Production and Storage of Cassava Chips for Reconversion into Gari

Akinwande, B.A.*, Ngoddy, P.O., Olajide, J.O. and Fakolujo, A.D.
Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
* E-mail of the corresponding author: baakinwande@lautech.edu.ng; baishng@yahoo.com

Abstract
Cassava chips (7% moisture level) produced from cassava root (IITA 94/0561) was stored for 6 months in high density polyethylene bag. Stored chips were coarse milled, rehydrated to 62.51% and seeded with fresh cassava mash (FCM) at levels of 5%, 10% and 20%. The resulting mash was fermented for 72 hr, with pH monitored every 24 hr, and processed to gari. Yield and swelling capacity of gari were determined. Sensory evaluation was carried out on water soaked gari and gari paste ('eba'). While least values for pH was obtained in FCM throughout the fermentation period, there was reduction in values in all samples with increase in fermentation time from 30.01 to 33.40%. Yield of gari from the seeded chips ranged from 64.4-72.3%, while that of FCM was 18.7%. Swelling capacity of gari ranged from 2.0 - 3.0 in FCM and that seeded with 20% FCM, respectively. Sensory evaluation result revealed that gari produced from cassava chips seeded at 10% level is adequate for making 'eba' while that seeded at 5% level is adequate for consumption as soaked gari ($p<0.05$). Use of stored cassava chips with 10% FCM for gari production could be encouraged to reduce postharvest problem of cassava roots and the drudgery of gari processing.
Keywords: Cassava chips, cassava mash, gari, 'eba', postharvest losses, storage

1. Introduction

Cassava (*Manihot esculenta* Crantz) is an important staple crop in Africa due to its ease of availability and as a very cheap source of carbohydrate. It is widely cultivated in the tropical zone due to its ability to withstand drought, pests and poor soil conditions (Wanapat *et al*., 2006). Nigeria ranks first as the producer of cassava in the world (FAOSTAT, 2012). The high moisture content characteristic of roots and tubers makes them difficult to store for any length of time. Also they are bulky and difficult to handle and transport to distant markets. Over many years traditional processes have evolved which yield a more durable product and in many instances a more convenient product for domestic use. Processing of cassava roots into shelve stable dried chips reduces transportation and storage cost and enhances its availability as material for both domestic and industrial raw use.
In many village communities root crops remain a staple and hence are often the main part of the meal. Gari is a very popular staple food in West African countries like Nigeria, Ghana, Benin and Togo. It is a creamy-white fermented and gelatinized dry coarse flour produced from fresh cassava tubers. Its ability to store well and its acceptance as a "convenience food" is responsible for its increasing popularity in the urban areas of West and Central Africa. It is often consumed as the main meal in the form of a dough or a thin porridge. Both are prepared in the household by mixing dry gari with hot or cold water and cooking and are served with soup or stew. Gari is also eaten as a snack when mixed in cold water with sugar and groundnut, and sometimes milk. It swells three to four times its volume when mixed with cold water.
Cassava chips are unfermented white dried products of cassava roots. Chipping of cassava has long been documented to be the best option for processing cassava roots with low cyanogens (Graffham et al., 1999). It has also been established to be cheaper, less labour intensive, with lower microbial load and less loss of starch when compared to grating. It has been established that gari of acceptable chemical and sensory quality could be obtained from dried cassava chips inoculated with fermented liquor (Oluwole *et al*., 2004; Ekwu and Ehirim 2008). While protein, carbohydrate and energy contents are similar in the gari from the two samples, gari from chips has lower cyanide content (Ekwu and Ehirim, 2008).
The traditional production of gari is a long and tedious process. Women (whether young or old, healthy or sick) can be found across the developing world working long hours without rest. The following unit operations are involved in the production of gari: peeling, grating, fermentation and pressing, sieving, frying and cooling. In other to reduce post-harvest losses of fresh. In other to reduce the post-harvest problem of fresh cassava root and drudgery of gari production, use of stored cassava chips for production of gari was studied. Processing of cassava chips from fresh roots during glut would address food security problem.

2. Materials and Methods

2.1 Material

Freshly harvested yellow cassava roots (IITA 94/0561) were obtained from the research farm of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The variety is one of the most common improved varieties that are planted in the zone. The roots, in three replicates, were processed immediately to prevent vascular streaking.

2.2 Production of chips from cassava roots

The production process comprised of simple operations using simple, locally fabricated cassava chipping machine obtained at IITA. Harvested roots were sorted for wholesomeness and foreign materials were removed. Quantity of 100 kg was weighed from sorted roots and they were manually peeled with knives and washed in potable water to free them of adhering soil and dirts. The washed roots were divided into four equal parts. A quarter was weighed, converted to fresh cassava mash (FCM) and processed into gari in the conventional way (control). The remaining three quarters were chipped with chipping machine that was fabricated at IITA. The chips were bagged in perforated plastic sacs and pressed with hydraulic press to reduce the moisture content. The pressed chips were spread on black nylon and exposed to sunlight at the ambient temperature of 32±2 ^{o}C. They were sundried for three consecutive days when moisture level of 7% was obtained (Figure 1). Cooled dried chips were weighed, divided into three equal parts, packed in high density polyethylene bags and stored for six months under ambient condition.

Cassava roots
↓
Peeling
↓
Washing
↓
Chipping
↓
Pressing
↓
Sun-drying (3 days)
↓
Cassava chips
↓
Packaging

Figure 1: Flow chart for production of cassava chips

2.3 Conversion of cassava chips to gari

Each of the three packed chips samples was coarse milled using a hammer mill (model D comminuting machine, M.J. Fitzpatrick Co., Chicago, USA) to an average particle size of 0.25-0.45 mm. The milled mass was rehydrated to 62.51% moisture level to simulate the moisture level of the fresh cassava, and seeded with freshly grated cassava mash at different levels of 5%, 10% and 20%, respectively. The blends were stirred to allow admixing of the seed and packed in perforated plastic sacks. The mash was fermented for 72 hr and dewatered with manually operated hydraulic press. The solid cake obtained after dewatering was broken up and sieved to remove the large lumps and fibre (from the central vascular strands) and to obtain a homogenous product. The broken up mash was processed into gari using traditional method in shallow cast-iron pans. The gari was scooped out and cooled by spreading it on a clean mat before packaging.

2.5 Flour preparation

The dried chips and gari were milled into flour with a micro mill to pass through a mesh of 150 μm screen size. The flour samples were put in zip-lock bags and kept in covered plastic containers until used for analyses.

2.6 Determination of properties of various materials

Proximate composition of fresh cassava root and chips were determined according to standard methods of AOAC (2000). Free sugar and starch contents of the two samples were determined using the methods of Dubois *et al*. (1956) and Mcready (1970). The pH of the mash was monitored every 24 hr (AOAC, 2000). About 10 g sample was mixed in 100 ml of distilled water and the pH of the decanted solution was measured.

Yield of gari obtained from fresh cassava roots and seeded cassava mash were determined using the formula indicated below:

$$\%\ \text{yield of Gari} = \frac{\text{Weight of gari}}{\text{Weight of fresh peeled roots/chips}} \times 100$$

Swelling capacity of gari was determined by weighing 20 g of each sample into 100 ml measuring cylinder which was tapped on the table 10 times. Water was poured into the cylinder up to mark and the content was mixed with stirring rod. The mixture was subsequently allowed to swell for 2 hr. The initial and final volume was noted and the swelling capacity was calculated as the ratio of the final volume to the initial volume.

2.8 Sensory evaluation of gari and 'eba'

Sensory evaluation was carried out on both gari that was soaked in excess water and its reconstituted dough ('eba') using preference test. Fifty untrained sensory panelists that were involved in the experiment were selected from the students and staff of Ladoke Akintola University of Technology, Ogbomoso, Nigeria, as a result of interest, availability and familiarity with the products. Each panelist was asked to pour excess portable water (at room temperature) on the provided gari samples in the disposable cups and assess them for color, aroma, mouth feel, taste, particle size and overall availability using a 9-point hedonic scale (9 = like extremely, 5 = neither like nor dislike and 1 = dislike extremely).

'Eba' was made by reconstituting gari in hot portable water immediately after boiling (96±2 ^{o}C) to obtain dough. This was made by sprinkling gari in the water at ratio of 1:2.5 (w/v). The gelatinized dough was mixed with wooden spatula to obtain uniform consistency and texture. Each sample of dough (about 20 g) was wrapped with cling film, placed in a labeled container and kept inside a food pack warmer until ready to be served for sensory analysis. 'Eba' samples were assessed for color, aroma, mouth feel, taste, molding ability and overall acceptability also using a 9-point hedonic scale (9 = like extremely, 5 = neither like nor dislike and 1 = dislike extremely).

2.9 Statistical analysis

Statistical analysis of all data obtained from three replicated samples was done with the Statistical Analysis Systems (SAS) package (version 9.2 of SAS Institute Inc, 2006). Statistically significant differences ($p \leq 0.05$) in all data were determined by Analysis of Variance (ANOVA) while Least Significant Difference (LSD) was used to separate the means.

3. Results

The proximate composition of fresh cassava root and chips is shown in Table 1. There was significant difference ($p<0.05$) in all the variables that were measured in the two materials. pH values of the seeded mash samples were higher than that of freshly grated cassava mash throughout the fermentation period. There was decrease in the values of all the samples with increase in fermentation time (Figure 1). Highest rate of reduction was obtained within the first 24 hr in fresh mash (31.82%) when compared to others, with least value in the sample seeded with 10% of fresh mash (4.48%). All the seeded samples had highest reduction rates within 24 and 48 hr (16.48% in 5% seeded mash to 24.87% in 20% seeded mash). At the end of the 72 hr fermentation period, there was reduction in values in all samples from 30.01% in 10% seeded mash to 33.40% in 5% seeded mash. Least value of 4.02 was obtained in fresh mash at the end of 72 hr period of fermentation.

Table 1: Proximate composition (%) of fresh cassava root and chips

Cassava form	Moisture content	Protein content	Fat content	Ash content	Crude fiber content	Sugar content	Starch content
Fresh root	62.51a	0.94b	0.11b	0.80b	1.05b	7.61a	26.98a
Dried chips	8.66b	1.17a	0.72a	2.05a	2.18a	3.16b	82.06b

Means followed by the same letter down the column are not significantly different ($p<0.05$) from one another

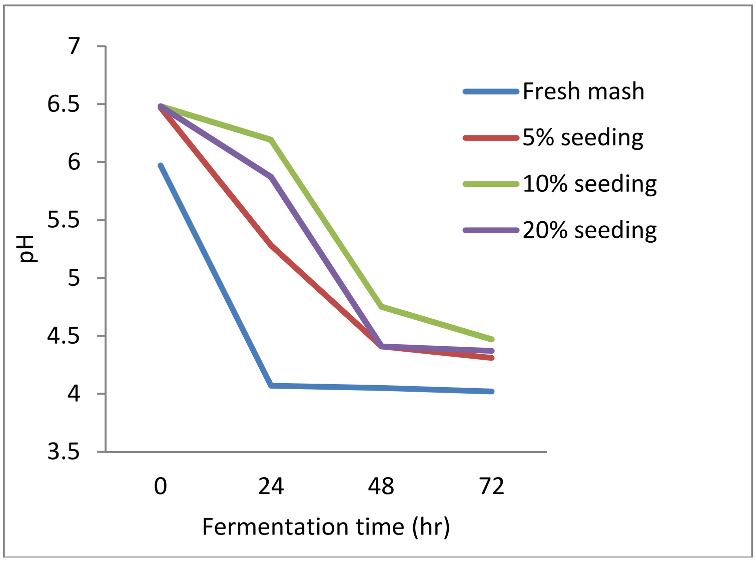

Figure 1: pH values of cassava mash during fermentation

The yield of gari from the seeded mash ranged from 64.4% (in 5% seeded mash) to 72.3% (in 10% seeded mash), while value of 18.7% was obtained in the control sample (FCM) (Table 2). All the values are significantly different from one another. Swelling capacity of gari increased from 2.6 to 3.0 in samples produced from 5% and 20% fresh mash, respectively, while least value of 2.0 was obtained in the one made from fresh cassava mash.
Mean scores of all the sensory attributes of soaked gari revealed that control sample had highest acceptability values with significant difference (p<0.05) from others (Table 3). The scores were followed by the ratings for gari from 5% and 10% seeded mash in terms of mouth feel, particle size and overall acceptability as well as color aroma and taste, respectively. Gari from 10% seeded mash had highest ratings for color, aroma and taste when compared to other samples from cassava chips at different seeding levels.
Highest sensory scores were recorded for sensory attributes of 'eba' produced from fresh cassava mash (Table 4). Except for moulding ability. The scores were followed by ratings in 'eba' produced from mash with 10% seeding level, with no significant difference in terms of color, aroma and mouth feel.

Table 2: Yield and swelling capacity of gari produced from different mash samples

Mash type	Yield (%)	Swelling capacity
Fresh cassava mash	18.7d	2.0d
5% seeding	64.4c	2.6c
10% seeding	72.3a	2.8b
20% seeding	70.0b	3.0a

Means followed by the same letter down the column are not significantly different (p<0.05) from one another

Table 3: Sensory attribute *scores of soaked gari

Mash used for gari	Color	Aroma	Mouth feel	Taste	Particle size	Overall acceptability
FCM	8.67a	7.89a	8.00a	8.33a	8.22a	8.22a
5% seeding	4.44b	5.33b	4.89b	5.22b	6.00b	5.56b
10% seeding	5.22b	5.44b	4.56b	6.33b	5.33b	5.00b
20% seeding	5.11b	5.22b	4.44b	5.33b	5.44b	5.11b

Means followed by the same letter down the column are not significantly different (p<0.05) from one another
*Scores: 9 = like extremely; 8 = like strongly; 7 = like moderately; 6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly; dislike moderately; dislike strongly; and 1 = dislike extremely

Table 4: Sensory attribute *scores of 'eba'

Mash used for gari	Color	Aroma	Mouth feel	Taste	Molding ability	Overall acceptability
Fresh root	8.44a	7.89a	8.00a	8.78a	8.56a	8.44a
5% seeding	3.56c	5.22b	5.00b	4.78b	6.67b	5.33b
10% seeding	7.33ab	6.22ab	6.44ab	5.67b	6.78b	6.44b
20% seeding	5.67b	5.00b	5.11b	4.44b	5.56b	5.00b

Means followed by the same letter down the column are not significantly different (p<0.05) from one another
*Scores: 9 = like extremely; 8 = like strongly; 7 = like moderately; 6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly; dislike moderately; dislike strongly; and 1 = dislike extremely

4. Discussion

Like any other biomaterial, constituents (i.e. proximate composition) of the cassava root increased when moisture was removed except for fat and sugar contents. However, there was no comparison of gari produced from fresh cassava tuber and chips did not show that one is better with different varieties of cassava according to the report of Ekwu and Ehirim (2008).
Production of organic acids from carbohydrates in the fermenting mash could be responsible for the reduction in pH values. Rate of production of organic acids in the seeded mash samples is lower than in fresh cassava mash. Reduction in pH is more pronounced in fresh cassava and seeded mash samples in the first 24 and 48 hr, respectively. Gari of lower pH values could be obtained in gari produced from fresh cassava mash compared to that from dried chips (Ekwu and Ehirim 2008).
Low value obtained for yield of gari produced from fresh cassava mash, compared to others, could be as a result of high dry matter content of dried chips. The milled chips were re-hydrated with water before being seeded with

different levels of fresh cassava mash. According to the report of Karim *et al*. (2009), higher values were obtained for yield (range of 20.9 – 31.2%) were obtained from fresh cassava roots stored under different traditional conditions. Differences in value could be associated to variations in varieties and moisture content of the fresh roots.

1) High swelling capacity in gari from seeded mash samples could be due to higher content of starch and/or sugars that were not completely metabolized to organic acids, as indicated by high pH values. According to Sanni *et al*. (2001), swelling index of gari granules reflects the extent of associative forces within the granules. Higher swelling index indicates lower associative forces within the granules.

Despite the variation in the pH and swelling capacity values of cassava mashes at different seeding levels, there was no significant difference between the ratings for all the sensory qualities of gari samples that were produced from them. The trend in scores obtained for moulding ability of 'eba' samples was inversely related to the swelling capacity of gari. The one produced from 20% seeded mash that had highest swelling capacity had the least rating for moulding ability.

2)

5. Conclusion

Results from sensory evaluation revealed that 10% seeding level of cassava chips is adequate for making 'eba' while 5% seeding level is adequate for production of gari to be consumed in soaked form. Use of stored cassava chips up to six months with 10% seeding level for gari production is possible and should be encouraged to reduce postharvest losses of cassava roots and the drudgery of gari processing.

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