drying. The coatings used were based on native and modified maize and cassava starch. Edible coating application resulted in production of dehydrated pumpkin products with high pro-vitamin A content. Chinma *et al.* (2013) studied the chemical, functional and rheological properties of cassava starch and soy protein concentrate blends for biofilm processing. Results suggested that the addition of soy protein concentrate to cassava starch affected the studied functional properties of cassava starch as evidenced by changes such as reduced syneresis, and solubility both are desirable when considering this biopolymer as an edible biofilm.

CASSAVA IN ETHANOL PRODUCTION

Generally ethanol is produced by fermentation of sugar, cellulose, or converted starch and has long history. Cassava is a good feed stock to produce ethanol because it has high starch content (Leng *et al.,* 2008). Cassava starch can be converted readily to ethyl alcohol in a two-stage process involving the hydrolysis of starch slurry into glucose by liquefaction to obtain dextrin and subsequently fermentable sugar. The glucose solution is diluted and converted to ethyl alcohol by the anaerobic action of yeast, ethanol of 95.6% w/w comes out through dehydration which is concentrated to 99.5% w/w (Ramasamy and Paramasamy 2001; Kosugi *et al.,* 2009). Thus cassava-based fuel ethanol is produced and it is usually denatured by small volume of gasoline or other materials added preventing people from drinking it (Leng *et al.,* 2008). The ethanol produced is of high quality similar to cereal alcohol (Taiwo 2006). The cassava chips can be used instead of the tuber in which case the chips are ground, cooked to release the starch. Saccharification can be accomplished either by hydrolytic process or biological process. The hydrolytic process uses hydrochloric acid or sulphuric acid. Yields are low and continuous use of acid causes equipment corrosion and is dangerous to handlers. The biological process uses amylolytic enzymes, which can be obtained from barley malt and moulds that grow on rice or wheat bran. Some cassava products of industrial importance are mentioned in Table 2.

FERMENTED CASSAVA PRODUCTS

The fermentation process for preservation of cassava root constitutes a vital body of indigenous knowledge and passed from one generation to the next. In addition to providing flavor, variety and preserving the product, the fermentation process also help in detoxification of cassava roots. Well known fermented products of cassava are cassava bread, fermented cassava flour, fermented starch, fufu, lafun, akeyeke and gari. Some traditional fermented staple foods processed from cassava roots in different regions are mentioned in Table 3 and Fig. 5.

CASSAVA IN GARI PRODUCTION

Gari is the most commercial and useful product of cassava processing. It is creamy white, pregelatinized, granular and calorie rich food with bit sour taste (Flade and Akingbala 2010). *Gari* is dehydrated flour consumed raw or cooked and can be stored for

Table 2: Some cassava products of industrial importance

Common Name	Description of product	Reference
Tapioca	Partially gelatinized dried cassava starch	Adebowale *et al.,* (2007)
Chips and pellets	Dried irregular slices of root	Adamade and Azogu (2013)
Cassava flour	Milled cassava chip/ reconstituted mash	Taiwo (2006)
Cassava puddings	Grated cassava root and mixed with banana	Falade and Akingbala (2010)
Cassava bread	Made from wheat and cassava flour	Shittu *et al.,* (2008)
Fermented cassava starch	Fermented root used for baking	Srinivas (2007)
Gari	Pregelatinized granulated mash	Fadeyibi (2012)

Table 3: Some traditional fermented staple foods processed from cassava roots

Fermented product of Cassava	**Region/ Location**	**Product detail**
Cassava beer	Uganda	Cassava flour boiled with water, yeast added, after 7 days the liquid is drained, sugar added and the beer is allowed to ferment for 4 days. It is drunk as such or distilled.
Beiju	Asia	Beiju is naturally fermented cassava mass which resembles Koji in Oriental countries. Beiju is used for the production of an indigenous alcoholic beverage called liquira.
Gatot	Camerouns	Gaplek (dried cassava) is cut into pieces, steamed and spread on to bamboo mat. The pieces are kept wet by continuous sprinkling of water. The pieces changes to black color and acquires a characteristic taste. This meal can be served after steaming.
Farina	South America/ west Indies	Peeled fresh tubers are pressed in a wooden screw press, forcing the pulp through a sieve and finally, roasting it on a slow fire.
Kasili	Indian	The Wayana Indians boil cassava flour in river water and as the mash boils, the women chew cassava cake and spit it into the pot so as to aid fermentation process with saliva.
Oyek	Indonesia	Cassava roots are peeled and soaked in water for about 7 days, drained and milled. The ground cassava is kneaded with little water, steamed and sun dried to prepare this Indonesian dish.
Peujeum	Java	The peeled roots are steamed until tender, allowed to cool and then dusted with finely powdered *ragi* (a mixture of flour and spices in which fungi and yeast are active). The cassava mash mixed with *ragi* is wrapped in banana leaves in an earthenware pot and left for 1-2 days to ferment aerobically.
Chick-wangue	West Africa	After removing the rind and skin, cassava is soaked in water, pounded and made into a paste. The wet paste is made into balls, packed in leaves on a screen over the hearth and left for 15 days. The paste is sun dried or smoke dried. The leaves are then removed and the black coating formed is scrapped off. The dried paste is ground and sieved to produce flour.
Mingao	Amazon	Mingao drink is prepared in the Amazon region by dissolving fermented starch in boiling water and simmering for a period. Palm fruits, pineapple or bananas may be used to mask the unpleasant taste of the drink.

Source: Kolawole *et al.*, 2010

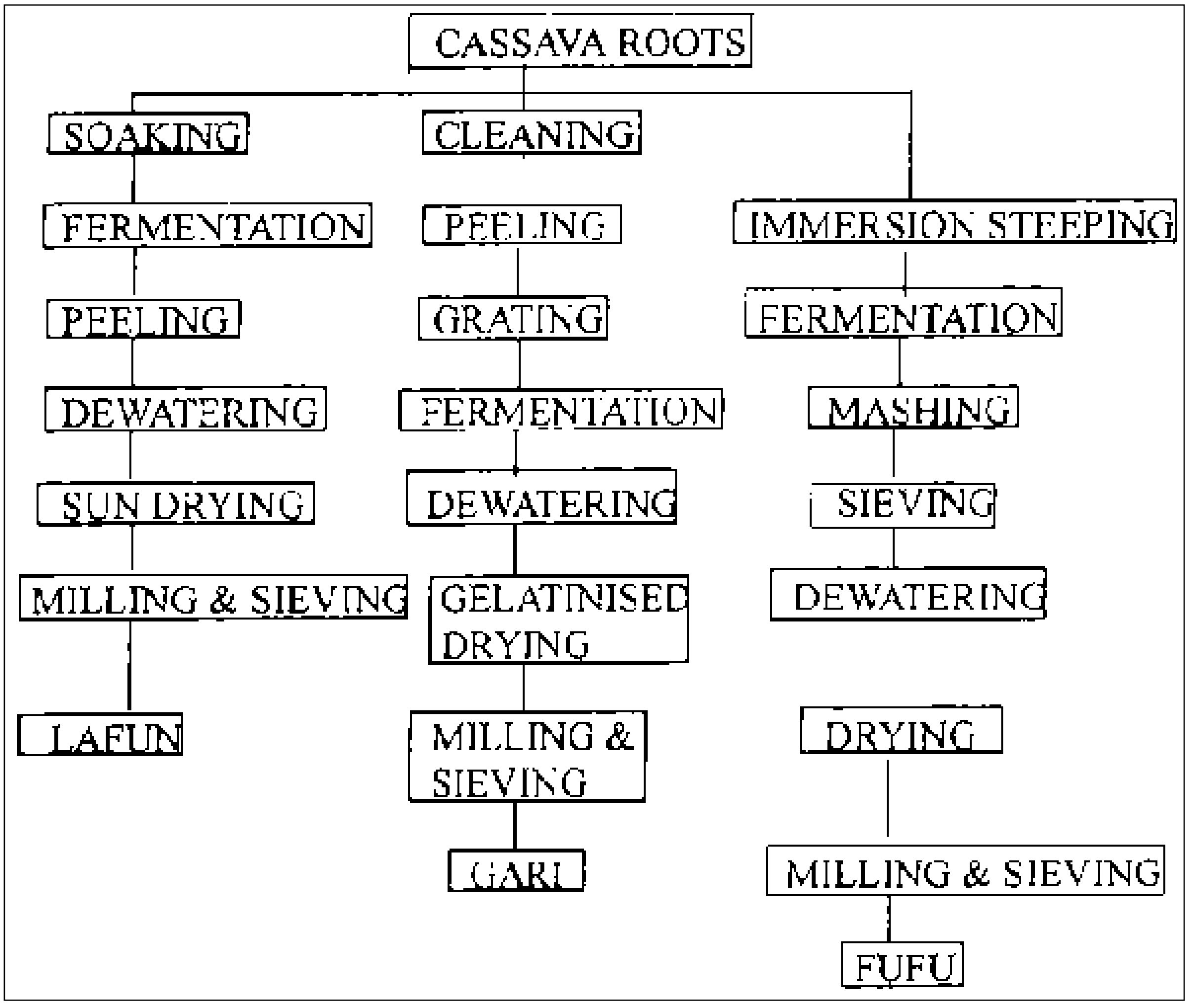

Fig. 5: Preparation of fermented products from cassava roots (Agbon *et al.*, 2010)

several months. *Gari* is processed by women at small or medium scale with average moisture content of 12 to 14 per cent. Traditionally, the processing takes 3 to 5 days and involves peeling, washing, pulverizing and frying. It involves minimal mechanical processing and gives the product with good organoleptic quality (Kehinde *at al.*, 2001).

A new process for *Gari*-production has been developed. The single steps have been established by controlling the chemical and physical characteristics of the intermediate and end products. The roots are peeled mechanically and ground to a mash which is fermented anaerobically. The fermented mash must be washed after fermentation to remove the cyanohydrin. The washed mash is drained mechanically and afterwards dried and/or roasted in a two stage process. The dried product can be ground to any required granulation size. The end products, *Gari* or *Lafun etc.*, can be stored without any change in taste for more than one year with a water content of less than 12%. (Meuser and Smolnik, 1980).

In Ghana, pulp made from cassava is placed in cloth bags or sacks made from jute and allowed to ferment for 3-10 days. After fermentation, the partially dried cassava pulp is taken out and sieved to remove the fibrous material. It is then heated in shallow iron pans and stirred continuously until it becomes light and crisp. Good quality *gari* is normally creamy yellow in color, with uniform grains and should swell to three times its volume when placed in water (Balagopalan *et al.*, 1988)

The major constraints to production, continuous availability and utilization of cassava are mainly related to the quality of cassava roots, transportation and processing. Cassava is mainly used for food and feed, though some industrial applications are getting increasingly important. As food cassava is mainly processed into flour by traditional methods which produce poor quality products. The different methods of processing of cassava depend upon history, cultural and socio-economic issues of the consumers. However, processing of cassava to various products worldwide is very less. Upgrading technology into commercial production and applications of cassava in food, starch, fermentation and pharmaceutical industry will upgrade the supply and manufacturing aspects of production as well as improve the quality. This crop can grow in marginal soils where no other crop can grow, so cultivation of cassava can benefit the poor.

CONCLUSION

Cassava is widely used as food and feed and its industrial applications are becoming increasingly important. The food and starch industry in India should take advantage of cassava production by guiding the farmers about its easy cultivation on marginal soils where other crops are unable to grow and can develop a local raw material base. Making cassava an industrial base by developing industries of cassava starch-derived products is a way to obtain a high added-value for cassava. Cassava could make a much more important contribution to national economies and provide a more stable base for industries. Utilization of cassava would break the vicious cyclic effect associated with its production, increase stakeholders' income, create more jobs, solve some health problems, and reduce dependence on wheat as a staple crop. In summary, the easy cultivation of cassava should be regarded as a natural plea for its exploration in order to fully maximize its potential as an industrial base for food, starch and pharmaceutical industries.

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