Studies on the Production and Utilization of Dried Cassava Chips as Human Food

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is a major staple food in tropical countries. Nigeria is the world's largest producer of cassava, with the potential for higher production. Cassava tubers cannot be stored for long in the fresh form because they are highly perishable. Thus, it is necessary to develop other means of utilizing the surpluses. Drying of cassava naturally in the sun or artificially in ovens is practiced to improve the shelf life of the tuber and reduce post-harvest losses. The roots, after peeling and washing, are chipped into smaller sizes for faster drying. Cassava chips are mostly used in the production of starch and animal feeds. The need to expand the utilization base of dried cassava chips has prompted different studies on the utilization/conversion of cassava chips into various food products such as *gari, fufu,* and *lafun* for human consumption. This chapter reviews studies on the conversion of cassava chips into different food products.

The proximate composition, physico-chemical and functional properties, and the yield of *gari* and *fufu* from cassava chips are comparable to those processed from fresh tubers. However, the sensory qualities of the products are yet to be perfected. The temperature at which the chips are dried greatly influences the functional properties and sensory qualities of the food products. Sensory evaluation showed that products processed from chips dried in the oven were preferred to those dried in the sun. Therefore, oven drying of cassava tubers to chips is highly recommended.

Introduction

Cassava (*Manihot esculenta* Crantz) belongs to the family *Euphorbiaceae* and is a perennial woody shrub producing enlarged tuberous roots. The roots are the main storage organs and in some areas it is cultivated as a perennial plant with the storage roots being harvested during the first or second year (Aloys and Ming, 2006). Cassava is an important food crop in the tropics and a major carbohydrate staple consumed in various forms by humans. It contributes significantly to the nutrition and livelihood of 800 million people and thousands of processors and traders around the world, and forms a base for a wide variety of fermented foods in Africa, Asia and Latin America. In addition, it serves as raw material in the manufacture of processed foods, animal feed and industrial products (Balagopalan, 2002; Aloys and Mings, 2006; Taiwo, 2006).

Production

World production of cassava is around 250 million tonnes (Mt) a year with Africa contributing to more than half of the global supply. Nigeria at around 45 Mt produces more than a third of African production and is also the largest world producer by far (UNCTAD, 2013).

Limit to Utilization in Fresh Form

Cassava contains cyanide which limits its utilization in the fresh unprocessed form. The roots need to be processed to reduce the cyanide content to safe levels before consumption. Once harvested, cassava tubers begin to deteriorate and cannot be stored for more than a few days. They are bulky with about 70% moisture content which makes transportation of the tubers to urban markets difficult and expensive. Thus, there is a need for rapid processing of the tubers (before spoilage sets in) into various products with increased shelf life. These shelf stable products are easier to transport and market, cost less to transport and contain less cyanide.

Products from Cassava

Traditional cassava processing methods involve several unit processes including peeling, drying, milling, roasting, sieving, steaming, pounding and mixing in cold or hot water. Specific combinations of these processes lead to a myriad of different cassava products with acceptable tastes to a wide range of consumers. Generally, these steps are intended to reduce toxicity and improve palatability. There are four major processed forms of cassava tuber: meal, flour, chips and starch. In Nigeria, the main food products of considerable domestic importance are *gari, lafun* and *fufu* or *akpu* (Taiwo, 2006).

Gari is the most common food product processed from cassava in West Africa. Production involves peeling, washing and grating of the roots. The grated mash is put in jute sacks which are pressed using an hydraulic or screw press and the dewatered mash is then sieved and fried. The average moisture content of *gari* ranges from 8 to 14% which makes it suitable for long term storage. It is usually eaten in the form of snacks by soaking in water, or in the meal form where it is reconstituted by stirring in hot water to form a dough (*eba)* which is eaten with soup (Udoro, 2012).

Lafun is fermented cassava flour and is popular in Nigeria. It is prepared by soaking the tuber in water (either with the peel or after peeling) for 3 to 4 days. The tubers are then manually disintegrated by crushing, decanted and the mash spread on a flat surface. The mash is dried and milled to obtain the fermented *lafun* flour. The flour is prepared by stirring in hot water to make smooth, elastic dough which is eaten along with vegetable soup.

Fufu (also referred to as *akpu)* is a meal made from soaked fermented cassava in Eastern Nigeria. The tubers are peeled, washed, cut into thick chunks and soaked in water for 4 to 5 days. During this period, the cassava tubers ferment and soften, releasing hydrogen cyanide (HCN) into the soak water. A characteristic flavour of retted cassava meal is also produced. The retted tubers are disintegrated in clean water, sieved and the starchy particles that pass through the sieve are allowed to settle for about 3 to 4 hours. The water is decanted while the sediment is packed into a cloth bag, tied, squeezed and subjected to a heavy pressure to expel excess water. The resulting meal is rolled into balls and cooked in boiling water for about 30 to 40 minutes. The cooked mass is pounded with a mortar and pestle to produce a paste (*fufu)* that can be eaten with sauce, soups or stew (Balangopalan, 2002).

Several studies have shown that cassava chips may be converted into common human food products such as starch, flour, *fufu* and *gari*. This chapter reviews studies on the utilization of dried unfermented cassava chips in human food products.

Cassava Chips

Cassava chips are unfermented, dry products of cassava. Roots are chipped into smaller sizes for fast drying that also helps the process of detoxification. Cassava can be dried naturally in the sun or artificially in an oven (FIIRO, 2005; Irinkoyenikan *et al.,* 2008) to produce cassava chips that vary in size, usually not exceeding 5cm in length and about 2 ± 1mm thick (Figure 1). They are used mostly in animal feed production but have potential for human consumption although this has not been fully explored (Sanni *et al.,* 2007; Taiwo and Okesola, 2009). In some West African countries, chips are utilized in the production of flour and starch.

Figure 1: Dried cassava chips. Source: FAO (2006).

Traditionally, cassava is processed into dry whole roots that have undesirable colour, irregular shapes and are often contaminated with dust. A process technology has been developed for converting freshly harvested cassava into dried cassava chips having at least 18 months shelf life and cyanogenic glycosides concentrations within the permitted safe limits suitable for export and other uses. In the process technology, the washed, peeled cassava roots are fed into a cassava chipping machine designed to produce chips of regular sizes and shapes. Alternatively, the tubers can be manually cut into round chips of uniform sizes. The shape, size and thickness of the chip influences how fast it dries; diffusion and the rate of drying are fastest in small chips. When chips are thick, the outer layer easily compacts, thereby preventing the free air movement through the mass (FIIRO, 2005). Thick slices may appear dry on the surface but their internal moisture content will still be high. Therefore, for effective drying, the chips shape/size and loading rate should permit air and moisture to readily pass through the mass when drying. The optimal chip geometry for natural drying is a bar 5cm x 1cm x 1cm (Cock, 1985). The yield of dried chips (typical final moisture content of about 8 to 10%) from roots is about 20 to 40%.

Sun Drying Of Cassava Chips

Sun drying is the simplest method of drying and traditionally cassava is sun dried in the open air, either on the ground or on a raised platform (Atikson *et al*; 1983). The practice involves spreading out freshly sliced cassava roots on drying areas or concrete floors of various dimensions with the chips being turned over at intervals with the use of a shovel or rake. The time of drying and chip quality are affected by the chip shape and size. Interrupted sun drying affects the quality of the finished chips. Sun drying has been reported to be more effective in the elimination of cyanide than oven drying as it allows more contact time between linamarase and the cyanoglycosides and also retains water, essential for linamarase action, for a longer time in the tubers.

Oven Drying Of Cassava Chips

This is an artificial means of drying in which the drying atmosphere is under control. Some of the artificial drying methods include drum drying, freeze drying, kiln drying, tunnel drying and cabinet drying. Cabinet drying in which the chips are loaded thinly on a tray is most applicable to solid foods. Fresh air enters the cabinet drawn by the fan through the heater coils and is then blown across the food trays. The rate of drying depends on the chip size, loading density and initial moisture (Kormawa, 2003). This artificial method has a great advantage over sun drying and it is more efficient. In oven drying, there is reduction in space and labour requirement compared to sun drying, and the whole operation is independent of the weather. Thus there is better quality control and little chance of mould growth and bacterial contamination. Oven drying for the production of cassava chips has been carried out at temperatures ranging from 45 to 165°C with a focus on cyanide removal. Temperatures less than 100°C gave the most preferred results. After drying the chips are cooled, packed in sacks or polyethylene bags and stored on raised platforms in clean, dry and airy places. Damp and warm environments should be avoided (FAO, 2006).

Effects of Drying on Cyanide Content of Cassava Chips

Gomez *et al.* (1984) reported that sun and oven drying reduced the cyanide content in the dried chips to approximately 15 to 30% of the initial cyanide content of fresh chips; cyanide reduction was higher in sun drying on a concrete floor than oven drying on trays. Most of the total cyanide in sun dried chips was found as free cyanide (59 to 76%), whereas in oven dried chips, the largest proportion of the total cyanide was still present as bound cyanide (59 to 69%).

Bourdoux *et al.* (1982) studied the effects of oven drying on cassava tuber pieces at 60, 105, and 165 ^{0}C. They found that the cyanide content in fresh tubers decreased from 116.7mg/kg to 73.5 mg/kg when the chips were dried at 60 ^{0}C but was reduced to 28.8 mg/kg at 105^{0}C and less than 1.0 mg/kg at 165^{0}C (Padmaja, 1995). The breakdown of linamarin at higher temperatures has been reported to be responsible for the low cyanide values at 105 and 165 ^{0}C. They found that cyanide retention was dependent on the drying temperature and chip thickness. More cyanide was retained during drying at 70 than 50 ^{0}C. Likewise thinner chips (3mm) retained more cyanide than thick chips, which is as a result of faster drying of thin chips which reduced the contact time between linamarase and cyanoglucosides. Udoro (2012) reported that sun dried chips had the least cyanide content when compared to the chips dried at 50 and 70 °C in the oven, corroborating the findings of earlier workers. Udoro (2012) also reported that the drying temperatures (sun, 50 and 70 °C) did not significantly influence the proximate composition of the chips.

Oven drying resulted in greater shrinkage (Figure 2) in sample width (diameter) (62%) than sun dried cassava chips (52%). Oven dried samples shrunk faster than sundried samples (10 hours) than the sundried samples which took up to longer hours to get to the optimal shrinkage. The drying rate for cassava was observed to increase with increase in temperature. Oven dried samples resulted in greater shrinkage in thickness (20%) than sundried cassava chips (14%). Oven dried samples reduced in thickness faster than sundried samples to get to the optimal shrinkage. The temperature of drying (60°C and 70°C) did not affect shrinkage of blanched and oven dried chips (Akinrelere, 2011).

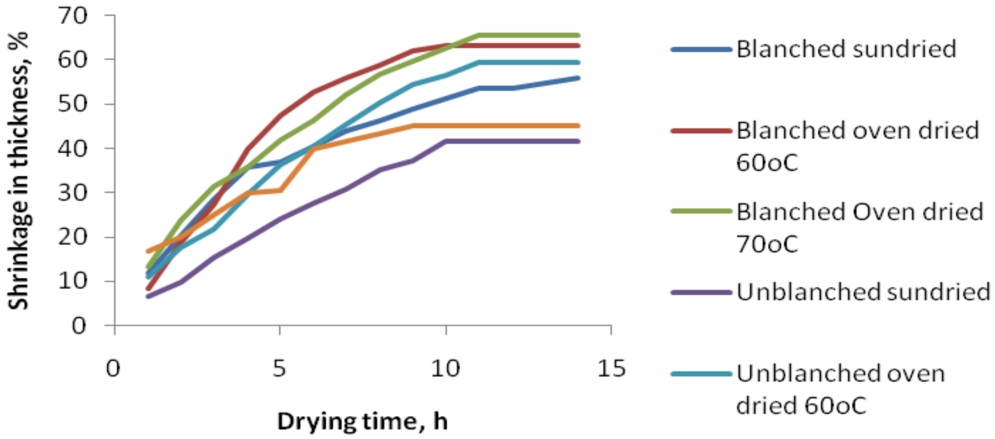

Figure 2: Effect of blanching and drying temperature on changes in thickness of cassava chips. Source: Akinrelere (2011).

Utilization of Cassava Chips as Human Food

Gari is the most commonly traded product obtained from cassava. In a study by Oluwole *et al*. (2004) on the conversion of dried cassava chips to *gari* by seeding with fresh cassava mash at 0%, 5%, 10%, 15% and 20%, *gari* was successfully processed with a yield of 83 to 85%; a yield of 24.9% was obtained for fresh cassava tubers. Sensory evaluation indicated that 5% and 15% seeded cassava chips gave good quality *gari* suitable for making the traditional *gari* paste *eba*. Also 5% and 10% gave suitable *gari* for drinking. It was recommended that fresh mash as 'seed' be introduced in the dried chips prior to fermentation to at least 5% of the carbohydrate base.

In another study, Taiwo and Okesola (2009) initiated fermentation using old liquor and other processing variables including method of drying the chips, fermentation time and rehydrating conditions. Their results showed that a good yield (18 to 23%) of *gari* could be obtained from sundried chips rehydrated at room temperature and allowed to undergo fermentation for 4 days (Taiwo and Okesola, 2009). These authors reported that *gari* processed from sun dried chips were darker in colour than *gari* from oven dried chips. Sensory scores showed that *gari* from oven dried chips had similar scores in terms of texture with those processed traditionally from fresh tubers. *Gari* from chips were darker in colour and therefore scored low (Figure 3). *Gari* samples from sun dried chips generally had lower scores than those from oven dried chips. Traditionally processed *gari* was more acceptable in terms of colour, but other attributes such as odour and texture were of comparable acceptance to *gari* from chips. Therefore, further investigation was recommended to improve on product colour for optimal acceptance.

Ikunjelola and Omosuli (2009) reported that *gari* from the dehydrated chips ranked better in terms of particle size and aroma, while *gari* from fresh roots ranked better in colour and mouth feel. Since both *gari* samples were generally acceptable, it was therefore established that using dehydrated cassava chips (which provide a good form of storage for cassava), could be processed into good quality *gari*.

Udoro (2012) showed that *gari* samples from oven dried chips were rated higher than *gari* samples obtained from sun dried chips in terms of colour, aroma, taste and overall acceptability. However, *gari* produced from fresh cassava tubers was most preferred in all the quality attributes. Among the experimental samples, however, the period of soaking, particle size distribution and drying temperature were some of the factors that influenced the quality attributes. The proximate composition, cyanide content and pasting temperatures of *gari* from dried chips were not significantly different from *gari* processed from fresh tubers.

B - SD 2, Sun dried chips (soaked three days and pressed three days)
C- SD 3, Sun dried chips (soaked four days and pressed two days)
E - OV 50.2, Oven dried chips at 50°C (soaked three days and pressed three days)
F - OV 50.3, Oven dried chips at 50°C (soaked four days and pressed two days)
H - OV 70.2, Oven dried chips at 70°C (soaked three days and pressed three days)
I - OV 70.3, Oven dried chips at 70°C (soaked four days and pressed two days)
J - Control, processed from fresh cassava tubers

Figure 3: Colour of *gari* samples from different processing conditions
Source: Udoro (2012).

Fufu Processed from Cassava Chips

The potential utilization of dehydrated cassava chips for the production of *fufu* has been investigated; *fufu* of good quality can be processed from dried cassava chips with a combination of processing variables (Irinkoyenikan *et al.,* 2008). In this study the drying temperature (sun, 35 and 60°C), size of chips, soaking medium (water and old liquor) and temperature of soaking (room temperature and 45°C) were varied. The results obtained showed that the physicochemical and pasting characteristics of *fufu* from chips were comparable to those from fresh tubers. The sensory attributes were also comparable to *fufu* made from fresh cassava except for *fufu* made from chips that were sun dried (darker in colour). This study established that soaking chips in water at room temperature and at 45°C gave no yield, that is, no retting of the soaked chips took place. The findings of Taiwo and Okesola (2009) confirmed this in the processing of *gari* from dried cassava chips.

Starch and Flour from Chips

Flour is often made from cassava chips. Fermented chips that have been milled into flour are called *lafun* in some parts of the Nigeria. If the chips are not fermented before conversion into flour, such flour or the chips may serve as animal feed. Alternatively, dehydrated cassava chips for livestock feed can be processed directly from fresh roots by chipping whole roots and then sun- or smoke-drying the wet chips. The chips made by any of the above methods are then converted to flour by milling and possibly followed by sieving. Abera and Rakshit (2003) extracted starch using wet milling and dry milling methods from three varieties of dry cassava chips and compared their physicochemical and functional properties with starch from fresh tubers. The differences observed in the quality of starch from both methods were minimal. There were no indications of major changes of granule structure for dry-chip starch that would alter the properties relative to fresh root starch.

Olomo and Ajibola (2006) reported an optimal yield of 80% w/w of dried product for oven dried starch extracted from oven dried flour (milled chips). Ikujenlola and Omosuli (2009) reported that the yield of starch from the dehydrated chips was higher than that of the fresh roots; however, it was easier to process fresh roots to starch than using the dehydrated chips. With the advanced technology used in the starch manufacturing industry today, it would be possible to obtain starch from dried chips with similar quality from the fresh root. This would enable the industry to overcome the seasonal fluctuations in the yield of cassava (Abera and Rakshit, 2003).

Summary

The factors influencing the production of dried cassava chips were discussed and results showed that cyanide content was least in sun dried chips. The potential use as food of dried cassava chips has been demonstrated and utilization can be both at cottage or industrial levels. The physicochemical properties of the foods have been shown to be comparable to those processed from fresh roots. The use of oven drying was preferred to sun drying with respect to the quality of chips and its influence on the sensory (especially colour) of the food products. Based on these results, surplus cassava can be oven dried (using solar cabinet driers) to prolong the life of the roots which would enable the industry to overcome the seasonal fluctuations in the yield of cassava.

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