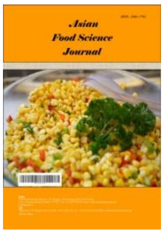

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Quality Evaluation of Garri Produced from Cassava Mash and Soybean Flour

J. I. Okoye [a*], N. U. Ihiasota [a] and A. E. Egbujie [a]

[a] *Department of Food Science and Technology, Enugu State University of Science and Technology (ESUT), P.M.B-01660, Enugu, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was designed specifically to evaluate the chemical composition, functional and sensory properties of garri samples prepared from blends of grated cassava mash and soybean flour. The grated cassava mash and soybean flour were blended in the ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50, respectively and used to produce soy-garri samples. The samples of soy-garri produced were evaluated for chemical composition, functional and sensory properties using standard methods. The moisture, crude protein, ash, crude fibre and fat contents of the soy-garri samples increased significantly (p<0.05) with increased substitution of soybean flour from 7.19 - 8.92%, 2.64 – 15.10%, 1.25 – 2.64%, 1.65 – 2.82% and 2.37 – 4.32%, while the carbohydrate, energy and cyanide contents decreased from 84.90 – 66.20%, 371.49 – 364.08 KJ/100g and 24.05 – 8.12%, respectively. The mineral content of the samples showed that the calcium, potassium, magnesium, zinc and iron contents of the products ranged from 1.16 – 14.32mg/100g, 3.35 – 18.71mg/100g, 1.17 – 16.37mg/100g, 12.17 – 35.73mg/100g, 1.25 – 12.62mg/100g and 1.61 – 3.90mg/100g, respectively. The control (100% cassava garri) and the sample produced from 50% grated cassava mash and 50% soybean flour had the least and highest values for all the minerals evaluated. The vitamin content of the samples also revealed that the thiamine, riboflavin, niacin, ascorbic acid, vitamin A and vitamin E contents of the products increased significantly (p<0.05) with increased substitution of soybean flour in the samples. The control (100% cassava garri) had the least values for all the vitamins evaluated. The functional properties of the samples also showed significant (p<0.05) increases in bulk density, water absorption capacity, oil absorption capacity and solubility index with increased substitution of soybean flour in the products with the

**Corresponding author: Email: okoyejoseph6@gmail.com, Josepj.okoye@esut.edu.ng;*

exception of swelling and gelation capacities which had least values, respectively. The sensory properties of the samples showed that the control sample was the most acceptable to the panelists and also differed significantly ($p<0.05$) from the other samples in colour, texture, taste and flavour. Although, the control sample was scored highest in all the parameters evaluated, it recorded least values in nutrient contents and some functional properties compared to the substituted samples. The study, therefore, showed that soybean flour could be used to improve the nutrient contents, bulk density, water absorption capacity, oil absorption capacity and solubility index of soy-garri samples.

Keywords: Garri; cassava mash; soybean flour; nutrient composition; functional properties; sensory properties.

1. INTRODUCTION

Cassava (Manihot esculenta crantz), also known as manio, mandioc, and tapioca, is a Euphorbiacae family perennial woody plant. It is grown mostly for its swelling roots, but it is also eaten in some regions of Africa for its leaves. The roots are high in starch (between 25 and 30 percent), but low in protein, vitamins, and minerals [1]. After rice, wheat, and maize, cassava is the world's fourth most important staple food [2]. It is also an important element of the diet of more than half a billion people in Africa, Latin America, and Asia who live in tropical regions [1]. Cassava's popularity stems from its use in dishes such as gari, fufu, chips, Lafun, and industrial starch. The cassava roots decay quickly after harvesting, as demonstrated by discoloration and deterioration of the roots, thus they must be processed within 24 hours of harvesting to avoid this problem.

Garri is a free-flowing particulate product made from gelatinized and dried cassava particles [3]. Garri is probably Nigeria's most important traditional food [4], and the growth of genuine significance in cassava processing has focused on its production [5]. In many parts of tropical Africa, including large cities, garri, a fermented gelatinous granular flour, is a major source of nutritional energy for low-income consumers. The presence of toxic compounds in the form of glucosides in cassava renders the raw tuber harmful, which is largely removed through garri preparation. The processing methods that bring about the reduction in cyanogenic glucosides include peeling, washing, grating, fermentation, pressing and frying [1]. These processes have vigorous effect on the elimination of the toxins and affect the properties of the final product. Garri is usually consumed by mixing with boiling water to form a stiff paste and eaten with stews or soups as accompaniment. It may also be eaten with fried or roasted fish, coconuts, palm kernel and groundnuts when mixed with cold water, with or without the addition of sugar. Sometimes, garri is eaten dry as snack by children [6]. Garri's widespread usage has been linked to its comparatively extended shelf life compared to other cassava-based foods, as well as its ease of preparation for consumption [7,1]. Garri of acceptable quality has also been reported to be made from dried cassava chips [8], with a shelf life of six (6) months or more when properly stored [9]. Acceptability is based on conformance with the primary qualitative attributes desired in garri by many garri consumers. Garri, on the other hand, takes on a ketone and aldehyde flavour as the hydrocyanic acid breaks down. The break down of the toxic hydrocyanic acid is responsible for the flavour as well as sourness of garri which is also desirable due to the formation of ethanol during fermentation.

Soybean is a type of legume that is used as a food crop. Glycine max is the botanical name for it. It is a bushy, erect annual herbaceous plant with a leafy plant structure. Its height ranges from 40 to 100cm. Soybeans are thought to have been a part of Chinese history for almost 5,000 years, but their production has now spread to other regions of the globe. The number of seeds in each pod ranges from 2 to 5. Soybeans were initially brought into Nigeria in 1908 according to Fennel [10], but the Malayan variety, which was found suitable for commercial production in Benue state, north central Nigeria, was the first successful cultivation in 1973. Siulapwa and Mwambungu [11] revealed that soybean has been used as food for centuries and its exceptionally good nutritional value is well known. They noted that soybean contains 40% high quality protein, 20% edible vegetable oil and a good balance of amino-acid and has therefore tremendous potential to improve the nutritional status and welfare of the families of low income earners and poor farmers. According to Ugwu and Nwoke [12], the benefits of soybean over other grain legumes commonly grown by smallholders, such as groundnut (*Arachis hypogea*), cowpea (*Vigna unguiculata*) and common bean (*Phaseolus vulgaris*) include lower susceptibility to pests and diseases, better grains storage quality, a large leaf biomass, which gives a soil fertility benefit to subsequent crops and a secure commercial market for the crop. Nigeria is the largest producer of soybeans for food in West and Central Africa [13]. Nigerian scientists have therefore investigated several ways of enriching cassava products by fortifying it with protein rich legumes, such as soybean, bambara groundnut and cowpea. More attention has been drawn to the low levels of some minerals and amino acids in garri such as phosphorus, calcium, iron, methionine, lysine, tryptophan, phenylalanine and tyrosine e.t.c. Soybean (*Glycine max*) contains a reasonable amount of protein, minerals, vitamins and even phyto- chemicals such as isoflavones which are naturally lacking in garri. The choice of soybean is not far-fetched from the fact that it contains high amount of protein and phytoestrogens which have been found to reduce the onset of cardiovascular diseases and improve the brain and nerve functions in man. The results of previous studies of fortification of cassava products with soybean have shown that fortification improves the nutritional quality of the resulting meals [14, 15]. Foods are processed in order to improve their digestibility and attractiveness to the consumers. Processing also helps to extend the availability of foods beyond the region and season in which they are produced, thereby stabilising supply and boosting food security at the national and household levels [16]. Another key component of food processing is that it allows for more diet diversification by providing consumers with a wide choice of products and a better range of nutrients than they would otherwise consume. The objective of the present study, therefore, is to evaluate the quality characteristics of garri produced from cassava mash and soybean flour at different proportions.

2. MATERIALS AND METHODS

Freshly harvested cassava roots (*Manihot esculenta)* were purchased from peasant farmers in Agbogwugwu Market, Awgu, while the soybean seeds (*Glycine max)* were purchased from Ogbete Main Market, Enugu, Enugu State, Nigeria.

2.1 Preparation of Soybean Flour

The malted soybean flour was prepared according to the method adopted by Naik and Gleason [17]. One kilogramme (1kg) of soybean seeds were manually sorted to remove the dirt and other extraneous materials. The sorted seeds were thoroughly cleaned and steeped in 2.5litres of potable water in a plastic bowl at room temperature (30±2^{o}C) for 24 h with a change of water at intervals of 6 h to prevent fermentation. The steeped seeds were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the seeds. The seeds were rinsed for five consecutive times with excess water and cast on a moistened jute bag, covered with a polyethylene bag and left for 24 h to fasten sprouting. The sprouted seeds were spread carefully on the jute bag and allowed to germinate in the germinating chamber at room temperature (30±2^{o}C) and relative humidity of 95% for 96 h. During this period, the seeds were sprinkled with water at intervals of 6 h to facilitate germination. Non-germinated seeds were handpicked and discarded. The germinated seeds were collected, spread on the trays and dried in a cabinet dryer (Model EU 850D, UK) at 60^{o}C for 24 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried malted soybean seeds were cleaned and rubbed in-between palms to remove the roots and shoots along with the hulls. The dehulled soybean malts were milled in a hammer mill and sieved through a 500 micron mesh-sieve. The flour produced was packaged in a lidded plastic container, labeled and kept in a refrigerator until needed for further use.

2.2 Preparation of Soy-Garri Samples

Fresh cassava roots were peeled to remove the woody back. The peeled roots were washed with 3.5 litres of potable water to remove dirt and other foreign materials. The washed roots were grated with a mechanical grater to produce grated cassava pulp. Soybean flour was incorporated into the grated cassava mash in the ratios of 90:10, 80:20, 70:30, 60:40 and 50:50, respectively before bagging them separately in jute bags for fermentation. The remaining batch without any substitution (100% cassava garri) was used as control. The samples were left to ferment for 72 h at ambient temperature (30±2^{o}C) for 48 h after which they were dewatered in a mechanical press. The dewatered soy-cassava garri were pulverized with hands and sifted separately on a local raffia made sieve of mesh (0.3cm x 0.3cm) mounted on a rectangular wooden frame (40cm^{2}) to remove the fibrous materials. The soy-garri samples were transferred separately into cast aluminum pans and toasted under fire wood with continuous stirring of the samples using a self-insulating manual baffle made of calabash to prevent dextrinization of the samples. The toasted garri samples were individually removed from the wide aluminium pans, spread over a large clean surface of wooven Hessian sack and allowed to cool at ambient temperature. The cooled samples of soy-garri produced were packaged and stored separately in lidded plastic containers, labeled and kept under ambient temperature (30±2^{o} C) until needed for analysis

2.3 Chemical Analysis

The moisture, crude protein, ash, fat and crude fibre contents of the samples were determined in triplicates according to the standard analytical methods of AOAC [18]. The carbohydrate was calculated by difference on dry sample weight by subtracting the summation of the percentage values of moisture, protein, fat, ash and crude fibre contents from 100%. The energy content was calculated by multiplying the percentages of protein, fat and carbohydrate using the Atwater factors of 4, 9 and 4, respectively [18]. The cyanide content was determined by the method described by Nwabueze and Anoruoh [19]. The calcium, magnesium and zinc contents of the samples were determined using atomic absorption spectrophotometer (Perkin-Elmer Model 1033, Norwalk CT, USA) according to the methods of AOAC [18]. The potassium and iron contents of the samples were determined by the use of a flame photometer (Model 405, Corning UK) according to the methods described by Ndie *et al.* [20]. The phosphorus content was determined by the vanadomolybdate calorimetric method described by Onwuka [21]. The niacin, ascorbic acid and vitamin E contents of the samples were determined by the methods of AOAC [18]. The thiamine, riboflavin and vitamin A contents of the samples were determined according to the flourimetric methods described by Onwuka [21].

2.4 Functional Properties

The bulk density was determined according to the method of AOAC [18]. The water absorption capacity, oil absorption capacity, swelling capacity, solubility index and the gelation capacity were determined according to the methods described by Onwuka [21]. All determinations were carried out in triplicate samples.

2.5 Sensory Analysis

The samples of soy-garri prepared and the control sample (100% cassava garri) were separately reconstituted into "Eba" by stirring each of the samples with boiling water in a plastic bowl with a wooden stirrer. Eighty grams (80g) of each sample of garri was individually reconstituted into "Eba" with one hundred and twenty milliliters (120mL) of boiling water with continuous stirring in a plastic bowl with a wooden stirrer until it became thick. After that, the samples of "Eba" produced were separately coded, placed in white plastic plates and served with vegetable soup to a panel of twenty (20) semi-trained judges consisting of staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria who are habitual garri consumers at ambient temperature (30±2^{o}C). The panelists were equally provided with plastic spoons and instructed to evaluate the samples for the attributes of colour, taste, aroma, texture and overall acceptability using a nine-point Hedonic scale with 1 and 9, representing dislike extremely and like extremely, respectively [22]. Clean potable water was provided to the panelists to rinse their month in-between testing of each sample to avoid residual effect. The judges were asked to taste, assess and score each sample of "Eba" based on their likeness and acceptance of the samples. Expectoration cups with lids were also provided for the panelists who would not like to swallow the samples after testing each of them.

2.6 Statistical Analysis

The data generated were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, Version 20) software. Significant means were separated using Duncan's New Multiple Range Test (DNMRT) at $p< 0.05$.

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Soy-Garri Samples

The chemical composition of soy-garri samples are presented in Table 1. The moisture content of the samples varied significantly ($p<0.05$) from each other. The moisture content ranged from 7.19 to 8.92% with the control sample (100% cassava garri) having the lowest moisture content (7.19%), while the sample substituted with 50% soybean flour had the highest moisture content (8.92%). The moisture content of all the substituted soy-garri samples reported in this study were within the recommended moisture contents of dried foods [23]. The lower the moisture content of a food product, the longer the shelf stability of such a product without any adverse effect on its quality attributes upon storage. The ash content of the samples ranged from 1.25 to 2.64% with the control sample having the lowest value (1.25%), while the garri substituted with 50% soybean flour had the highest ash content (2.64%). The increase in ash content observed could be attributed to high mineral content of soybean flour. The values (1.25-2.64%) obtained in this study were lower than the ash content (1.83-3.47%) reported by Oluwamukomi and Adeyemi [24] for "garri" semolina enriched with different types of soy-melon supplements. The crude fibre content of the samples ranged from 1.65-2.82%. The fibre content of the soy-garri samples was observed to increase with increased substitution of soybean flour in the products. The values (1.65-2.82%) obtained in this study were similar to the fibre content (1.66-2.81%) of soy-enriched tapioca reported by Folake *et al.* [25].Fibre plays an important role in reducing the onset of diabetes, high blood pressure, piles and obesity in human body. The fat content of the samples ranged from 2.37 to 4.32%. The fat content of the control sample was significantly (p<0.05) lower than the fat content of all the substituted samples. The increase could be attributed to the addition of high levels of soybean flour which drastically increased the fat contents of the samples [26]. The high fat contents of the food products may be desirable to consumers interested in the consumption of high fat food products. This is because fat increases the energy density and also provides essential fatty acids needed in the body for proper neural development [27]. The crude protein content of the samples ranged from 2.64 – 15.10%. The crude protein content of the samples was observed to increase with increase in substitution with soybean flour. The observed increase in the levels of protein could be attributed to the addition of high proportions of soybean flour in the products and this is in agreement with the report that soybean is a good source of protein [28]. The high protein contents of soy-garri samples produced in this study would be of great importance in reducing the problems of protein-energy malnutrition and micro-nutrients deficiencies resulting from high cost of conventional animal products especially in Nigeria and other developing countries of the world. Protein is important for growth and tissue replacement [29]. The cyanide content of soy-garri samples ranged from 8.12% to 24.05% with the control sample having the highest cyanide content (24.05%), while the sample substituted with 50% soybean flour had the least value (8.12%). The variations in cyanide content of the samples could be attributed to the prolonged action of micro-organisms responsible for fermentation of garri coupled with the addition of soybean flour in the products. Since cyanide interfere with the absorption of oxygen in the body, increased exposure of individuals to cyanide could result in headache, confusion, weakness, fatigue, loss of coordination, hyperventilation and loss of consciousness [6]. The carbohydrate content of the samples ranged from 66.20 to 84.90%. The carbohydrate content of all the soy-garri samples were significantly (p<0.05) lower than the control. The increase in the carbohydrate content of the control sample could be attributed to the high proportion of cassava mash used. The values (66.20 to 84.90%) obtained in this study were lower than the carbohydrate content (79.91 – 94.88%) of soybean – fortified garri and tapioca reported by Kolapo and Sanni [30]. The energy content of the samples ranged from 364.08 – 371.49KJ/100g. The control sample had the highest energy content (371.49KJ/100g), while the sample substituted with 50% soy bean flour had the lowest energy content (364.08 KJ/100g). The result obtained in this study is in agreement with the findings of Folake *et al.* [25] who reported the same decrease in the gross energy content of soy-enriched tapioca. The substitution of cassava mash with soybean flour greatly increased the protein, ash, crude fibre and fat contents of the soy-garri samples.

3.2 Mineral Composition of Soy- Garri Samples

The mineral composition of soy-garri samples are presented in Table 2. The calcium, potassium, phosphorus, magnesium, zinc and iron contents of the samples increased with increased substitution with soybean flour. The calcium content of the samples ranged from 1.16 to 14.32mg/100g. The control sample (100% cassava garri) had the least value (1.16mg/100g), while the sample substituted with 50% soybean flour had the highest calcium content (14.32mg/100g). The increase in calcium content observed in all the samples substituted with soybean flour at different graded levels could be attributed to increase in the addition of soybean flour in the products. The values obtained in this study (1.16 to 14.32mg/100g) were higher than the findings of Siulapwa and Mwambungu [11] who reported a decrease in the calcium content (0.21 – 1.81mg/100g) of tapioca fortified with soybean flour. Calcium in conjunction with magnesium is important for proper bone development [29]. The potassium content of the soy-garri samples which ranged from 3.35 to 18.71 mg/100g increased significantly ($p<0.05$) with increase in substitution with soybean flour in the products. The observed increase in the potassium content is an indication that soybean is a good source of potassium ([5].Potassium is very essential in blood clotting and muscle contraction in human body. The phosphorus content of the soy-garri samples varied from 1.17 -16.37mg/100g. The control sample had the least phosphorus content (1.17mg/100g), while the sample substituted with 50% soybean flour had the highest value (16.37mg/100g). The values obtained in this study (1.17-16.37mg/100g) were comparable to the phosphorus content (16.25-49.49mg/100g) of soy-melon garri reported by Oluwamukomi *et al*. [31]. Phosphorus is an important mineral element that plays a significant role in the formation of Adenosine Triphosphate (ATP) in the body [29]. The magnesium content of the soy-garri samples varied from 12.17 – 35.73mg/100g. The magnesium content increased significantly ($p<0.05$) with increased substitution of soybean flour in the samples. The observed increase in the magnesium content of the samples is an indication that soybean is a good source of magnesium [11]. This report is in agreement with the findings of Hassan and Sherif [32] for soybean enriched products. The zinc content of the soy-garri samples ranged from 1.25-12.62mg/100g. The sample substituted with 50% soybean flour had the highest zinc content (12.62mg/100g), while the control sample had the least zinc content (1.25mg/100g). The increase in zinc content of the sample could be attributed to the addition of high proportion of soybean flour in the product [33]. Zinc supports normal growth and development during pregnancy. The iron content of soy-garri samples varied significantly ($p<0.05$) from each other. The sample substituted with 50% soybean flour had the highest iron content (3.90mg/100g), while the control (100% cassava garri) had the least iron content (1.61mg/m). Iron is a component of myoglobin, a protein that provides oxygen to the muscle and supports metabolism in humans [34]. The substitution of cassava mash with soybean flour increased the mineral contents of the products.

3.3 Vitamin Composition of Soy-Garri Samples

The vitamin content of the soy-garri samples are presented in Table 3. The ascorbic acid, niacin, thiamine, riboflavin, tocopherol and vitamin A contents of the samples increased as the level of substitution with soybean flour increased. The thiamine content of the soy-garri samples varied from 0.01 to 1.67nmg/100g with the control and the sample substituted with 50% soybean flour having the least (0.01mg/100g) and highest (1.07mg/100g) values, respectively. The increase in thiamine content observed in all the substituted samples could be attributed to the addition of soybean flour in the products at different graded levels. Thiamine functions as a co-enzyme in energy metabolism and also helps in the treatment of beri-beri and maintenance of proper mental attitude [29]. The riboflavin content of the soy-garri samples increased with increased substitution of soybean flour in the products. The control sample had the lowest riboflavin content (0.03mg/100g), while the garri substituted with 50% soybean flour had the highest value (1.01mg/100g). Riboflavin is also necessary for growth and development [35]. The niacin content of the soy–garri samples varied significantly ($p<0.05$) from each other. The sample substituted with 50% soybean flour had the highest value (1.06mg/100g), while the control had the least niacin content(0.05mg/100g) The niacin content (0.05-1.06mg/100g) of the soy-garri samples reported in this study were lower than the niacin content (3.43-4.56mg/100g) of garri fortified with groundnut flour reported by Arisa *et al.* [6]. Niacin is responsible for tissue oxidation in the body. The ascorbic acid content of the soy-garri samples varied from 4.19 to 13.48mg/100g. The control sample had the least ascorbic acid content (4.19mg/100g), while the sample substituted with 50% soybean flour had the highest value (13.48mg/100g).The increase could be due to substitution effect. Ascorbic acid is very essential to health as it helps in the repair of tissues and healing of the wounds. It also helps in boosting of immunity in humans. The vitamin A content of the substituted samples increased significantly ($p<0.05$) with the addition of soybean flour. The control sample had the lowest vitamin A content (0.04mg/100g), while the sample substituted with 50% soybean flour had the highest vitamin A content (2.03mg/100g). The increase could be attributed to high level of soybean flour added to the sample.

Table 1. Chemical composition (%) of soy- garri samples

Samples	% Substitution CM : SF	Moisture	Ash	Crude fibre	Fat	Crude protein	Cyanide	Carbohydrate	Energy (KJ/100g)
A	100 : 0	7.19^{f} ±0.01	1.25^{f} ±0.02	1.65^{f} ±0.04	2.37^{f} ±0.00	2.64^{f} ±0.04	24.05^{a} ±0.04	84.90^{a} ±0.02	371.49^{a}±0.01
B	90 : 10	7.38^{e} ±0.01	1.68^{e} ± 0.01	1.83^{e} ±0.03	2.78^{e} ±0.04	4.53^{e} ±0.02	21.75^{b} ±0.00	81.80^{b} ±0.01	370.34^{b}±0.02
C	80 : 20	7.87^{d} ±0.06	1.87^{d} ±0.00	2.08d±0.01	3.24^{d} ±0.03	7.34^{d} ±0.01	18.08^{c} ±0.06	77.60^{c} ±0.03	368.92^{c}±0.08
D	70 : 30	8.24^{c} ±0.04	2.04^{c} ±0.06	2.24^{c} ±0.02	3.78^{c} ±0.05	10.78^{c} ±0.03	15.36^{d} ±0.11	72.92^{d} ±0.04	368.82^{d}±0.06
E	60 : 40	8.68^{b} ±0.02	2.38^{b} ±0.01	2.53^{b} ±0.01	4.08^{b} ±0.00	13.26^{b} ±0.05	12.66^{e} ±0.03	69.07^{e} ±0.02	366.05^{e}±0.00
F	50 : 50	8.92^{a} ±0.01	2.64^{a} ±0.02	2.82^{a} ±0.06	4.32^{a} ±0.02	15.10^{a} ±0.03	8.12^{f} ±0.03	66.20^{f} ±0.03	364.08^{f}±0.03

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05); CM – Cassava Mash, SF – Soybean Flour; A- Garri made with 100% cassava mash, B-Garri made with 90% cassava mash and 10% soybean flour, C- Garri made with 80% cassava mash and 20% soybean flour, D- Garri made with 70% cassava mash and 30% soybean flour, E- Garri made with 60% cassava mash and 40% soybean flour, F- Garri made with 50% cassava mash and 50% soybean flour.

Table 2. Mineral composition (mg/100g) of soy- garri samples

Samples	% Substitution CM : SF	Calcium	Potassium	Phosphorus	Magnesium	Zinc	Iron
A	100 : 0	1.16^{f} ±0.03	3.35^{f} ±0.18	1.17^{f} ±0.01	12.17^{f} ±0.02	1.25^{f} ±0.42	1.61^{f} ± 0.01
B	90 : 10	3.51^{e} ± 0.01	4.74^{e} ± 0.06	2.47^{e} ± 0.04	14.42^{e} ±0.03	2.20^{e} ± 0.03	1.92^{e} ± 0.11
C	80 : 20	3.67^{d} ±0.10	8.51^{d} ±0.13	6.49^{d} ±0.10	16.46^{d} ±0.02	4.18^{d} ±0.04	2.38^{d} ± 0.04
D	70 : 30	5.81^{c} ±0.01	12.77^{c} ± 0.10	9.47^{c} ±0.19	18.90^{c} ±0.03	7.34^{c} ±0.03	2.91^{c} ±0.02
E	60 : 40	9.83^{b} ± 0.01	17.17^{b} ±0.75	14.19^{b} ±0.04	22.62^{b} ±0.03	11.33^{b} ±0.11	3.51^{b} ±0.04
F	50 : 50	14.32a± 0.06	18.71^{a} ±0.75	16.37^{a} ±0.05	35.73^{a} ± 0.01	12.62^{a} ± 0.03	3.90^{a} ±0.07

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05); CM – Cassava Mash, SF – Soybean Flour; A- Garri made with 100% cassava mash, B-Garri made with 90% cassava mash and 10% soybean flour, C- Garri made with 80% cassava mash and 20% soybean flour, D- Garri made with 70% cassava mash and 30% soybean flour, E- Garri made with 60% cassava mash and 40% soybean flour, F- Garri made with 50% cassava mash and 50% soybean flour.

Table 3. Vitamin composition (mg/100g) soy- garri samples

Samples	%Substitution CM : SF	Thiamine	Riboflavin	Niacin	Ascorbic Acid	Vitamin A	Vitamin E
A	100 : 0	0.01^{f} ± 0.00	0.03^{f} ± 0.00	0.05^{f} ± 0.01	4.19^{f} ± 0.05	0.04^{f} ± 0.01	1.41^{f} ± 0.06
B	90 : 10	0.05^{e} ± 0.00	0.29^{e} ± 0.33	0.84^{e} ±0.02	5.71^{e} ±1.54	0.09^{e} ±0.00	2.71^{e} ±0.16
C	80 : 20	0.63^{d} ±0.01	0.44^{d} ±0.03	0.95^{d} ±0.42	8.48^{d} ±0.18	1.04^{d} ±0.01	3.65^{d} ±0.13
D	70 : 30	0.94^{c} ±0.06	0.52^{c} ±0.50	1.02^{c} ±0.00	10.95^{c} ±0.04	1.08^{c} ±0.00	4.11^{c} ±0.01
E	60 : 40	1.29^{b} ±0.05	0.66^{b} ±0.60	1.04^{b} ±0.00	12.67^{b} ±0.04	1.09^{b} ±0.00	6.79^{b} ±0.04
F	50 : 50	1.67^{a} ±0.07	1.01^{a} ±0.00	1.06^{a} ±0.00	13.48^{a} ±0.11	2.03^{a} ±0.00	8.41^{a} ±0.10

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05); CM – Cassava Mash, SF – Soybean Flour; A- Garri made with 100% cassava mash, B-Garri made with 90% cassava mash and 10% soybean flour, C- Garri made with 80% cassava mash and 20% soybean flour, D- Garri made with 70% cassava mash and 30% soybean flour, E- Garri made with 60% cassava mash and 40% soybean flour, F- Garri made with 50% cassava mash and 50% soybean flour.

The deficiency of vitamin A leads to blindness, failure of normal bone and tooth development in the young children. Also, diseases of the epithelial cells and membranes of the nose, throat and eyes can occur [29]. The vitamin E content of the soy-garri samples ranged from 1.41 to 8.41mg/100g with the control and the sample substituted with 50% soybean flour having the least and highest values, respectively. Vitamin E is a strong antioxidant which aids in the absorption of iron and the protection of cell walls [36]. The substitution of cassava mash with soybean flour drastically enhanced the vitamin contents of the samples.

3.4 Functional Properties of Soy-Garri Samples

The functional properties of soy-garri samples are presented in Table 4. The water absorption capacity of the soy-garri samples ranged from 29.00 to 149.07ml/g with the control sample (100% cassava garri) having the highest value (149.07ml/g), while the sample substituted with 50% soybean flour had the least value (29.00ml/g). The values (29.00-149.07ml/g) obtained in this study were higher than the water absorption capacity (11.00-42.82ml/g) reported by Oluwafemi and Udeh [37] for garri samples produced from cassava mash. The water absorption capacity is the ratio of the weight of water absorbed by a food material in saturated state to the weight of the dry material. The bulk density of the soy-garri samples ranged from 0.45 to 0.76g/ml with the sample substituted with 50% soybean flour having the highest value (0.76g/ml), while the control sample had the least value (0.45g/ml). The values (0.45-0.76g/ml) obtained in this study were similar to the values (0.48-0.75g/ml) reported by Bankole *et al.* [36] for garri fortified with bambara groundnut flour. The bulk density is influenced by factors such as dryness and particle size distribution of the sample. The bulk density of a good quality garri is usually 0.5g/ml [38]. High bulk density increases the rate of dispersion which is important in the reconstitution of garri with hot water to produce a stiff paste. Bulk density is also important in the determination of packaging requirement and material handling in the processing and preparation of food products [39]. The oil absorption capacity of the soy-garri samples increased significantly ($p<0.05$) with increase in substitution with soybean flour in the products. The sample substituted with 50% soybean flour had the highest value (5.25ml/g), while the control had the least value (1.66ml/g). The oil absorption capacity of a food product is important in monitoring the rate of spoilage as well as the ability of protein to bind fats. The swelling capacity of the soy-gari samples ranged from 4.30 to 7.50%. The control sample had the highest value (7.50%), while the sample substituted with 50% soybean flour had the least swelling capacity (4.30%). The swelling capacity of garri is influenced by the starch content and the degree of gelatinization of starch. The swelling capacity of garri depends on the temperature of water used in its reconstitution. The swelling capacity of a good quality garri should be at least 3.00% [40]. The gelation capacity of the samples ranged from 46.72 to 51.38% with the control and the sample substituted with 50% soybean flour having the highest (51.38%) and the least (46.72%) values, respectively. Starch gelatinization is a process of breaking down of the intermolecular bonds of the starch molecules in the presence of water and heat thereby, allowing the hydrogen bonding sites to engage more water [36]. The solubility index of the garri samples varied significantly ($p<0.05$) from 14.74 to 20.63%. The sample substituted with 50% soybean flour had the highest value (20.63%), while the control sample (100% cassava garri) had the least value (14.74%). The increase could be due to the inclusion of high amount of soybean flour in the sample. Enidiok *et al.* [41] reported that flexible protein molecules can rapidly reduce surface tension to give good solubility. Furthermore, legumes have high amount of surface active saponins which are also water soluble due to their high protein content and this may, therefore, influence the solubility index [42]. Generally, the result showed that the bulk density, oil absorption capacity and solubility index of soy-garri samples increased with increase in soybean flour substitution, while the swelling, water absorption and gelation capacities decreased drastically in the products.

3.5 Sensory Properties of Soy-Garri Samples

The sensory properties of soy-garri samples are presented in Table 5. The sensory scores of the products prepared from both the control and the substituted samples showed significant ($p<0.05$) differences in colour, taste, aroma, texture and overall acceptability. The control sample was scored highest by the judges in all the sensory attributes evaluated compared to all the test samples. The garri made from 100% cassava mash (control) and those prepared from the samples substituted with 10-50% soybean flour

Table 4. Functional properties of soy- garri samples

Samples	%Substitution CM : SF	Bulk density (g/ml)	Swelling capacity (%)	Water Absorption Capacity (ml/g)	Oil Absorption Capacity (ml/g)	Gelation Capacity (%)	Solubility Index (%)
A	100 : 0	0.45^{f}± 0.00	7.50^{a} ± 0.11	149.07^{f}± 1.14	1.66^{f} ± 0.06	51.38^{a} ± 0.17	14.47^{f} ± 0.20
B	90 : 10	0.52^{e}± 0.00	6.90^{b}±0.03	117.06^{b}± 1.36	1.89^{e} ± 0.01	51.19^{b} ± 0.13	15.69^{e} ± 0.38
C	80 : 20	0.58^{d}±0.00	6.18^{c}± 0.03	102.27^{c} ± 0.21	2.48^{d} ± 0.03	50.14^{c} ± 0.06	16.39^{d} ± 0.13
D	70 : 30	0.64^{c}± 0.00	5.17^{d}± 0.02	88.43^{d}± 0.66	3.40^{c} ± 0.03	48.52^{d} ± 1.02	17.82^{c} ± 0.08
E	60 : 40	0.70^{b}± 0.00	4.52^{e}± 0.11	61.82^{e} ± 1.39	4.29^{b} ± 0.01	47.51^{e} ± 0.59	18.42^{b} ± 0.19
F	50 : 50	0.76^{a}± 0.00	4.30^{f}± 0.11	29.00^{a} ±1.32	5.25^{a} ± 0.69	46.72^{f} ± 1.43	20.63^{a} ±0.41

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05); CM – Cassava Mash, SF – Soybean Flour; A- Garri made with 100% cassava mash, B- Garri made with 90% cassava mash and 10% soybean flour, C- Garri made with 80% cassava mash and 20% soybean flour, D- Garri made with 70% cassava mash and 30% soybean flour, E- Garri made with 60% cassava mash and 40% soybean flour, F- Garri made with 50% cassava mash and 50% soybean flour.

Table 5. Sensory properties of soy- garri samples

Samples	% Substitution CM : SF	Colour	Taste	Aroma	Texture	Overall Acceptability
A	100 : 0	8.00^{a} ± 1.48	8.05^{a} ± 1.10	8.75^{a} ± 1.22	8.95^{a}± 1.46	8.90^{a} ± 1.41
B	90 : 10	7.90^{b} ± 1.19	7.15^{b} ± 1.32	7.70^{b}±1.10	7.85^{b} ±1.49	7.75^{b} ±1.54
C	80 : 20	6.80^{c} ±1.14	6.80^{c} ±1.18	7.40^{c} ±1.41	6.70^{c} ±1.31	5.75^{b}±1.27
D	70 : 30	5.70^{d} ±1.13	6.60^{d} ±0.10	6.30^{d}±1.13	5.60^{d} ±1.23	5.70^{c} ±1.16
E	60 : 40	5.60e ±1.21	5.20^{e} ±1.28	6.15^{e} ±1.12	4.55^{e} ±1.14	4.45^{d} ±1.41
F	50 : 50	4.45^{f} ±1.44	5.05^{f} ±1.31	6.00^{f} ±1.31	3.40^{f} ±1.47	4.40^{e} ±1.34

Values are mean ± standard deviation of twenty (20) semi-trained judges. Means in the same column with different superscripts are significantly different (p< 0.05); CM – Cassava Mash, SF – Soybean Flour; A- Garri made with 100% cassava mash, B- Garri made with 90% cassava mash and 10% soybean flour, C- Garri made with 80% cassava mash and 20% soybean flour, D- Garri made with 70% cassava mash and 30% soybean flour, E- Garri made with 60% cassava mash and 40% soybean flour, F- Garri made with 50% cassava mash and 50% soybean flour.

were generally acceptable. The increase in substitution of soybean flour resulted in decrease in acceptability of the products as indicated by the significantly ($p<0.05$) low values for the sample substituted with 50% soybean flour. The change in colour observed, could be due to increased substitution of the soybean flour in the samples. Colour appeared to be a very important criterion for the initial acceptability of the food product by the consumer. The garri samples containing 50% soybean flour were also reported to have crumbly texture due to increased substitution with soybean flour. The result of the sensory evaluation showed that the substitution of garri with soybean flour had significant effect on the sensory attributes of the samples. The panelists showed more preference to the control sample (100% cassava garri) than the substituted samples. Therefore, the substitution of cassava mash with 10-20% soybean flour could be used to produce organoleptically acceptable soy-garri samples.

4. CONCLUSION

The study showed that garri of good nutrient contents, functional and sensory qualities could be produced by the addition of soybean flour to the cassava mash. The garri samples substituted with soybean flour at different graded levels were relatively high in protein, fat, ash and crude fibre contents compared to the control sample (100% cassava garri). It was also observed from the result that the substitution of cassava mash with soybean flour in the preparation of soy-garri samples greatly increased the calcium, potassium, phosphorus, magnesium, zinc and iron contents of the products. The levels of thiamine, riboflavin, niacin, ascorbic acid and vitamin A were also found to increase with increased substitution of soybean flour in the samples. The functional properties of the samples also showed that the bulk density, oil absorption capacity and solubility index of the samples increased with increased substitution of soybean flour, while their swelling, water absorption and gelation capacities decreased drastically. The decrease could be attributed to the high levels of fat and protein in soybean flour which affected these parameters in the substituted samples. The sensory properties of the samples revealed that the control sample (100% cassava garri) was the most acceptable to the panelists and also differed significantly ($p<0.05$) in colour, texture, taste and aroma from the substituted samples. Although, the control sample was organoleptically more acceptable compared to the substituted samples, it was lowest in nutrient contents than the substituted samples. However, the addition of soybean flour to cassava mash in the production of garri could be used to improve the nutrient contents and some functional properties of soy-garri samples.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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