Nutrient Composition and Acceptability of Soy Enriched *Gari*: Implications for Food Security in Nigeria

***Okwulehie, F.C; Lemchi S.N; Iheme, G.O; Obi-Anyanwu, J.N**

Department of Home Economics, Alvan Ikoku Federal College of Education, Owerri. PMB: 1033, Owerri, Imo State Imo State. Nigeria

***Corresponding Author:** tonyokwulehie@yahoo.com*

ABSTRACT

***Background:** Gari, granular flour is one of the major staple foods in Nigeria. It has a drawback with regard to its crude protein content which is as low as 1%. There is a need to enrich gari with local legumes to improve nutrient content and acceptability.*

***Objective**: The study examined the nutrient composition and general acceptability of soy enriched gari products.*

*Method: Improved Cassava TMS 30575 and raw Soybean seeds were used. Cassava tubers were peeled, washed, milled, fermented spontaneously for five days and dewatered. Soybean seeds were boiled in 2.5% sodium bicarbonate for 20 minutes to remove beany taste, de-hulled, dried and milled into flour. Dewatered cassava mash was enriched with soybean flour at varying proportions to generate three samples at the ratio of 100g cassava mash:10g soybean flour (sample A), 100g cassava mash:20 soybean flour (sample B) and 100 cassava mash:30 soybean flour (sample C) to obtain soy-gari, while two other samples containing cassava mash only and cassava mash with 20ml palm oil served as controls. The effect of the enrichment on proximate content of the soy- samples and acceptability of the cooked paste (eba and fufu) and snack (soaked gari) were evaluated. Nutrient composition was determined following standard procedure, while. **S**ensory evaluation was carried out with a twenty-man panel using a nine – point hedonic scale. Data obtained were subjected to Analysis of Variance (ANOVA) to compare the means of the samples. Duncan's new multiple range was used for mean separation at 5% probability.*

***Result**: The result showed that the strong acid taste of gari which is desirable was not affected by enrichment with soybean. The moisture content of the samples was considerably low and is capable of having long shelf life. The nutrient content of the samples improved with the addition of soybean flour in all the nutrients evaluated. Its consumption as Fufu was generally accepted.*

***Conclusion**: The enrichment of gari with soybean flour improved its nutrient content and has potential to reduce malnutrition and food insecurity among the rural poor in Nigeria who depend on largely on gari as a major staple.*

Keywords: Soybean, cassava, enriched-*gari*, acceptability, Food security

INTRODUCTION

Gari is a fermented and roasted coarse granular flour of varying texture made from the roots of cassava (*Manihot Esculenta Crantz*) through series of processing steps (1) Currently it is produced in Nigeria by small farm holders, mainly women, by the spontaneous fermentation of the mash produced from grated cassava and the organoleptic properties of *gari* presently produced as a result of this practice are highly variable (1). The acceptability of *gari* is based on its organoleptic properties (color, taste, aroma, extraneous matter and texture): physical (swelling or raising capacity, particle size distribution): and chemical (pH, water activity and residual HCN) properties (2). Other important properties include: appearance– white or yellow (if palm oil is added), sour taste (total acidity<1% lactic acid), gritty texture, dryness and residual hydrogen cyanide level less than 50ppm/kg (2).

Formally *gari* was referred to as the common man's bread (3), now it is a food of choice even in the face of alternative food options in urban area (4). The ability to store *gari* well, its cheapness, ease of preparation for consumption and acceptance as a convenience food have combined to make it extremely popular among the urban dwellers of Nigeria and other West African countries (5). It is known to be finding its way to eminent Nigerian communities in United States and Europe (6). Soaked in cold water, it is an excellent snack cherished by children and adults alike on a very hot day. It could be consumed along with sugar, coconut, roasted groundnuts, dry fish, or boiled cowpea (1). It could be cooked in hot water to make dough-like meal called *eba,* which is traditionally consumed with various soups and stew (1).

Cassava tubers which is the raw food material for *gari* processing is carbohydrate dense and has very high fibre content. The high fibre content makes it very filling, and good in preventing the likelihood of constipation and bowel diseases. It has the drawback of very low protein (1.2-1.5%) content which can lead to malnutrition when consumed over prolonged period in a low protein diet ((1)). The rapid economic transition in many developing countries has led to increase in under nutrition, over nutrition, infection and chronic diseases co-existing over a long period (7). This food, therefore provide an excellent means of improving nutritional quality through incorporation of vegetable proteins. It is reported that protein fortification of *gari* with peanut grits was acceptable, its sourness (as % lactic acid) decreased; the swelling characteristic was not affected as well as colour and flavor (8).

In Nigeria, over 70% of the cassava yield is processed into *gari* (5, 9,). Among the processed forms of cassava, *gari* is an important product with regard to food security at household and community levels. Food security is a situation where people at all times have access to safe nutritious food to maintain a healthy and active life (10). It is the ability of the household to have all-year-round access to quality food either through its own production or purchases (11). Food security deals with food production, processing/preservation, food safety, availability, accessibility, food preference and utilization. Staple foods in developing nations are mainly carbohydrate dense usually of plant source; often low in protein hence protein deficiency diseases and anemia are common among families and threat to human survival (12). Diets adequate in energy; good quality easily digestible protein of high biological value; vitamin and minerals can be produced or formulated by appropriate processing technology such as extrusion, cooking, biotechnology and so on using variety of crops to guarantee food availability (12).

Food fortification is a technique in food processing where lacking or deficient nutrients can be easily added to create food of better nutritional quality to combat "hidden hunger" and other nutrient deficiencies (13). Food fortification is the public health policy of adding micronutrients (essential trace element and vitamins) to foodstuffs to ensure that minimum dietary requirements are met (14). In food fortification, commonly consumed foods (cereals, cassava, *gari*, legumes and so on) are used as vehicle to deliver one or more nutrients (protein, calcium, iron, niacin, riboflavin, thiamin and zinc.).

Food safety hazards often causes harm on humans who consume such foods like the cyanide toxicity (15). Cyanide occurs in cassava as *cyanogenic glucosides*, mostly linamarin (>80%) and to a lesser extent *lotaustralin* (16). The presence of *cyanogenic glucosides* (*Linamarin and Lotaustrain*) constitutes a major limitation to the use of cassava as human food. Fermentation detoxifies the toxic *cyanogenic glucosides (Linamarin and Lotoustralin*) which on hydrolysis produces glucose, toxic hydrogen cyanide (HCN) and acetone or propone. The consumption of improperly processed cassava with high cyanogen content was associated with cretinism, endemic goiter and even death (17). Study has reported that fermentation significantly reduced the cyanide content of either sweet or bitter variety of cassava from levels as high as 224.09 $\pm$0.858ppm to 86.63$\pm$1.049ppm after 2 days (18). Fermentation is an important processing step in *grri* production by which *cyanogenic glucosides* in *gari* are reduced. It results in the production of volatile compounds that give *gari* its unique flavour (5).

Gari production tremendously possesses the potentials for boosting food security in Nigeria. Its ease of production, cheapness and long shelf life makes *gari* available all-year-round ensuring food security. In this study, food processing technology was employed to improve the nutrient content, *organoleptic* quality, and general acceptability of *gari* fortified with soybean flour and its implication for improving food security in Nigeria.

Material and Methods

Procurement of raw materials

Improved cassava (*Manihot Esculenta Crantz*) tubers (TMS 30575) were harvested from the researchers' farm at Otulu Ahiazu Mbaise, Imo State, Nigeria and used for the experiment. Raw soybean seeds (*Glycine max*) were purchased from *Eke-Ukwu Owerri* market in Imo State, south-eastern Nigeria.

Cassava processing into mash

Fresh cassava tubers were washed before peeling to remove soil and reduce microbial load. The washed tubers were peeled manually with kitchen knife to remove thick peel and reduce cyanide content. The peeled tubers were washed again to eliminate sand grains, decrease cyanide content and reduce microbial load. The peeled cassava tubers were grated into mash and bagged with sack bag for four days to ferment and dewater. The dewatered mash was disintegrated with sieve of an aperture size of 1.5–2.0 mm to get granules of close to equal size for easy toasting (*garifying*) and removal of large lumps and fibre.

Processing of soybean into flour

The soybean seeds were cleaned by removing broken grains, pebbles and pre-matured seeds and washed. The clean seeds of soybean were boiled for 20 minutes in 2.5% sodium bicarbonate solution to remove the beany flavour (19). The boiled seeds were allowed to cool and de-hulled by rubbing between the palms. The hulls were removed by floatation in water and allowed to dry in the sun for 8hrs on a galvanized sheet. The dry cotyledons were milled into flour, packed in polyethylene bags and stored at room temperature to be used within one week of production.

Formulation of fortified *gari* with soybean

The sieved dewatered cassava mash and soy flour were measured according to the ratio below and mixed together in a corona petrol engine milling machine mixer for two minutes for homogeneity. The food samples were coded as shown in Table 1.

The sieved caked mash was toasted (*garified*) by stirring 2kg at a time constantly in a large but shallow cast-iron pan over fire generated from firewood with a piece of gourd and a wooden paddle until the granules are dried through hand feel. This is to reduce water activity (a_w), ensure gelatinization, decrease cyanide and prolong shelf-life. The toasted *gari* samples were allowed to cool on stainless galvanize trey and sieved with coarse gauze sieve of aperture size of 0.1cm to get granules of equal or close to equal sizes. Samples were packaged in polythene bags and stored at room temperature for future use.

Chemical analysis

A standard method (20) was adopted to determine the proximate content of the samples as well as the vitamin A, calcium and iron content of the samples following the method as described in Association of Official Analytical Chemists (AOAC) (20)

Sensory evaluation

Twenty-man panel comprising of students and staff of the Department of Home Economics, Alvan Ikoku Federal College of Education Owerri, Imo State of Nigeria who gave their consent to participate were selected and trained to evaluate the acceptability of the samples in terms of color, texture, flavour and taste. A sensory evaluation form consisting of nine - point hedonic scale for preference testing (21) was replicated into twenty based on the number of the panelists. The ratings

Table 1: Formulation ratio of the samples in percentage (%)

Sample code	%Cassava mash	%Soy-flour
A	90%	10%
B	80%	20%
C	70%	30%
D (Control1)	100% cassava mash only	
E (Control 2)	100% cassava mash + 20 ml Palm oil	

A=90% cassava mash +10% soybean flour, B = 80% cassava mash 20% soybean flour, C =70% cassava mash+ 30% soybean flour,D (Control 1) =100% cassava mash only, E (Control 2) =100% cassava mash + 20ml of palm oil.

for each sample were given numerical values ranging from like extremely (9) to dislike extremely (1) in which the panelists expressed their degree of liking or disliking of the product.

Preparation of soy enriched *gari* products

A total of two products were prepared from *gari* and include, *eba* and snack. The procedures are described as follows:

Preparation of *gari* sample eaten as snack (soaked in water)

About 50g of *gari* was added to 200ml of cold water in a bowl. Each sample was prepared for testing freshly after the other so that it will not soften more than expected. A glass of water was provided for each member to rinse his/her mouth before tasting the next sample to avoid taste interference. No sugar or sweetener was added as not to influence the taste of the product. Each member of the panel was provided with a sensory test questionnaire and a pen to record their level of likeness.

Preparation of *gari* eaten as *eba* (dough eaten with soup):

About 2kg of *gari* was stirred into 2liters of boiling water and mixed into medium soft dough. This was served with *Egusi* (melon seed) soup prepared by the authors for the panelist to taste and indicate their level of likeness.

Statistical analysis:

Data obtained were recorded as means, standard deviation and percentages. Analysis of variance (ANOVA) was used to compare the means; while Duncan's new multiple range was used for mean separation at 5% probability.

The result in Table 2 on the nutrient content of soy fortified *gari* showed variation in the moisture content of the samples which ranged from 5.10 in sample C to 10.03 in the control sample (D). The oil content of the samples was highest (4.10) in sample C while sample E had the least value (1.50). The crude protein content of the samples ranged from 1.70 as observed in sample E (control 2) to 6.50 which was observed in sample C. All the enriched samples were higher in protein than the control samples that were not enriched. Crude fiber content of all the enriched samples was highest (5.60) in sample C while the two controls (samples D and E) had the least values (1.85 and 2.15), respectively. The calcium value of the samples was 16.68mg, 19.18mg, 20.00mg, 14.18mg and 14.76mg, respectively. Vitamin A recorded as retinol equivalent (RE) of the samples were high in the enriched samples with sample C having the highest (3,280mg) value while samples D and E had values of 944mg and 947mg. Carbohydrate calculated by difference as the nitrogen free extract was observed to be higher in the two control samples.

Organoleptic attributes of the *gari* samples eaten as "soak"

Table 3 shows the organoleptic characteristics of the *gari* samples eaten as snack (soaked in water). Sample D (control 1) had highest mean value (8.05) in terms of colour and flavor (8.350) while samples A, B and C showed no significant difference (P>0.05) in colour. The taste rating of samples C (7.500), D (7.500) and E (7.200) were similar (p>0.05). The two control samples (P>0.05) with equal mean value of 8.000 than the fortified samples followed by sample A (7.250).

Table 2. Nutrient content of soy enriched *gari samples*

Determinations	A	B	C	D	E
Moisture (%)	8.95	7.88	5.10	10.03	8.97
Oil (Fat) %	2.00	3.95	4.10	0.20	1.50
Ash %	1.20	1.00	0.90	0.70	0.86
Crude Protein %	5.78	6.24	6.50	2.10	1.70
Crude fiber %	2.95	3.95	5.60	1.85	2.15
Carbohydrate	79.12	76.98	76.80	85.09	84.92
Ca mg/100g	16.68	19.18	20.00	14.18	14.76
Fe mg/100g	6.87	8.12	8.75	5.62	4.37

Key: A=90% cassava mash +10% soybean flour, B = 80% cassava mash 20% soybean flour, C =70% cassava mash+ 30% soybean flour, D (Control 1) =100% cassava mash only, E (Control 2) =100% cassava mash + 20ml of palm oil.

Table 3: Mean sensory scores of soy fortified *gari* eaten as snack (soaked in water)

Parameters				
Samples	Colour	Flavour	Taste	General Acceptability
Sample A	7.350^{b}	6.800^{cd}	6.650^{b}	7.250^{ab}
Sample B	7.250^{b}	6.050^{de}	4.950^{c}	6.900^{bcd}
Sample C	7.350^{b}	5.350^{e}	7.500^{a}	8.000^{a}
Sample D	8.050^{a}	8.350^{a}	7.500^{a}	8.000^{a}
Sample E	5.750^{c}	7.050^{bc}	7.200^{a}	6.350^{d}

Sample A = 90% cassava mash: 10% soy flour; Sample B = 80% cassava mash: 20% soy flour;
Sample C = 70% cassava mash: 30% soy flour; Sample D = Cassava Mash only (Control 1),
Sample E = Cassava mash/20ml palm oil (control 2).
Means within a column with the same superscript are not significantly different (P>0.05).

Parameters				
Sample	Colour	Flavour	Texture	General acceptability
Sample A	7.900	7.400 8.100	8.050	
Sample B	8.150^{a}	6.450^{de}8.300^{a}	8.350^{a}	
Sample C	8.200^{a}	6.150^{e}8.650^{a}	8.450^{a}	
Sample D	7.700^{ab}	8.400^{a}7.050^{c}	7.150^{c}	
Sample E	6.750^{c}	7.050^{bd}7.300^{c}	7.400^{bc}	

Sample A = 90% cassava mash: 10% soy flour; Sample B = 80% cassava mash: 20% soy flour;
Sample C = 70% cassava mash: 30% soy flour; Sample D = Cassava Mash only (Control 1),
Sample E = Cassava mash/20ml palm oil (control 2).
Means within a column with the same superscript are not significantly different (P>0.05).

Discussion

The proximate result indicates that there was wide variation in moisture content of the samples which might be due to the fact that the samples were toasted (*garified*) differently; the heat and time were not regulated. However, the moisture content of the samples was considerably low and is capable of having long shelf life. This is in agreement with the recommendation that "for good storability, the moisture content of *gari* should be below 12 %" (12).The oil content increased with the increase of soy flour which according to Mudambi and Rajagopal (22) might be due to the fact that soy bean has total fat/oil content of 19.9g/100g higher than cassava. The enriched samples have advantage over the control in its oil content because soybean contain Omega -3 and Omega-6 fatty acid at the ratio of 3:1, respectively (23). The products have the advantage of having long shelf life since their oil content were not very high, and so cannot go rancid easily.

The crude protein content of the products was observed to increase with the increase of soy flour. Samples D (control1) 2.13% and sample E (control 2) 1.70% that had no addition of soy flour were observed to have low content of crude protein. Yet among the two controls there were observed difference in their crude protein content. Control 2 (sample E), which was treated with palm oil, had lower crude protein content than control 1 which was not treated with oil. This could mean that, the palm oil added had a negative effect on the protein level of the product. It could also be deduced that the proliferation of micro-organism due to long time of 4 days (96h) fermentation might account for part of the protein content in control 1 which might have been affected by the oil treatment in control 2 (sample E) since the microorganisms have the ability to synthesize amino acids (24).With the crude protein of *gari* which has been said to be as low as 1% being raised to 6.50% by fortifying it with soy flour at the ratio of 70% cassava mash: 30% soy flour (1kg cassava: 300g soy flour), result shows that this method of *gari* production could go a long way to fight protein energy malnutrition among the poor who make up the bulk of the population.

The treated samples recorded higher fibre value than the controls. This then followed that if the nutritive value of fibre is to be considered, the treated samples are recommended to provide fiber in the diet than the controls, which were not treated with soy flour. The calcium content of the treated samples was observed to have increased with the increase of the soy flour. This is because soy flour has higher calcium content (277mg/100gm) than cassava (23). Therefore, increasing the content of soy flour invariably had addition effect as it increased the calcium content of the products. The iron values of the treated samples were also raised above the controls. Sample C had the highest value of 8.75mg/100g followed closely by sample B 8.12mg/100g. This can be attributed to the fact that soybean has 15.7mg/100gm iron content23. The raised values of calcium and iron in the treated samples are also added advantage over the two controls. The sample treated with the highest quantity of soy flour (sample C: 70% cassava mash: 30% soy flour) indicated higher value of vitamin A of 3,280 RE/100g. The value of the other treated samples increased with the increase of soy flour. This could be attributed to the vitamin A value of 2.00 IU of soy bean (23). This showed that the soy fortified *gari* have advantage of vitamin A over the ordinary *gari* even when palm oil, which is a source of vitamin A, was added.

The result on the sensory evaluation showed that there were no colour alteration in the soy fortified *gari* samples since there were no significant difference (P>0.05) between sample D (control 1 Cassava mash only) and the fortified samples eaten as both snacks and *eba*. This could be attributed to the fact that the soybean was not fermented. It could also be that the period of sun drying was short (8h) which did not affect the colour of the soybean flour after processing. However, the colour of the two controls were significantly different (P>0.05), this is due to the fact that control 2 was treated with palm oil which gave it a yellow colour.

The flavour of the soy fortified *gari* was generally accepted since there were no significant difference (P>0.05) between the fortified samples and control samples. The taste of the fortified *gari* was desirable, the cassava mash was fermented for 96h (four days) and the strong acid taste in *gari* acquired from a long period of fermentation which is appreciated by people was not affected. Also, the soybean was treated in 2.5% bicarbonate solution to remove the beany taste which could not influence the taste of the *gari*. The texture of the soy fortified samples was preferred when eaten as *eba* (fufu) than the two controls. This indicated that treatment with soy flour improved the texture of *gari* and made it more preferable. This could be as a result of high protein (38/40%) as well as high oil (20%) composition of soybean which improved the texture of the soy fortified *gari* as soy protein according to Pamplona-Roger, (23) is used for emulsification and texturing.

Conclusion:

Gari fortified with soy flour had better nutrient content than plain *gari* in all the nutrients evaluated; protein, oil, vitamin A, calcium, iron and fiber. Although, the plain *gari* (sample D) used as Control 1(one) was seen to be generally preferred for snacks in all the attributes, yet it had no significant difference with fortified samples C and A. The palatability of fortified samples C (70% cassava mash: 30% soy flour) and sample B (80% cassava: 20% soy flour) when eaten as *Eba* were generally accepted. The high fibre content is an advantage over the controls nutritionally. Although, the flavour was not highly desirable in sample C, but this is negligible considering their nutritive value. The color of all the fortified samples was generally acceptable as there were no significant difference (P>0.05) between the color of the samples and control 1(one). The strong acid taste which is desirable was not affected by fortification with soy flour. Processing cassava into *gari* ensures food safety through elimination of toxins, improves shelf life and ensures availability. *Gari* fortification with soybean flour modifies its natural nutrient content to a more functional food; an implication for improving food security in Nigeria.

It is therefore recommended that the use of soy-enriched *gari* among children should be promoted mostly in the rural areas as a means to fight protein energy malnutrition among the core poor who make up the bulk of the society and who are dependent on *gari* as major complementary food for infants and major food for adults. Since the soy enriched *gari* has good storability, it should be recommended to disaster zones to help fight protein energy malnutrition among children in internally displaced persons (IDP) camps.

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