



Chemical Changes during the Fortification of Cassava Meal (Gari) with African breadfruit (*Treculia africana*) Residue

*¹ONASOGA, M. OLUWAFUNMILAYO, ²AYODELE, D. OLUWAFUNMILAYO
³OYEYIPO O. OLUWATIMILEHIN

¹Department of Biological Sciences, ²Department of Chemical Sciences, Oduduwa University, Ipetu-Modu, Osun State, Nigeria

³Department of Microbiology, University of Port Harcourt, Rivers State, Nigeria
e-mails : funmilayo4live@yahoo.com, olufunmilayoydl@yahoo.com, drtim4real@gmail.com

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ABSTRACT: The nutritional enrichment of a cassava meal (gari) with African breadfruit seed residue was investigated. Grated cassava (70%) was fermented for 3 days with the incorporation of African breadfruit seed residue (30%) at different stages of the fermentation. The fortified and unfortified gari samples were subjected to nutritional and sensory evaluation. Total cyanide was 1.78 ± 0.2 mgHCN/100g, for the unfortified gari (batch A) while samples from the two fortified gari (batches B and C) had 1.52 ± 0.1 mgHCN/100g and 1.50 ± 0.2 mgHCN/100g respectively. The water activity of African breadfruit-fortified gari was 1.11-1.13, the swelling capacity was 3.0-3.3, pH was 4.49 ± 0.3 . Proximate composition shows that, gari (Batch A) had lower crude protein content (1.96 ± 0.2) as against 9.62 ± 0.3 and 10.71 ± 0.2 , for batches B and C respectively. In contrast, unfortified gari had higher crude carbohydrate (81.99 ± 0.2). Ash, moisture and fibre contents were comparable in all samples. Sensory evaluation gave no statistically significant ($p > 0.05$) differences. The fortified gari is capable of reducing the level of malnutrition among the poor in the developing countries, especially in West Africa where gari is a staple. © JASEM

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Food security is one of the world's most pressing problems. It is one problem made more critical by the explosive rate of population increase and is more prevalent in Africa where up to 200 million people are currently suffering from it due to famine and ravages of war (Onilude *et al.*, 2004). The latter has brought about limitations in the sources of high biological value proteins since there is heavy loss of livestock. In the continuous search for solution to the problem of malnutrition in its various forms, mainly among people of developing countries, views have been expressed of the need to improve nutritive quality of our local food through better processing and enrichment (Okafor, 1992).

Cassava (*Manihot esculenta* Crantz) belongs to the family, *Eupobiaceae*. It is native to tropical America (Abercombie and Hickman, 1990), and is one of the most important starchy root tubers of the tropics. The tubers as well as the other parts of the plant contain glycosides of hydrocyanic acid which render them poisonous if eaten fresh. Cassava tubers contain mainly carbohydrate, approximately 87% starch, and very little protein, less than 2%, free sugar, minerals and vitamins including ascorbic acid. The glucoside contained in cassava has been referred to as "linamarin", and the enzyme that acts on it is

termed "linamarase". In Nigeria, cassava is used as a cheap source of carbohydrate for human and animal consumption in the form of lafun (cassava flour), fufu (cassava mash), cassava starch, 'kpokpo gari' and gari (FAO, 1997; Oyeyipo, 2011).

Gari is a fermented, gritty, starchy food or free flowing dry granular product produced from cassava. However, its use as food source is limited by its perishability, low protein content and potential toxicity. The traditional method of processing cassava for gari includes peeling of the cassava tubers by hand with knife, washing the cassava tubers, grating, dewatering/fermentation (during which microorganisms such as Lactic acid bacteria; *Lactobacillus* spp. and *Corynebacterium* spp. and yeast; *Geotrichum* spp., degrade starch, lower pH, reduce cyanide content and add flavor compounds that is retained by the final product) granulation, sifting followed by roasting to reduce toxicity. Gari is consumed as a main meal (eba), taken as a snack when soaked in cold water, sweetened with sugar and consumed with roasted groundnut, coconut or dry fish (Sanni and Sobmiwa, 1994).

African breadfruit belongs to the family *Moraceae*. It has a protein content of 19-22%. The processing start

by loosening of seeds from the fruit head as a result of the actions of various microorganisms. The action of selected microorganisms on various substrates such as soybean, African yam bean, melon seeds and barley resulting in tempe are fermentation processes. The main purpose of subjecting these legumes to fermentation is to modify their organoleptic and nutritious properties rather than a means of preservation. Fermented foods on average account for one-third of total food consumption by human beings (Oyeyipo, 2011).

The complementary effect of amino acid from one protein on the nutritive value of another is well recognized, therefore, an economical and practical way to improve protein quality as well as quantity is the combined use of complementary proteins. Supplementations of inexpensive staples such as cassava, maize or legumes have resulted in products of high nutritional value (Marero *et al.*, 1988; Nout *et al.*, 1989; Uwaegbute and Nnanyelugo, 1989; Onilude *et al.*, 1999; Onilude *et al.*, 2004; Amusa *et al.*, 2005; Oyeyipo, 2011).

An acceptable, nutritionally-enriched food that can be stored in the home should be produced for consumption in areas where protein intake is low (Sanni and Sobamiwa, 1994). This paper therefore describes two methods for fortifying gari with African breadfruit seeds to produce such food.

MATERIALS AND METHODS

Source of cassava and African breadfruit seeds: Freshly harvested Cassava (*Manihot esculenta* Crantz) was procured from a farm settlement in Ozuoba, Obio Akpor Local Government Area in Rivers State of Nigeria. African Breadfruits (*Treculia africana*) was purchased from Ndele market in Ikwerre Local Government Area in Rivers State of Nigeria.

Production of unfortified gari (Batch A): Gari (Batch A) was produced essentially as described (Hahn, 1989; Odunfa, 1998). Fresh roots were peeled manually using a knife (as practiced traditionally), washed twice in water to remove dirt's and debris and grated. The grated pulp was put in sacks (polypropylene) and the sacks were pressed with a hydraulic jack between wooden platforms for 3 days to express excess liquid from the pulp while it was fermenting. The dewatered and fermented lumps of pulp were crumbled by hand and most of the fibrous matter was removed. The remaining mass was sieved with traditional sieves (made of woven splinters of cane). After being sieved, the fine pulp was then roasted in an iron pan over a fire.

Production of African breadfruit fortified gari (Batches B and C): Two kilogram (2kg) of freshly harvested breadfruit seeds was measured and sorted. The sorted seeds were parboiled in water for 20minutes and dehulled manually and then wet milled using a commercial milling machine. A muslin cloth was used to extract the milk from the wet sample to give the residue (Anon, 1988).

Two batches of fortified gari were processed in duplicate. Grated cassava and African Breadfruit residue were combined in the ratio 70:30. The critical stages involved in the processing of the different batches are illustrated below, batch B had African Breadfruit residue added after grating while batch C had African Breadfruit residue added after dewatering (Figure 1).

Proximate Analysis: Proximate analyses of gari samples: The lipid, carbohydrate, moisture and percentage ash of gari sample were analyzed based on standard methods (Osborne and Voogt, 1978). Crude protein content was determined using the Kjeldahl method in which the nitrogen percentage was multiplied by a factor of 6.25 to obtain crude protein (AOAC, 1990). The same was done for the enriched gari samples.

Physico-chemical analysis:

The pH, titratable acidity and the hydrocyanide content of the products were determined (AOAC, 1990). Swelling capacity was assessed (Sanni and Sobamiwa, 1994).

ratio of 1:4). The water was brought to boil on a gas cooker in a pot. The flame was put off and the gari was poured into the boiled water with some aggressive turning using a local turning stick. The gari was turned to form a thick paste of consistent appearance (Oyewole and Afolami, 2001). Sensory evaluation was carried out within ten minutes of preparation. A trained 10-member panel evaluated the samples for visual appearance, texture, taste, aroma and overall acceptability at various intervals. The panelists were familiar with the scoring scale and the assessment method during the preliminary training session. The samples were arranged randomly and presented to the judges in the same type of plates and each sample was coded in such a way that the panelists could not be biased by the coding system as a set of three digits of random numbers were assigned to each sample. A nine-point hedonic scale (where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly,

*¹ONASOGA, M. OLUWAFUNMILAYO¹, AYODELE, D. OLUWAFUNMILAYO² OYEYIPO O. OLUWATIMILEHIN³

7 = like moderately, 8 = like very much and 9 = like extremely) was used (Oyeyipo, 2011).

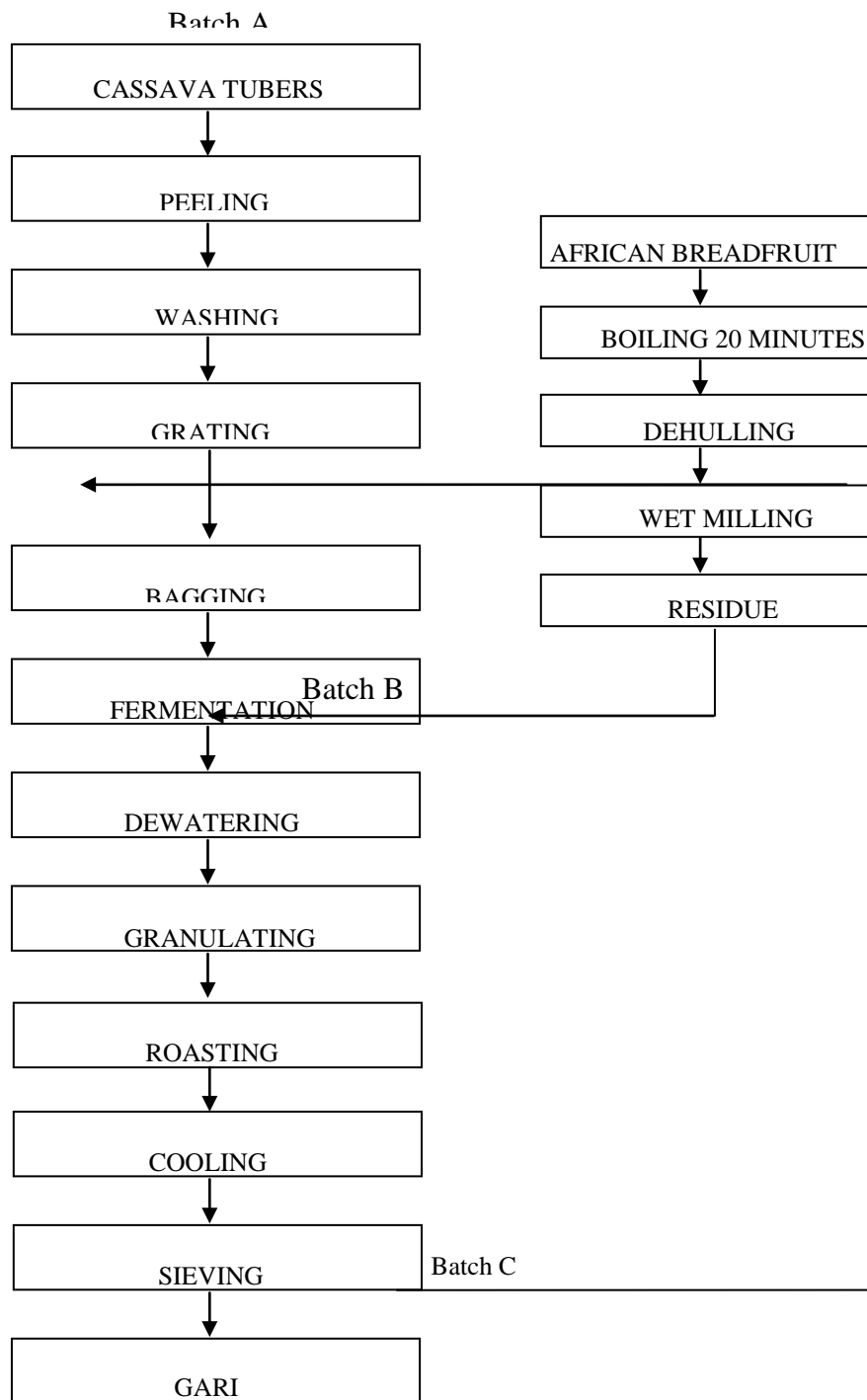


Fig1: The processing of unfortified and African breadfruit-fortified gari. Batch A = Cassava only (unfortified); Batch B = African breadfruit residue added to cassava (30:70, w/w) after grating; Batch C = African breadfruit residue added to cassava (30:70, w/w) after dewatering.

**¹ ONASOGA, M. OLUWAFUNMILAYO¹, AYODELE, D. OLUWAFUNMILAYO² OYEYIPO O. OLUWATIMILEHIN³*

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Statistical analysis: Means and standard deviations were calculated to analyze sample attributes and proximate analysis. The data obtained were subjected to analysis using a one-way analysis of variance (ANOVA) and means were separated using the Least Significant Difference method where significant differences were established (Steel and Torries, 1980).

RESULTS AND DISCUSSION

In this study, Batch A gari was easily processed. Batch B which had African breadfruit residue added after grating was difficult to process while batch C, which had African breadfruit residue added after dewatering was more difficult to granulate and roast.

The fortified gari had its pH value drop from about 6.32 to 5.40 at 24hours and to 4.45 at 72hours. For the gari-African breadfruit residue, significant decreases in pH occurred with the formation of the mixture (Table 1). The decrease in pH of cassava from 6.32 to 4.45 at the end of the three day fermentation was due to the degradation of starch in the substrates by microorganisms with the production of various organic acids, consequently, lowering the pH of the substrates. Sanni and Sobamiwa (1994), Oyerekua, (2009), obtained values comparable to these during cassava fermentation for gari production (5.70 to 4.45) and co-fermentation of cassava/cowpea/carrot (6.30 to 4.71) respectively. Lactic acid bacteria (*Lactobacillus* spp. and *Corynebacterium* spp.) and yeast (*Geotrichum* spp.)

are very significant in the fermentation of cassava. The lactics degrade starch in the substrates with the production of various organic acids, and the lowering of pH. The yeast produces a variety of aldehyde and esters that are responsible for the characteristic desirable taste and aroma of the fermented products. The Titratable Acidity (TTA) increased from 0.08 (g lactic acid/100g dry sample) to 0.21 (g lactic acid/100g) for gari sample and the gari-African breadfruit blends ranged from 0.08 to 0.18 (g lactic acid/100g) (Table 1). Similar findings have previously been reported (Sanni and Sobamiwa, 1994, Oyeyipo, 2011).

Total hydrocyanide contents of gari and gari-African breadfruit residue are indicated in table 1. The total HCN content of batch A gari was 1.78 mg HCN/100g while the fortified gari had a relatively low total HCN content (1.52 mg HCN/100g and 1.50 mg HCN/100g, for batches B and C respectively). The total cyanide content of the batches was 1.78, 1.52 and 1.50mg HCN/100g for BTA, BTB and BTC, respectively. Sanni (1991) found that, after 3 days fermentation, gari had a total cyanide content of 2.0 and 1.7mg HCN/100g during the dry and wet seasons respectively. Properly processed gari should not contain more than 3.0mgHCN/100g material, the suggested maximum concentration for safe human consumption (Akinrele, 1986; Ajibola *et al.*, 1987).

The swelling capacity was 3.5 for the unfortified gari while the fortified samples range was 3.0-3.3. Values similar to these have been reported by Sanni and Sobamiwa, 1994. This difference could be attributed to the reduction of starch in the fortified samples due to the addition of African breadfruit residues.

Unfortified gari (batch A) was superior to other samples in terms of all sensory parameters, while batch C consistently had the poorest rating. All three batches differed significantly in visual appearance, aroma, taste, texture and overall acceptability (Table 2). There was no significant difference between the fortified samples in terms of aroma. Sensory evaluation of samples revealed that there was no significant difference between samples in terms of visual appearance (6.8, 6.6 and 6.8, respectively); they all appeared whitish in appearance. Ratings on visual appearance demonstrated that supplementation of gari with African Breadfruit residue did not affect the appearance. Batch A had better aroma than BTB and BTC. The differences in aroma ratings between samples could be attributed to the processes applied. Fermentation, fortification and heat treatment significantly impact characteristic odour which is retained by food products (FAO, 1997; Oyewole and

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Afolami, 2001; Blanca *et al.*, 2009, Oyeyipo, 2011). However, this difference was not statistically significant (Table 3). In term of taste BTA scored the highest. The explanation logically follows the argument in the case of aroma. The texture of BTA, BTB and BTB were comparable in this study (Table 3). However, BTC scored highest.

The results of the proximate composition of gari samples are shown in table 3. The moisture content of the samples varied from 1.11% to 1.13%. The batch B gari had the lowest moisture content of 2.08% while batch C had the highest moisture content value of 2.13%. Crude fiber ranged between 3.40% - 3.62%. The crude protein content range was 1.96% - 10.71%. Also, the ash content varied from 4.42% - 4.61%. The carbohydrate content of the samples ranged between 74.25% - 81.99%. Ash, moisture and fibre contents of BTA, BTB and BTC were comparable (Table 3). BTB and BTC recorded (3.42, 2.08, 3.41 and 3.53, 2.13, 3.40) respectively as against (3.61, 2.11 and 3.62) for BTA. The moisture content is indicative of the level of processing (dewatering and roasting). The fibre content is within

the nutritionally maximum level (3-3.5%) recommended (FAO, 1997). The carbohydrate content of BTA was higher than that of BTB and BTC samples (81.99%, 75.54% and 74.25%, respectively). The high carbohydrate content of the gari samples makes it a good source of energy in communities where it is consumed as staple food. Higher lipid was observed in BTB and BTC (6.95, 6.98, respectively) than BTA (5.71) sample. Crude protein was higher in BTB and BTC samples (9.62, 10.71, respectively) than BTA sample (1.96). It has been reported that fortification of cassava with soybean or cowpea extract increased the protein content of cassava (Oyeyipo, 2011).

The fortification of gari in the present study gave a dual advantage in that protein content was increased while the cyanide content was decreased, resulting in a more nutritive and safer gari. The results obtained for proximate analysis shows that the fortified gari is of high nutritive value. Therefore, gari could be fortified with African breadfruit residue to alleviate malnutrition problems caused by root crop.

Table 1: Changes in pH, Cyanide and Titrable acidity (g lactic acid/100G)

Fermentation time (hour)	Cyanide						
	SC	Parameter	0	24	48	72	Mg
Gaari samples HNC/100g)							
BTA	3.5±0.2	pH	6.32±0.2	5.40±0.2	4.47±0.3	4.45±0.2	
1.78±0.2		Testable acidity	0.08±0.3	0.06±0.2	0.16±0.2	0.21±0.1	
BTB	3.0±0.2	Ph	6.32±0.2	5.45±0.1	4.50±0.2	4.49±0.3	
1.52±0.1		Tirable acidity	0.08±0.1	0.04±0.1	0.12±0.1	0.16±0.2	
BTC		pH	6.32 ±0.2	5.46±0.2	4.51±0.2	4.48±0.3	
			0.08±0.1	0.05±0.1	0.14±0.1	0.18±0.2	

Values are mean± standard deviation of two replicates (n = 2). BTA = Batch A (cassava only); BTB = Batch B (African breadfruit residue added after grating); BTC = Batch C (African breadfruit residue added after dewatering); SC = Swelling capacity

Table 2: Sensory evaluation test for gari and gari-African breadfruit residue Attributes' score

Sample	Visual appearance	Aroma	Taste	Texture	Overall acceptability
BTA	6.8±0.3	6.0±0.1	7.3±0.2	7.7±0.2	7.6±0.2
BTB	6.6±0.2	.8±0.2	.9±0.2	7.7±0.2	7.2±0.3 56
BTC	6.8±0.3	5.7±0.3	6.8±0.3	7.8±0.3	7.3±0.2

Values are mean± standard deviation of 10 scores from 10 panelists. Batch A = cassava only; batch B = African breadfruit residue added to cassava (30:70, w/w) after grating; batch C = African breadfruit residue added to cassava (30:70, w/w) after dewatering.

Table 3: Proximate Composition of gari and gari-African Breadfruit residue (g/100g)

Sample	Ash	Moisture	Protein	Fat	Fibre	Carbohydrate
BTA	1.08±0.2	4.61±0.1	1.96±0.2	5.71±0.2	3.62±0.2	81.99±0.2
BTB	4.42±0.2	1.11±0.3	9.62±0.3	6.93±0.2	3.41±0.3	75.74±0.2
BTC	4.53±0.2	1.13±0.2	10.71±0.2	6.98±0.2	3.40±0.1	74.25±0.2

Values are mean± standard deviation of two replicates (n = 2). Batch A = cassava only; batch B = African breadfruit residue added to cassava (30:70, w/w) after grating; batch C = African breadfruit residue added to cassava (30:70, w/w) after dewatering. Values are mean of two replicates.

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