Proximate, Physico-Chemical and Sensory Properties of Soy-Enriched Gari Samples

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ABSTRACT: *This study was aimed at evaluating the effect of soy (curd and residue) enrichment on chemical, physicochemical properties and consumer acceptability of gari. The soy (curd and residue) enriched gari was prepared from matured cassava tubers and soybean. Gari with 10% enrichment and control samples were evaluated for proximate composition and physico-chemical properties. Reconstituted thick paste "Eba" prepared from all the samples were evaluated for consumer acceptability. The proximate composition of gari samples ranged from 2.06 - 15.24% (crude protein), 1.66 - 11.02% (crude fat), 1.67 to 3.06% (total ash) while the carbohydrate decreased from 89.01 to 75.43% with enrichment. The packed bulk density (PBD), wettability (W) and water absorption capacity (WAC) increased with enrichment while swelling capacity (WC) and oil absorption capacity (OAC) decreased with enrichment. While the pH and average particle size increase with enrichment, the titratable acidity, decreased. Though higher sensory acceptability was obtained for the control sample, this study showed the possibility of enriching "gari" with soy curd or residue.*

KEY WORDS: Gari; soy curd; soy residue; soy-enriched gari; eba

INTRODUCTION

Nigeria is faced with the problem of malnutrition due to deficiency of protein and calories. The protein-calories sources of vegetable origin have been proposed as a solution to this problem. In Nigeria and many African countries, Cassava (*Manihot esculenta*, Crantz) is used as an inexpensive source of calories (Ogori *et al*., 2020). Cassava is a popular tuber in many countries of the world due to its high adaptability to several environmental conditions (Oluwamukomi and Adeyemi, 2015). However, being a high carbohydrate and very low protein (Adesina & Bolaji, 2013; Ogori et al., 2020) content food items, it is mostly regarded by many as food for the poor. Several products have been developed from cassava all over the countries where it is grown. It is a staple food for more than half of the Nigerian population. It is processed into various products that are useful as human and animal foods including *gari, fufu, tapioca, lafun, pupuru,* chips etc (Ogunnaike *et al*. 2015; Olarewaju and idowu, 2017). Gari, a toasted and fermented cassava product, is the most popular cassava product consumed in West Africa and the most important item in the diet of millions of Nigerians (Kordylas, 1990). It forms a

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significant part of the diet in many countries such as Ghana, Cameroun, Zaire and Brazil where it is called “farinha de manioc”.

Although cassava is high in linamarin (Vasconcelos, 1990), about 83% of the total cyanogenic glucoside (linamarin and lotaustralin) are detoxified during processing of the tuber into gari and 98% of the cyanide is lost when gari is made into “eba”, a hot water reconstituted paste (Oluwamukomi and Adeyemi, 2015). Moreover, cassava and its products are low in protein, deficient in essential amino acids and therefore have very low protein content. Thus, continuous dependence on gari without supplementation with meat, fish and other protein- rich sources would result in protein deficiency. However, because of the high cost of animal protein, the majority of the population cannot afford such supplementation (Aletor, 1993a). Supplementary protein sources must therefore be provided if cassava is to maintain its role as a major source of calories. Many attempts have been made to enrich gari products with proteins from different vegetable sources in order to alleviate this problem (Oluwamukomi and Adeyemi, 2015; IITA, 1990 and Sanni and Sobamiwa, 1994) but the use of soy supplement (curd and residue) has not been exploited.

Soy (curd and residue) being one of the world’s most important plant protein, offers good source of edible oil and nutrients for humans. It is extensively used in baked and confectionary products and it is also a valuable feed for farm animals (Mukhopadhyay and Ray, 1999). With the high level of unsaturated fatty acid (83%), it is believed to have reducing effect on coronary heart disease (Sirato-Yasumoto *et al.,* 2001); with high level of methionine and tryptophan, it is an excellent protein complement to other plant proteins. Since the unit cost of soy protein supplement (curd and residue) is relatively cheaper compared to other vegetables and animal proteins, it may be an inexpensive high quality protein source in food fortification and enrichment programmes. Therefore, the objectives of this study was to enrich *“gari”* with soy curd or residue and evaluate the impact of the enrichment on the proximate, physicochemical, functional as well as the quality acceptability of the dough meal.

MATERIALS AND METHODS

Sources of raw materials

Cassava roots (*Manihot esculenta* crantz) were obtained from the Teaching and Research farm of the Federal University of Technology, Akure, Nigeria. Soybean (*Glycine max* -TGX) was purchased from Michael Okpara University of Agriculture, Umudike, Nigeria.

Extraction of soy curd and residue

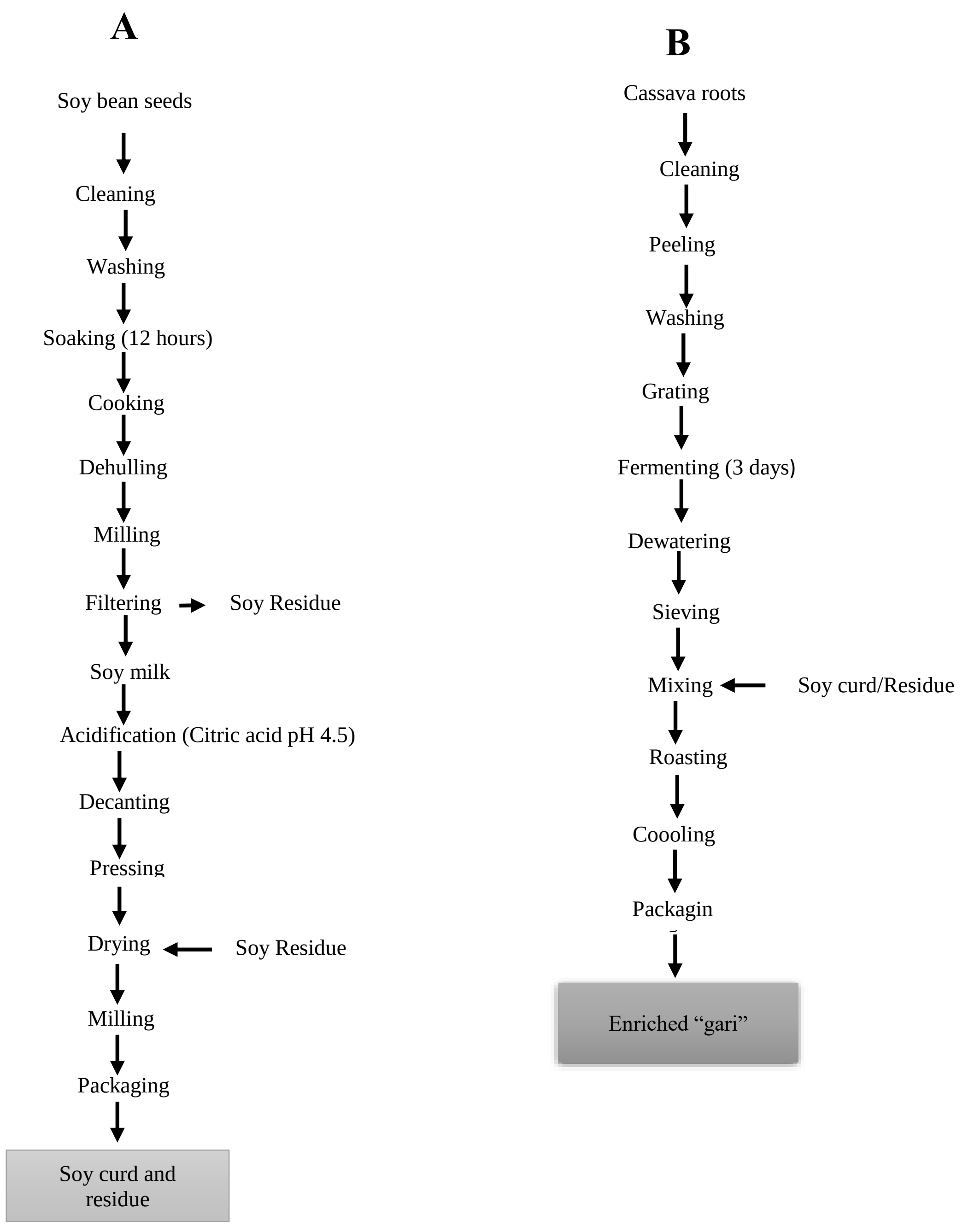
Soy bean seed (150 g) were sorted, cleaned, soaked (12 h) in 2 L of tap water containing 0.5 g $NaHC0_3$ in a cooking pot and boiled for 25 min. The boiled and dehulled soybean seeds were then wet milled in a hammer mill. Water was added in ratio 1:8 and a muslin cloth was used to extract the milk (pH 6.40) and the residue was kept separate. Thereafter, the pH of the extracted milk was adjusted to 4.6 by adding 1 M citric acid. The soy milk was allowed to stand and the clear whey at the upper part was decanted while the lower part (curd) was collected after six hours. The curd and residue was oven dried 60^{o}C, 24 h), milled, packaged in high density polyethylene HDPE and stored in the refrigerator until needed for further use. Figure 1A shows the production chart for the curd and residue.

Production and enrichment of "gari"

Production of unfortified gari was produced essentially as described (Hahn, 1989; Odunfa, 1998). Fresh roots were manually peeled using a knife (as practiced traditionally), washed twice in water to remove dirts 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). Then, the fine pulp was divided into two portions (Figure 1B) before frying. One portion was used as control (GIC) while the other portion was enriched with either dry soy curd or residue using Pearson scale with 10% enrichment during roasting in an iron pan over a fire. Sample supplemented with curd was named *"gari"* enriched with curd" (GMC) and the other sample *"gari"* enriched with residue" (GMR). A commercial "gari" sample (GEC) was obtained from FIIRO Oshodi, Lagos for comparism.

Proximate analysis:

Moisture content, protein, crude fat, crude fibre, total ash of gari samples, and their blends were determined using the AOAC (2000) methods. Carbohydrate content was calculated by difference.



Sources: Osuji and Anyaiwe (2010)

Figure 1: Production of soy supplement (curd and residue) (A) and enriched "gari" samples (B)

Functional properties
The pack bulk density, loose bulk density and wettability were determined using the method of Nwanekezi et al. (2001). Swelling capacity for the samples was determined according to the method adopted by Sanni et al. (2001). Reconstitution index, oil absorption capacity and water absorption capacity were determined according to the procedure described by Iwuoha (2004) respectively.

Physico-chemical properties
Determination of total titratable acidity.
For the determination of titratable acidity, 10 g of sample was weighed and crushed with 105 ml water (40°C) in porcelain mortar. This solution was filtered and 25 ml of filtered solution was used for titration. Three drops of phenolphthalein were added and titrated with 0.1N NaOH until the first permanent pink color (Hayaloglu et al., 2008).

$$Percentage\ of\ \text{lactic acid} = \frac{(\text{0.1N NaOH amount (ml) x 0.009 x 100})}{Weight\ of\ sample\ (W_1)}\ x\ 100$$

Determination of pH
The pH of "gari" samples were measured using pH meter (model 7020 Electroc Ltd, England) after standardization with pH 4 and buffer (BDH, England). The slurry of "gari" was obtained by dipping the electrode into a reconstituted dried "gari" samples in a beaker with temperature ranging between 20 - 25°C after pH meter calibration.

Sensory evaluation
Soy enriched gari and control samples were reconstituted into 'eba' with boiling water in ratios 1:2.2 (w/v) using the method of Oluwamukomi *et al.* (2005). The reconstituted 'eba' samples were evaluated in terms of colour, flavour, taste and overall acceptability by a untrained panellist of ten people who were already used to the consumption of gari in form of 'eba'. The parameters were scored on a 9-point Hedonic scale ranging from 1= disliked extremely to 9= liked extremely (Oboh and Akindahunsi, 2003).

Statistical analysis
Data were subjected to analysis of variance (ANOVA) and the means were separated using Duncan Multiple Range Test at ($P \leq 0.05$) using Statistical Package for Social Scientists (SPSS) version 17.

RESULTS AND DISCUSSION

Proximate Composition of Gari Samples
Table 1 shows the results of the proximate composition of the soy enriched and control gari samples. All the samples showed considerably low moisture content which ranged from 4.17 (GMR) to 6.32% (GEC). The moisture content agrees with the work of Ukpabi and Ndimele (1990). This suggests that the enriched gari can keep for a reasonable length of time when stored in packaging materials that have low moisture permeability and low relative humidity

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since gari with its low moisture content could be hygroscopic. Supplementation with residue slight increased the fat content of the samples (3.63%) compared to fat content of control gari (1.66%). In contrast, enrichment with the curd significantly increased the fat content to 11%. The fat contents in this study are higher than 0.1% previously reported by Oyetoro *et al.* (2007). Likewise, enrichment with both curd and residue increased the crude protein content considerably. While the addition of the residue led to over five times increase (548%), the curd produced seven times increment (726%). The improvements in crude protein content are very significant when compared to 2.10% obtained for the control sample or lower values (0.7-1.2%) reported in previous study (Oluwamukomi *et al.*, 2005). The crude fibre of the samples was high. Nigerian Industrial Standard, NIS (1988) recommended that gari should have crude fibre of less than 2.0%. However, the samples had crude fibre values ranging from 2.88 to 5.88% for gari from GMC and GIC respectively. Ukpabi and Ndimele (1990) found that market gari had a crude fibre range of 0.5 to 3.0%. The increased fibre content could be attributed to the improved varieties of cassava used.

Table 1: Proximate Composition of Gari Supplemented with Soy Curd and Residue (%)

Sample	Moisture	Protein	Crude Fibre	Crude Fat	T total Ash	Carbohydrate	Energy (MJ/g)
GIC	6.14 ± 0.00^a	2.06 ± 0.02^d	5.88 ± 0.13^a	1.66 ± 0.11^e	1.74 ± 0.01^d	88.66 ± 0.29^a	356.74 ± 0.54^c
GEC	6.32 ± 0.02^a	2.10 ± 0.03^d	5.53 ± 0.00^a	1.69 ± 0.01^e	1.67 ± 0.00^d	89.01 ± 0.37^a	351.40 ± 1.96^c
GMC	5.49 ± 0.02^a	15.24 ± 0.79^b	2.88 ± 0.13^c	11.02 ± 0.81^c	2.60 ± 0.01^c	77.43 ± 0.25^b	414.17 ± 0.31^b
GMR	4.17 ± 0.51^b	11.52 ± 0.00^c	3.63 ± 0.13^b	3.21 ± 0.20^d	3.06 ± 0.02^b	78.58 ± 1.59^b	359.13 ± 0.78^c

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p<0.05$) KEY: GIC = Control sample, GEC= commercial sample GMC, = “gari” enriched with 10% curd, GMR= “gari” enriched with 10% residue.

Functional properties of gari samples

The functional properties of the samples were determined to evaluate its usage in product development. The packed bulk density (Table 2) ranged from 0.63 to 0.72g/cm^3. The bulk density values of the enriched samples were higher when compared with the gari without enrichment. The higher values observed in the enriched gari samples suggest that they were heavier and with larger particle size. The bulk density is generally affected by the particle size, density of flour or flour blends which is very important in determining the packaging requirement, raw material handling and application in the food industry (Adebowale *et al.*, 2008, Ajanaku *et al.*, 2012). The water absorption capacity is a term, which describes the ability of the flour to absorb or take in water during processing.

The enriched gari samples exhibited a significant higher water absorption capacity 5.00 g/cm^3 when compared with the control sample 2.00 g/cm^3. No significant difference was observed in the water absorption capacity of enriched gari. Water absorption capacity improves yield, consistency and give body to food. These higher values of water absorption capacity can be attributed to loose structure of starch polymers while lower value indicates the compactness of the structure (Adebowale *et al*., 2005; Oladipo and Nwokocha, 2011). The ability of flour materials to absorb water is sometimes attributed to their protein content thus; the observed water absorption capacity of the enriched samples could therefore be attributed to their protein content as provided by the soybean flour. The water absorption capacity of enriched samples is comparatively similar to that for reported African yam bean flour 5.45-6.38 g/cm^3 (Padilla *et al*., 1996) but lower than 118-179% observed by Oshadi *et al*. (1997) for lima bean flours and 130-140% for lima beans (Adeyeye and Aye, 2005)

Table 2: Functional properties of gari enriched with soy curd and residue

Samples	**Packed Bulk Density** g/cm^3	**Water Absorption Capacity** g/cm^3	**Swelling Capacity** g/cm^3	**Reconstitution Index (** ml)	**Wettability** (mins)	**Oil Absorption Capacity** (g/cm^3)
GIC	0.63±0.00^{cd}	2.00±0.00^{d}	4.67±0.05^{a}	4.40±0.00^{a}	39.33±1.53^{c}	1.83±0.00^{a}
GEC	0.66±0.00^{c}	3.17±0.00$_{c}$	4.58±0.00^{a}	4.38±0.05^{a}	39.33±1.53^{c}	1.81±0.00^{a}
GMC	0.71±0.00^{a}	5.89±0.00^{a}	3.05±0.00^{c}	3.25±0.05^{c}	97.00±4.00^{a}	0.93±0.00^{c}
GMR	0.72±0.00^{b}	5.00±0.00^{b}	3.49±0.00^{b}	3.40±0.00^{b}	76.00±6.00^{b}	1.00±0.00^{b}

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p<0.05$) KEY: GIC = Control sample, GEC= commercial sample GMC, = "gari" enriched with 10% curd, GMR= "gari" enriched with 10% residue.

High value of water absorption capacity is an indication of flour usefulness and impact on food structure (Olaofe *et al*., 1998). Swelling capacity provides information on the nature of the associative forces within starch granules (Ogunmola *et al*., 2001). Enrichment of gari with soy supplement (curd and residue) significantly reduced the swelling capacity of the products. Adebowale *et al*. (2012) reported that the presence of substances such as lipids or phosphate groups can lower the swelling capacity and solubility of starch. It also agreed with the findings of Oluwamukomi *et al*. (2005) and Oluwamukomi *et al*. (2007) that the presence of lipids affects the swelling capacity of gari. In another study by Prinyawiwatkul *et al*. (1994), reduced swelling capacity was attributed to high fat content, which might have reduced the ability of the mixture of wheat and peanut flours to bind water. Cheftel *et al*. (1985) also attributed this phenomenon to the presence of lipids in the soy-melon supplement, which must have reduced the swelling capacity of the gari granules.

There was significant difference (P≤0.05) in wettability between the enriched gari with soy curd, soy residue and control samples which ranged from 97.00 to 76.00 mins and 39.33 mins, respectively. The result showed that enriched samples took longer period to sink in water. This may be due to the effect of the soy supplement which must have changed the physical and chemical compositions of the gari and made it less susceptible to imbibe water, hence the wettability is impaired and reduced drastically (Oluwamukomi *et al*., 2007). This result is in agreement with the previous findings of 27-35 mins reported for *Discorea alata* yam flour (Udensi *et al*., 1988) and 42.5mins reported for *Discorea rotundata* yam (Udensi and Okaka, 2000).

Oil absorption capacity of gari samples values ranged from 0.0.93 to 1.83g/cm^3. The highest oil absorption capacity for gari samples was observed in the control sample 1.83 g/cm^3 and did not differ significantly with the commercial sample 1.81g/cm^3 which might be due to their similar composition. These results showed that the oil absorption capacity of gari samples decreased with enrichment. The oil absorption capacity is influenced by the lipophilic nature of the granular surface and interior which affect the functional properties of starches (Babu and Parimalavalli, 2012). The reconstitution index decreased with enrichment from 4.40 to 3.25ml. The lower value obtained for the enriched samples (3.25-3.40ml), could be due to the higher concentration of oil in the soy supplement. This behavior is similar to that of swelling index which was also found to decrease with enrichment (Oluwamukomi *et al.*, 2013). It has been shown that the presence of lipids acted as a buffer thus lowering the swelling power of starch granules (Almazan, 1992).

pH and total titratable acidity of gari samples

Table 3 shows the physico-chemical – total titratable acidity (TTA), pH and average particle size of *"gari"* samples. Significant difference (p≤0.05) was observed between the enriched and control samples. The titratable acidity (TTA) correspondingly decreased from 0.90 (GIC) to 0.60% (GMC) while the pH values ranged between 3.73 (GIC) and 4.17 (GMC). Expectedly, partial supplementation with soy curd and residue reduced the acidity of the product.

Table 3: Physico-chemical properties of enriched "Gari" and control sample

Samples	TTA (%)	P H	Average Particle Size (mm)
GIC	0.90 ± 0.00^b	3.73 ± 0.15^b	0.35 ± 0.01^b
GEC	0.98 ± 0.05^a	3.93 ± 0.15^b	0.32 ± 0.02^b
GEC	0.60 ± 0.45^c	4.17 ± 0.06^a	0.46 ± 0.01^a
GER	0.65 ± 0.05^c	4.15 ± 0.10^a	0.41 ± 0.02^a

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different (p<0.05) KEY: GIC = Control sample, GEC= commercial sample GMC, = "gari" enriched with 10% curd, GMR= "gari" enriched with 10% residue.

However, this may have quality implications especially regarding taste and aroma because

Consumers are already familiar with the acidic parameters thereby resulting in reduced acceptability. The obtained values are however within the recommended range (3.50-4.5) for acid-fermented products (Oluwamukomi *et al*., 2005). The values are also comparable to previous result reported for *'gari'* from different cultivars (Oyewole & Afolami, 2001).

In contrast, the TTA values were indirectly correlated with the pH values with the enriched samples having higher TTA values (4.15 and 4.17) when compared to control and commercial samples (3.73 and 3.93). These values are within the previous 0.6–1.2 reported for cassava products (Ogori et al., 2020; Ogunnaike et al., 2015; Taiwo et al., 2016) but considerably lower than those earlier reported 6.4-6.9 (Oyewole & Afolami, 2001). The values are also in agreement with Nigerian Industrial Standard (NIS, 2004) who recommended less than 1.00% TTA for cassava products. A range of 0.77 and 1.62% TTA were also reported by (Ray & Sivakumar, 2009). The acidity of cassava products has been attributed to the activity lactic acid bacteria during fermentation of cassava root (Oyewole & Afolami, 2001).

Particle-size distributions of all the samples are as shown and summarized (Table 3). Control and commercial 'gari' samples had a greater proportion of small or finer particles 0.35 (GIC) and 0.32 mm (GEC) than the soy enriched samples with particle sizes ranging from 0.41 (GER) to 0.46 mm (GEC) and this might be because of adhesion.

Sensory qualities of enriched "lafun" and control Samples

Sensory evaluation is an important aspect in new product development. It is often used to measure the relative comparison and acceptability of the new product to other existing alternatives or substitutes Oluwamukomi *et al*. (2013). Untrained panellists were used to evaluate different attributes and overall acceptability of "gari" and the enriched samples. "Gari" enriched with soy curd and residue was light brown in appearance (Table 4) with the ratings ranging between 7.30 (GMR) and 7.90 (GMC) and were significantly different ($p \le 0.05$) from the commercial (GEC,8.53) and control (GIC,8.95) samples. The control and commercial samples were rated better virtually in all the sensory qualities evaluated (appearance, taste, aroma, texture and overall acceptability) except for the texture attribute where the enriched samples were rated better. Ratings on visual appearance demonstrated that enrichment of "gari" with soy supplement affected the colour.

Since application of heat had been reported to affect the colour of food products (Blanca *et al*., 2009), light brown coloration observed in the enriched samples may be attributed to browning reaction. Evaluation of sensory qualities of a food item is a subjective measurement and is often affected by the panellist bias. Panellists often rate food items that they are already familiar with and have accepted in terms of taste, appearance, texture, aroma better than a new food product regardless of improved nutritional benefits the new product may offer (Oboh and Akindahunsi, 2003).

Table 4: Sensory Analysis of Gari Samples

Samples	Appearance	Taste	Aroma	Texture	Overall Acceptability
GIC	8.95±1.15[a]	8.95±1.43[a]	9.30±1.38[a]	6.55±1.36[b]	9.69±1.31[a]
GEC	8.53±1.12[a]	8.00±1.15[b]	8.05±1.27[a]	6.68±1.00[b]	8.32±0.93[b]
GMC	7.90±1.07[b]	7.85±1.31[b]	7.65±1.09[b]	8.35±1.39[a]	6.69±1.32[c]
GMR	7.30±1.72[c]	6.45±2.01[c]	7.10±1.57[c]	8.25±1.52[a]	6.03±1.54[d]

Data represent mean ± standard deviation of three replicates, values with different superscripts along the same column are significantly different ($p<0.05$) KEY: GIC = Control sample, GEC= commercial sample GMC, = "gari" enriched with 10% curd, GMR= "gari" enriched with 10% residue.

Previous studies comparing new food product with existing one have also reported similar trends of lower rating when compared with the previously existing ones. For instance, the higher ratings obtained for the control samples may be attributed to the organic acid produced by microorganisms during fermentation process which was totally diluted with supplement (Oboh and Akindahunsi, 2003). There was also a lower rating in aroma for the enriched samples since the panellists are already familiar with acidic aroma. When the prepared "gari" samples were finger-tested, the texture of the enriched was stronger, fluffier and slightly less cohesive than the control samples which was soft and highly elastic in nature. Observation showed that "gari" samples were smooth and not sticky to the hand. Consumers had described good gari texture as one that does not stick to their hands (Oluwamukomi & Adeyemi, 2013). The preference of control "gari" to the enriched was as result of the consumers being used to "gari" without enrichment. However, the values obtained for the enriched samples showed that the enriched "gari" could gain acceptability among consumers of the product and the feasibility of incorporating soy in "gari".

CONCLUSION

Enrichment of gari with soy curd and residue at 10% resulted in notable increase in protein content, which could be nutritionally advantageous to the consumers since gari is the main staple for many people. Some of the functional properties of the enriched gari obtained could be an advantage in industrial uses, such as the bulk density and water holding capacity. Therefore, supplementing gari with soy curd and residue at 10% will improve its nutritional qualities and it is also assumed that acceptability will improve as consumers become aware of its enhanced nutritional benefits.

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