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Optimization Of Nutritional, Anti-Nutritional And Anti-Oxidant Properties Of Soy-Millet-Fortified "Garri" Flours And Sensory Attributes Of Their Dumplings

Research Article

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Abstract

This study evaluated some nutritional, anti-nutritional and anti-oxidant properties of "garri" fortified with soy and millet flours for preparation of functional dough meal. Blends of flours were optimized for protein (10-20%) and fibre(3-5%), using Design Expert Version 6.0.8. and variables "garri"(56-65%), soy-cake(13-24%) and whole millet (11-22%) flours, which generated 14 blends. 100% "garri" and three blends with highest protein and fibre contents were evaluated for proximate compositions, amino acid profiles, and protein quality, bioavailability of selected minerals and anti-oxidant potentials. Protein and fibre contents of blends increased (15.80-16.27% and 4.14-4.27%) as proportions of soy cake and millet flours increased, compared to 100% "garri" (2.11% and 2.08%) respectively. There was significant difference ($p<0.05$) between blends and 100% "garri" for bioavailability of calcium, iron and zinc, but no significant difference among blends ($p>0.05$), with values within safe standards. Amino acid profiles and protein quality indices increased significantly ($p<0.05$) in blends, with total amino acids and essential amino acid index of 65.51-70g/100gprotein and 46.55-58.68% in blends compared to 14.26g/100g protein and 14.25% respectively for 100% "garri". Sample GSM-1 had highest amino acid and protein quality values and produced the highest anti-oxidant potential. 100% "garri" produced dough meal with highest acceptability ratings, for all sensory parameters compared to blends which, however, also produced dough meal with high acceptability ratings, with sample GSM-1 having highest mean scores for most sensory parameters. Addition of soy-cake and millet flours to "garri" produced blends with improved nutritional status, high anti-oxidant potentials and dumplings of high consumer acceptability.

Keywords: Anti-Nutrients; Anti-Oxidant; Dumplings; Fortified 'garri"; Nutritional Properties; Optimization; Sensory Attributes.

Introduction

There exists close relationship between nutrition, health and national development have been established. Proper and adequate nutrition is a sine qua non to good health, while national development is hinged on the general well-being of the populace and absence or low prevalence of diseases. The prevalence of degenerative diseases like diabetes, obesity, arthritis, rheumatism, high blood pressure and cardio-vascular ailments in different parts of the world, especially in developing countries including Nigeria, is becoming alarming [1-3]. These diseases have considerable negative effects on the general well-being of the populace and consequently their ability to contribute to the overall development of their communities. Expensive synthetic drugs, which are often out of the reach of many people, are commonly used for the management of these diseases, but have been credited with serious adverse effects on their users after long time use, while it is believed that these drugs only treat the symptoms of these ailments and not their causes. It has therefore become necessary to explore alternative therapies for the control and management of the causes of these diseases to replace synthetic drugs. The use of indigenous plant foods for the management and control of degenerative diseases have been acknowledged, while many previous studies have shown that blends of indigenous plant-based materials have potentials for effective control and reduction of the prevalence of some of these diseases [4-6 etc.]. There is the need to explore the potentials of other commonly consumed indigenous staples in this regard. Cassava (Manihot esculenta

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Crantz), a root tuber, Soy bean (Glycine max Merril L.) (a legume or oil seed) and Pearl millet (Pennisetum glaucum), (a cereal grain) are important plant food crops used as food, feed and industrial raw materials in different regions of the world, including Africa, especially Nigeria [7-9, etc.].

Nigeria is ranked the world's largest producer of cassava of over 60 million tons in 2017, which constitutes almost 20% of total world production, and also produces large amounts of both soy beans and millet. One of the most common products of cassava is "garri", a toasted pre-gelatinized, granular flour, made from fermented grated cassava mash or pulp [10, 11], and eaten majorly in form of a dough meal, or "swallow", called "Eba", using different types of soups depending on the area [12]. However, like other products of cassava, "garri" consists mainly of carbohydrate, and completely lacking in major important nutrients like protein, fat, vitamins and minerals, as well as fibre [13, 14]. Soy beans is a cheap source of protein and its use in the improvement of protein of cereal-based diets, both quantitatively and qualitatively has been previously acknowledged by many studies [4, 5, 15, 16]. The role of diets high in soybean in reducing blood glucose concentration and prevalence of common degenerative diseases like diabetes, atherosclerosis, cancer and heart-related ailments has been previously reported [17-19]. Pearl millet (Pennisetumglaucum), like other millet varieties, contains essential nutrients like amino acids, vitamins such as thiamine, niacin, and riboflavin, and minerals, including calcium, iron and phosphorus as well as dietary fibre [8, 20]. The high dietary fibre content in pearl millet (8% to 9%) has been reported to improve bowl movement, and prevent heart disease and colon cancer, as well reduced blood glucose concentration, which makes it an appropriate diet for diabetic patients [21]. Combining soybean and millet flours with "garri" will therefore not only improve the nutritional status of the resulting composite flour, but also most likely result in a product with potential functional properties that may be used for the management of common degenerative ailments. This was the objective of this study.

Materials And Methods

Materials and sources

The materials used for this study were white "garri", soy (*Glycine max Merril, L.*) cake and pearl millet (*Pennisetum glaucum*)." Garri" and pearl millet were purchased from Oyingbo Retail Market on Lagos Mainland, Lagos, while soya cake was obtained from Agro Allied Nig. Ltd., Ibadan, Nigeria.

Preparation of samples

Soy cake flour was produced by cleaning the soy cake to remove dirt and drying in a cabinet dryer (Carlisle CA2 5DU, Mitchel Dryers Ltd, England, 3695-010) at 62 ± 1.5°C for 6hrs. The cleaned soy cake and 'garri" were separately milled in a grinding hammer mill (Type S/03 7.5HP, Petrel Limited, Birmingham England, 2121A), and sieved using a Test Sieve Shaker ((Endecotts, England). Materials which passed through sieve of mesh size 212µm were collected. Whole pearl millet flour was produced using a modified method of [22], by cleaning to remove dirt and damaged grains followed by milling, without sieving. The three flours were packaged in a high-density polyethylene bag and stored in a cool (25-27°C), moisture-free environment until used. Flour blends were prepared using D-Optimal model of Mixture Design of Design Expert Version 6.0.8., based on the optimization of protein from soy cake flour and fibre from whole millet flour, using variables "garri" flour (56-65%), soy cake flour (13-24%) and whole millet flour (11-22%), which targeted protein and fibre contents of 10-20% and 3-5%, respectively in the final product. The 14 blends generated were evaluated for protein and fibre contents and three blends with the highest protein and fibre contents were selected and for further studies, along with 100% "garri" flour.

Determination of protein and fibre contents of blends and proximate compositions of selected samples

Protein and fibre contents of blends generated by Design Expert and proximate composition of selected blends and 100% "garri" flour were determined using standard [23]. Carbohydrate content was obtained by difference and results expressed on dry weight basis, except for moisture.

Determination of anti-nutritional contents and mineral bioavailability

Phytate was determined using standard method [23], while total phenols, oxalate and hydrogen cyanide were determined using method of [24]. Phytate-mineral molar ratio for each sample for calcium, iron and zinc was determined using the method of [25]. The amount of phytate and each mineral was divided by their respective atomic weight, (phytate: 660g/mol; Fe: 56g/mol; Zn: 65g/mol; Ca: 40 g/mol) and the phytate-mineral molar ratio obtained by dividing the mole of phytate with the mole of the respective minerals.

Determination of amino acid profiles

Extraction and analysis for amino acid profiles of the flour samples were carried out using the methods described by [23] and [26] respectively.

Predicted protein quality indices

The amino acid profiles of each sample were used to calculate the respective total amino acid compositions as reported by [27]. These were: Total amino acid (TAA), Total essential amino acids (TEAA), Total non-essential amino acids (TNEAA), Sulphur amino acids (SAA) and Aromatic amino acids (AAA). Ratios TEAA/TAA and (TEAA/TNEAA) were also calculated.

Essential Amino Acid Index (EAAI) of eachflour sample was calculated by using the ratio of test protein to the reference protein for each eight essential amino acids plus Histidine in Eq. 1, asquoted by [28].

$$EAAI = 10\sqrt{\frac{100ax100bx100cx.....x100j}{avXbvXcvX....jv}} \quad \text{-----(1)}$$

where (a, b,…….j) represents Lysine, Threonine,Valine, Methionine, Isoleucine, Phenylalanine, Histidine, Tryptophan, Leucine and (Methionine + Cysteine) in test sample and av, bv,……..jv, represent content of the amino acid in standard protein % respectively.

Nutritional Index (NI) of samples were obtained using the equation quoted by [27].(Eq. 2)

$$NutritionIndex(\%) = \sqrt{\frac{EAAIX\%protein}{100}} \text{ ----- (2)}$$

where; EAAI is the Essential Amino Acid Index of each sample

Protein efficiency ratio (PER) of each flour sample was estimated using the regression equationquoted by [28],(Eq. 3).

$$PER = -468+0.454\ (LEU) - 0.105\ (TYR) \text{ ---- (3)}$$

Biological value (BV) of each sample was calculated using the regression equation quoted by [29].(Eq. 4).

$$BV = 1.09\ (EAAI) - 11.7 \text{ ----- (4)}$$

Estimation of total amino acid profiles and amino acid groups

The total amino acid profiles, amino acid groups, percentages of amino acid groups relative to total amino acids and percentages of selected amino acids in some selected amino acid groups were calculated as explained by [30]. These were: Total Neutral AA (TNAA), TotalAcidic AA (TAAA), Total BasicAA(TBAA), Total Sulphur-containing AA (TSAA), Total Aromatic AA (TArAA), Total Branched-Chain AA (TBCAA), and percentages of Cys in TSAA and Tyr in TArAA respectively.

Estimation of antioxidant activities

Antioxidant potentials of the samples were evaluated using DPPH radical scavenging, NO and OH free radicals and Iron chelation assays. (DPPH) radical scavenging activity assay, ferrous ion-chelating activity, and Hydroxyl (OH) free radicals scavenging activity were determined by the methods described by [31], while Nitric oxide (NO) free radical scavenging ability was determined by the method described by [32].

Statistical Analysis

Data were collected in triplicates and analyzed using the IBM SPSS version 23 [33], and results expressed as mean ± s.d. Significant difference between means was determined using the one-way analysis of Variance (ANOVA), while means were separated using the New Duncan Multiple Range Test (NDMRT) at 0.05.

Results And Discussion

Protein and fibre contents of generated blends and proximate composition of selected samples

The protein and fibre contents of the blends generated from optimization are presented in Table 1, while Table 2 shows the proximate compositions of 100% "garri" flour (CTL-1) and the three selected blends (RUNS 1, 2 and 11), (Table 1), which are coded GSM-1, GSM-2 and GSM-3 respectively. As the tables show, protein and fibre contents increased significantly ($p < 0.05$) in the blends compared to 100% "garri" flour, and among the blends as soy cake and millet flours increased in them. The protein contents of the blends ranged from 15.83% for sample GSM-1 to 16.25% for sample GSM-2, compared to 2.11% for 100% 'garri' flour, while the fibre contents also significantly increased ($p < 0.05$) in the blends (4.29, 4.17 and 4.12% for GSM-1, GSM-2 and GSM-3 respectively), compared to 1.68% for 100% 'garri' flour. These increases in protein and fibre contents were most probably due to high contents of protein in soya bean [7, 34]. and fibre in millet [8, 20], respectively. These results are similar to previous studies which reported increases in protein and fiber contents of plant-based food formulations with addition of soy cake and millet flours [5, 7, 15, 16, etc.]. There was significant difference ($p < 0.05$) among the blends for protein, while sample GSM-1 had slightly and significantly ($p < 0.05$) higher fibre content, while there was no significant difference ($p > 0.05$) among samples GSM-2 and GSM-3 for fibre. The slightly higher fibre content for sample GSM-1 could be attributed to its relatively higher proportion of millet, compared to other two blends. However, the protein and fibre contents of the blends meet the minimum recommended daily requirements specified by [35], which will be beneficial to the potential consumers of the dough meal prepared from the flour blends, compared to dough meal prepared from 100% "garri" flour. The moisture contents of all the samples, which ranged between 9.38% for GSM-1 (56.00:22.00:22.00) to 10.18% for 100% 'garri" flour were within the level for safe storage of flours without encountering deterioration, especially from moulds [36].

Anti-nutritional contents and bio-availability of selected minerals

Table 3 shows the anti-nutritional contents, mineral composition, mineral-mineral ratios and bio-availability of calcium, iron and zinc in 100% "garri" and the flour blends. There were significant ($p<0.05$) differences in the anti-nutritional contents among the blends and the blends and 100% "garri" flour, which had significantly ($p < 0.05$) lower values for most factors, compared to the blends. Sample GSM-1 had significantly ($p < 0.05$) higher contents of tannin and polyphenols, while sample GSM-2 had the lowest values for these parameters. However, with respect to phytate and oxalate contents, sample GSM-2 had significantly ($p < 0.05$) higher values (139.64mg/100g), while there was no significant difference ($p > 0.05$) between samples GSM-1 and GSM-3, which had values of 137.63, 66.42 and 137.86 and 137.86, 67.35mg/100g, respectively. The high contents of anti-nutritional factors in the blends, especially for tannin, phytate and polyphenols, could most probably be attributed to soy and millet flours in the blends, both of which have been reported to contain high amounts of these factors [37-39]. High contents of polyphenols (0.29-0.51g/100g), phytate (0.22-0.26g/100g) and tannins (0.01-0.30g/100g) in soaked and roasted soya bean flours had been previously reported [34]. High amounts ofsomeanti-nutritional factors in foodsis believed to be an impediment to full utilization of many plant foods in food preparation, since these anti-nutritional factors, especially phytate,are known to form complexes with metal ions, like calcium, iron and zinc, and reduce their bioavailability, and that of protein [40]. The anti-nutritional contents of the flours are higher than values obtained for blends of quality protein maize, soy cake and whole millet flours (Akinjayeju et al., 2019), but are lowerthan the safe thresholds of 2–5g/kg for oxalate, 50–60 mg/kgforphytate and not more than 50 mg/100g for polyphenols [41], but slightly higher than the critical value for tannins (30mg/kg) [42]. This means that consumers of dough meal prepared from the flours will not be exposed to any adverse consequences, as a result of high anti-nutritional contents.

Table 1. Protein and fibre contents of blends of 'garri', soy cake and whole millet flours.

Experimental Runs	"Garri" flour (%)	Soy cake Flour (%)	Pearl Millet Flour (%)	Crude protein content (%)	Crude fibre content (%)
1	56	22	22	14.36	3.78
2	60.5	24	15.5	14.66	3.82
3	60.5	17.5	22	12.27	3.48
4	65	18.5	16.5	12.19	3.47
5	65	13	22	10.18	3.19
6	62.75	16.88	20.37	11.82	3.42
7	65	13	22	10.21	3.16
8	62.75	22.38	14.87	13.84	3.7
9	60.5	20.75	18.75	13.46	3.65
10	65	24	11	14.21	3.76
11	58.25	22.38	19.37	14.32	3.8
12	65	18.5	16.5	12.24	3.4
13	56	22	22	14.46	3.85
14	65	24	11	13.98	3.8

Table 2. Proximate composition of blends of 'garri', soy cake and whole millet flours.

Parameters/Samples	GSM-1	GSM-2	GSM-3	CTL-1
Moisture content (%)	9.38 ± 0.10^{d}	9.94 ± 0.07^{b}	9.58 ± 0.15^{c}	10.18 ± 0.18^{a}
Crude protein (%)	15.80 ± 0.10^{b}	16.25 ± 0.22^{a}	15.83 ± 0.04^{b}	2.11 ± 0.03^{c}
Crude fat (%)	3.14 ± 0.05^{b}	3.34 ± 0.04^{a}	3.15 ± 0.06^{b}	1.20 ± 0.07^{c}
Total ash (%)	3.07 ± 0.03^{b}	3.20 ± 0.04^{a}	3.11 ± 0.09^{ab}	1.37 ± 0.06^{c}
Crude fibre (%)	4.29 ± 0.05^{a}	4.17 ± 0.07^{b}	4.12 ± 0.11^{b}	1.68 ± 0.10^{c}
Carbohydrate (%)	73.70 ± 0.08^{b}	73.04 ± 0.11^{c}	73.79 ± 0.30^{b}	93.64 ± 0.08^{a}

Means of triplicate determinations are reported and expressed on dry weight basis except for moisture
Means with different superscripts along rows are significantly different ($p < 0.05$)
GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour.

Table 3. Anti-nutritional factors and phytate/oxalate-mineral molar ratios of selected minerals of blends of 'garri', soy cake and whole millet flours.

Parameter/Samples	GSM-1	GSM-2	GSM-3	CTL-1
Tannins (mg/100g)	147.15 ± 0.24^{a}	103.77 ± 0.73^{c}	$129..01\pm0.10^{b}$	76.00 ± 0.08^{d}
Polyphenols (mg/100g)	171.28 ± 0.04^{a}	134.29 ± 0.07^{c}	154.18 ± 0.09^{b}	13.17 ± 0.00^{d}
Phytate (mg/100g)	137.63 ± 0.13^{b}	139.64 ± 0.12^{a}	137.86 ± 0.04^{b}	65.75 ± 0.05^{c}
Oxalate (mg/100g)	66.42 ± 0.04^{b}	68.47 ± 0.05^{a}	67.35 ± 0.06^{b}	32.20 ± 0.02^{d}
Calcium (mg/100g)	49.88 ± 0.03^{a}	50.00 ± 0.05^{a}	49.62 ± 0.05^{a}	0.78 ± 0.02^{b}
Magnesium(mg/100g)	92.26 ± 0.12^{a}	90.05 ± 0.18^{b}	90.10 ± 0.20^{b}	1.46 ± 0.01^{d}
Iron (mg/100g)	3.82 ± 0.03^{a}	3.53 ± 0.14^{b}	3.66 ± 0.02^{b}	0.22 ± 0.00^{c}
Zinc (mg/100g)	2.05 ± 0.02^{a}	1.96 ± 0.02^{b}	1.96 ± 0.05^{b}	0.96 ± 0.03^{c}
Oxa:Ca	0.61 ± 0.00^{b}	0.62 ± 0.01^{b}	0.62 ± 0.01^{b}	18.76 ± 0.03^{a}
[Oxa]/[(Ca+Mg)]	0.15 ± 0.01^{b}	0.16 ± 0.02^{b}	0.16 ± 0.01^{b}	4.60 ± 0.01^{a}
Phy:Ca	0.17 ± 0.00^{b}	0.17 ± 0.01^{b}	0.17 ± 0.01^{b}	5.11 ± 0.03^{a}
Phy:Fe	3.06 ± 0.01^{d}	3.37 ± 0.03^{b}	3.20 ± 0.02^{c}	25.36 ± 0.02^{a}
Phy:Zn	6.61 ± 0.02^{c}	7.02 ± 0.02^{b}	6.93 ± 0.02^{b}	6.75 ± 0.03^{a}
Ca:Phy	5.98 ± 0.05^{a}	5.91 ± 0.04^{ab}	5.86 ± 0.06^{b}	0.20 ± 0.01^{c}
[Ca] [Phy]/[Zn]	8.25 ± 0.03^{c}	8.77 ± 0.03^{a}	8.59 ± 0.03^{b}	0.21 ± 0.02^{d}

Means of triplicate determinations are reported and expressed and values expressed as Mean ± s.d
Means with different superscripts along rows are significantly different ($p < 0.05$)
GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour.

Moreover, the high anti-nutritional factors in the flour blends may provide certain health benefit to the consumers, since some anti-nutritional factors have been associated with certain health benefits, when consumed at acceptable safety levels. For instance, it has been previously reported [43] that when ingested at low levels, some anti-nutritional factors like polyphenols, oxalate and phytate, may reduce blood glucose levels and cancer risks, and also lessen growth dangers, while polyphenols and tannins have been reported to act as food bioactive compounds, with considerable beneficial health benefits [44, 45]. The mineral bio-availability for calcium, iron, magnesium and zinc as measured by their phytate and oxalate molar ratios are also presented in Table 3. These results showed that for all mineral bio-availability parameters, there were significant differences ($p < 0.05$) between the flour blends and 100% "Garri" flour, while there was no significant difference ($p > 0.05$) among the blends. The Oxa:Ca and [Oxa]/[(Ca + Mg)] molar ratios ranged from 0.61 to 0.62 and 0.15 to 0.16 for the flour blends, the values for 100% "garri" flour for these parameters are 18.76 and 4.60 respectively. Similarly, for Phy:Ca and Phy:Fe molar ratios, the values for 100% 'Garri" (5.11 and 25.36) were significantly ($p < 0.05$) higher than the values for the blends, which was 0.17 for all three blends and 3.06 - 3.37 respectively.

These mineral bio-availability values for the flour blends are slightly higher than values obtained for blends of quality protein maize, soy cake and whole millet flours for functional dough meal [16], and for blends of wheat, pigeon pea and cassava cortex flours [46]. The relatively high Phy: Zn molar ratios for the flour blends could be attributed to the slightly lower value of this mineral in the samples compared to the values of other minerals, especially calcium. The mineral bio-availability values of the flour blends with respect to their phytate-mineral molar ratios, were within the critical values of < 0.17 and 0.5 for Phy:Ca, 0.4 and < 1.0 for Phy:Fe and 10 for Phy:Zn [43, 47, 48]. However, the Phy:Zn ratio obtained for the flour blends are higher that the critical value of 1.5 proposed by [49]. With respect to Oxa:Ca, Ca:Phyand [Ca][Phy]/[Zn] molar ratios, there were significant differences ($p < 0.05$) between the flour blends and 100%"garri" flour, which had significantly ($p < 0.05$) higher value for Oxa:Ca (18.76), but significantly lower values for Ca:Phy, and [Ca][Phy]/[Zn] (0.20 and 0.21), compared to the blends with values of 0.61-0.62, 5.86 - 5.98 and 8.25 - 8.77 for Oxa:Ca,Ca:Phy and [Ca][Phy]/[Zn] respectively. The results for Oxa:Ca and Ca:Phy are within the critical values of 1.0 and 6.1 respectively, recommended by [48, 49].

These results show that the bio-availability of these minerals will not be impaired by both oxalate and phytate in the flour blends, when the dough meal prepared from them is consumed, unlike 100% "garri' flour, for which results showed low bio-availability for most minerals. This most probably also means that the bio-availability of minerals in other food items like meat and fish consumed with dough meal prepared from 100% "garri" flour may be impaired, which will be detrimental to consumers. There was very strong positive correlation between Oxa:Ca and Oxa/[(Ca + Mg)] values for the flour blends (r = 1.0), while results showed strong negative correlation between Ca:Phy and [Ca][Phy]/[Zn] (r = -0.7), which are in agreement with the observations of [46] for

Table 4. Amino acid profiles of blends of 'Garri', soy cake and whole millet flours (g/100g Protein).

Parameter/Samples	GSM-1	GSM-2	GSM-3	CTL-1
Essential amino acids				
Histidine	1.43 ± 0.01^a	1.23 ± 0.01^b	1.22 ± 0.00^b	0..67 ± 0.02^c
Isoleucine	2.26 ± 0.02^c	2.89 ± 0.03^a	2.60 ± 0.01^b	0.73 ± 0.00^d
Leucine	4.28 ± 0.03^c	4.34 ± 0.01^b	4.73 ± 0.02^a	0.89 ± 0.01^d
Lysine	2.97± 0.05^a	2.08 ± 0.03^b	2.05 ± 0.00^b	0.92 ± 0.01^d
Methionine	2.27 ± 0.03^a	2.01 ± 0.02^b	1.72 ± 0.02^c	0.15 ± 0.02^d
Phenylalanine	5.13 ± 0.02^a	3.91 ± 0.04^b	3.95 ± 0.03^b	0.63 ± 0.01^d
Threonine	2.62 ± 0.01^a	1.93 ± 0.02^b	1.44 ± 0.01^c	0.76 ± 0.02^d
Tryptophan	1.10 ± 0.02^b	1.26 ± 0.03^a	1.11± 0.01^b	0.52 ± 0.03^c
Valine	2.45 ± 0.01^a	1.91 ± 0.01^b	1.16 ± 0.00^c	1.07 ± 0.02^d
TEAA1	24.51 ± 0.13^a	21.56 ±0.10^b	19.98 ± 0.06^c	6.34 ± 0.09^d
Non-essential amino acids				
Alanine	4.45 ± 0.02^c	4.73 ± 0.01^b	4.84 ± 0.01^a	0.83 ± 0.02^d
Arginine	4.88 ±0.01^a	3.75 ± 0.03^b	2.44 ± 0.01^c	0.86 ± 0.02^d
Aspartate	5.37 ± 0.00^a	4.30 ± 0.01^b	3.34 ± 0.03^c	1.48 ± 0.02^d
Cysteine	1.68 ± 0.03^b	1.70 ± 0.02^b	1.71 ± 0.03^b	0.45 ± 0.01^d
Glutamate	19.31 ± 0.10^c	19.89 ± 0.02^b	21.80 ± 0.04^a	1.88 ±0.01^d
Glycine	2.39 ± 0.01^c	2.44 ± 0.01^b	2.63 ± 0.01^a	0.78 ± 0.01^d
Proline	3.06 ± 0.02^c	3.26 ± 0.00^b	3.68 ± 0.03^a	0.64 ± 0.02^d
Serine	2.27 ± 0.03^c	2.56 ± 0.03^b	2.65 ± 0.02^a	0.80 ± 0.01^d
Tyrosine	1.89 ± 0.01^c	2.14 ± 0.01^b	2.44 ± 0.05^a	0.20 ± 0.00^d
TNEAA2	45.50 ± 0.10^a	44.77 ± 0.04^b	45.53 ± 0.06^a	7.92 ± 0.11^c

Means of triplicate determinations are reported and expressed and values expressed as Mean ± s.d
Means with different superscripts along rows are significantly different ($p < 0.05$)
GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour.

blends of wheat, pigeon pea and cassava cortex flours.

Amino acid profiles of selected blends

The amino acid profiles of the flour blends and 100% "garri" flour are presented in Table 4, which showed that there were significant ($p < 0.05$) differences between the flour blends and 100% "garri' flour, on one hand, and among the blends on the other, for all essential and non-essential amino acid values. Addition of soy cake and millet flours significantly ($p < 0.05$) enhanced the amino acid profiles of the blends with respect to both essential and non-essential amino acids. High amino acid profiles of millet grains had been previously reported [20, 50, 51], while the importance of soy cake flour in improving the protein quantity and quality of plant-based diets had been acknowledged by previous studies [15, 16, 31].

The significantly ($p < 0.05$) low amino profiles of 100% "garri" flour obtained in this study are in agreement with previous studies for cassava-based products [52-54]. Addition of soy cake and millet flours will therefore improve the nutrient density of the flour blends with respect to fibre, amino acid profiles and protein quality, which will be beneficial to the consumers, especially those of low economic status, who may not be able to afford animal protein sources in their diets. Generally, for the flour blends, sample GSM-1 had slightly but significantly ($p < 0.05$) highest values for most essential amino acids, while, sample GSM-3 had slightly but significantly ($p < 0.05$) highest values for most non-essential amino acids. Leucine (4.28 - 4.73g/100g protein) and phenylalanine (3.91 - 5.13g/100g protein) were the highest amino acids in the blends, while tryptophan (1.10 - 1.26g/100g protein) and Histidine (1.22 - 1.43 g/100g protein) were the least essential amino acids. Sample GSM-1 had slightly but significantly ($p < 0.05$) highest values for essential amino acids His, Lys, Met, Thr and Val, while sample GSM-3 had slightly highest value for Leu. The slightly but significantly ($p < 0.05$) higher values of most essential amino acids in sample GSM-1 is most probably due to its relatively lowest proportion of "garri" flour (56%), and relatively higher proportions of soy cake (22%) and millet (22%) flours in this sample, which will most likely result in better protein complementation between soy cake and millet flours [31, 55, 56]. The high amount of phenylalanine in the blends, especially sample GSM-1, will be beneficial to the potential consumer, since this amino acid is regardedas a precursor of some body hormones andthe pigment melanin in the hair and eyes. Leucine, which is also high in the blends, compared to 100% "garri" flour, is considered an important dietary aminoacid, which is credited with ability to stimulate the synthesis of muscle protein and also play therapeutic role certain stress conditions [57]. Tryptophan, was the lowest amino acid in the blends, a result which is agreement with previous studies that this amino acid, along with Methionine, are the limiting amino acids in most plant food commodities, especially cereals and legumes [15, 58, 59].

The flour blends had full complements of the non-essential amino acids, with glutamate the highest (19.31, 19.89 and 21.80g/100g protein) for samples GSM-1, GSM-2 and GSM-3 respectively, while cysteine is the least non-essential amino acid (1.68 to 1.71g/100g protein), for which there was no significant difference ($p > 0.05$) among the blends. Glutamate is regarded as one of the most abundant amino acids with critical role in nutrition, metabolism and signaling as it is a major excitatory neurotransmitter and a truly functional amino acid [60], and also useful in thesynthesis of key molecules such as glutathione needed for removal of highly toxic peroxides andpoly glutamate folate cofactor [55, 61]. Aspartate, alanine and arginine are other non-essential amino acids in relatively high amounts in the flour blends, with sample GSM-1 having significantly ($p < 0.05$) highest values for both aspartate and arginine (5.37 and 4.88g/100g protein) respectively. This will be beneficial to the consumers, especially arginine, previously believed to be important only for children, but is now believed to beuseful for adults as well, by aiding healing of wounds, acting as immune and reducing blood pressure inhypertensive adults [62] [63].

Predicted protein quality indices of selected blends

The predicted protein quality indices and relevant amino acid groupings are presented in Table 5. Similar to amino acid profiles (Table 4), the predicted protein quality indices of the flour blends increased significantly ($p< 0.05$) compared to those for 100% "garri" flour, while sample GSM-1 had slightly but significantly ($p< 0.05$) higher values for most protein quality indices and amino acid groups including total essential (TEAA, 24.51g/100gprotein), total non-essential (TNEAA, 45.50g/100gprotein), total (TAA, 70.01g/100gprotein), total aromatic (TArAA, 7.02g/100gprotein), basic (TBAA, 9.28g/100gprotein) and neutral (TBAA, 34.93g/100g protein) amino acids, as well as essential amino acid index (EAAI, 58.63%), Biological value (BV, 52.21%) and nutrition index (NI, 9.26). The relatively higher protein quality indices values of sample GSM-1 is most probably due, partly to lower proportion of "garri" flour (56%), and partly due to the relative proportions of soy cake (22%) and whole millet (22%), compared to other two samples. Combination of cereal and legume flours have been acknowledged to result in improved protein quality [15, 31, 59]. This improvement in protein quality indices of the blends will be beneficial to the consumers, especially those who depend largely on meals from "garri" flour, and cannot afford animal protein along with such meals. Low protein quality of products from cassava, including "garri" had been reported by previous studies [53, 54].

The values for EAAI (58.63%), BV (52%) and PER (1.28)obtained for sample GSM-1 in this study are lower that the corresponding values obtained for blends of quality protein maize, soy cake and millet flours for functional dough meal [16], and for blends of wheat, soy cake and whole mille flour for potential functional bread [15], and also lower that the standard values of ≥ 70%, ≥ 70% and 2.7 respectively [27, 28]. However, the, ratio TEAA:TAA (35%) obtained for this sample is within the standard values of 39, 26 and 11% good quality protein food recommended infants, children and adults [35, 57], while the EAAI, BV and PER of the blends are expected to meet a substantial part of standard values recommended. There were significant differences ($p < 0.05$) for both sulphur and aromatic amino acids, for which sample GSM-1 also had slightly and significantly ($p < 0.05$) higher values (3.95 and 7.02g/100g protein respectively), compared to other blends.

The values for aromatic amino acids were relatively higher in the blends than for sulphur amino acids due to the relatively higher values of phenylalanine and tyrosine, which make up the aromatic group, compared to the low values of methionine and cysteine that constitute sulphur aminogroup. The TBAA/TAAA ratios of

Table 5. Predicted protein quality indices and total amino acid groups ofblends of 'Garri', soy cake and whole millet flours.

Parameter/Samples	GSM-1	GSM-2	GSM-3	CTL-1	*1RDA
TEAA (g/100g Protein)	24.51 ± 0.13^{a}	21.56 ± 0.10^{b}	19.98 ± 0.06^{c}	6.34 ± 0.09^{d}	33.9
TNEAA (g/100g Protein)	45.50 ± 0.10^{a}	44.77 ± 0.04^{b}	45.53 ± 0.06^{a}	7.92 ± 0.11^{c}	
TAA (g/100g Protein)	$70.01 \pm .13^{a}$	66.33 ± 0.16^{b}	65.51 ± 0.12^{c}	14.26 ± 0.04^{d}	
∑Sulf AA(Meth + Cys) g/100g Protein	3.95 ± 0.03^{a}	3.71 ± 0.03^{b}	3.43 ± 0.02^{c}	0.60 ± 0.02^{d}	2.2
∑AromaticAA(Phen+Tyr) g/100g Protein	7.02 ± 0.03^{a}	6.05 ± 0.01^{c}	6.39 ± 0.00^{b}	0.83 ± 0.01^{d}	
TAAA(g/100gProtein)	24.68 ± 0.05	24.19 ± 0.01	25.14 ± 0.03^{a}	3.36 ± 0.01	
TBAA(g/100g Protein)	9.28 ± 0.02^{a}	7.06 ± 0.02^{b}	5.71 ± 0.00^{c}	2.45 ± 0.0^{2d}	
TBCAA(g/100g Protein)	8.99 ± 0.03^{a}	9.14 ± 0.02^{a}	8.49 ± 0.04^{b}	2.69 ± 0.01^{c}	
TNAA(g/100g Protein)	34.93 ± 0.01^{a}	33.82 ± 0.02^{b}	33.55 ± 0.01^{b}	7.93 ± 0.03^{c}	
TBAA/TAAA	0.38 ± 0.02^{b}	0.29 ± 0.01^{c}	0.21 ± 0.01^{d}	0.74 ± 0.01^{a}	
TEAA+Hist+Arg/TAA(%)	44.02 ± 0.08^{b}	40.01 ± 0.03^{c}	36.09 ± 0.03^{d}	55.19 ± 0.05^{a}	
TEAA/TNEAA	0.54 ± 0.00^{b}	0.48 ± 0.03^{c}	0.44 ± 0.00^{d}	0.80 ± 0.01^{a}	
TEAA/TAA (%)	35.0 ± 0.04^{b}	32.50 ± 0.05^{c}	30.50 ± 0.02^{d}	$44.46\ 0.04^{a}$	
TNEAA/TAA (%)	64.99 ± 0.07^{c}	67.50 ± 0.05^{b}	69.50 ± 0.07^{a}	55.54 ± 0.02^{d}	
EAAI (%)	58.63 ± 0.18^{a}	52.41 ± 0.01^{b}	46.55 ± 0.15^{c}	14.25 ± 0.05^{d}	≥ 0.70
Predicted PER	1.28 ± 0.01^{b}	1.27 ± 0.00^{b}	1.42 ± 0.02^{a}	NA	2.7
Predicted BV (%)	52.21 ± 0.05^{a}	45.43 ± 0.03^{b}	39.04 ± 0.08^{c}	3.83 ± 0.06^{d}	≥ 70
Nutrition Index	9.26 ± 0.05^{a}	8.52 ± 0.04^{b}	7.37 ± 0.06^{b}	0.30 ± 0.00^{d}	
Arginine/Lysine2	1.64 ± 0.02^{b}	1.80 ± 0.04a	1.19 ± 0.05^{c}	0.93 ± 0.02^{d}	1:01
Glycine/Methionine2	1.05 ± 0.02^{d}	1.21 ± 0.03^{c}	1.53 ± 0.01^{b}	5.20 ± 0.02^{a}	2:01
Lue/Isolue	1.89 ± 0.02^{a}	1.50 ± 0.01^{b}	1.82 ± 0.02^{a}	1.10 ± 0.03^{c}	

Means of triplicate determinations are reported and expressed and values expressed as Mean ± s.d
Means with different superscripts along rows are significantly different ($p < 0.05$)
GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour
*: FAO/WHO/UNU (2007), Ijarotimi et al. (2015)
2: Venkatesh et al. (2017)

<1 gives an indication of higher acidic proteins, suggesting that the amino acids will not produce basic effects at physiological pH in the body [30, 64]. There was low negative correlation (r = -0.35) between the basic and acidic amino acid groups. The results for Arg:Lys and Gly:Met ratios showed significant differences ($p < 0.05$) among the flour blends. The Gly:Met ratios for the flour blends were 1.05, 1.21 and 1.53 for samples GSM-1, GSM-2 and GSM-3 respectively, which were within the recommended ratio of 2:1 by [65], while the Arg:Lys ratios of 1.19 to 1.80 were slightly higher than the recommended ratio of 1:1 by [65, 66]. The recommended ratio of 1:1 for Arg:Lys is however at variance with the report of [62] that high Arg:Lys is preferred, since high Arginine has been associated with low blood glucose effect. Since the ratios for the flour samples were within the recommended standards, especially Arg:Lys, consumers will not likely to be exposed to the risk of hypercholesterolemia, since high ratio has been reported to affect the metabolic pathway of hypertension [65]. The Leu/Isoleu ratios of the blends (> 1) show higher leucine contents in the blends than Isoleucine. High Leucine in diets has been reported to impair the metabolism of Trp and Niacin [67], which may be detrimental to the consumers. The slightly but significantly ($p < 0.05$) higher Leu/Isoleu ratio for sample GSM-1 is due to its lower Isoleucine value (2.26g/100g protein) compared to other two blends (Table 4).

Percentages of amino acid groups and selected amino acids

The percentages of some amino acid groups in total amino acids and selected amino acids in some amino acid groups are presented in Table 6, which showed significant difference ($p < 0.5$) between 100% "garri" flour and the blends, and among the blends, except for % TSAA for which there was no significant ($p > 0.05$) among the blends. %TAAA and % TBAA ranged from 35.25 to 38.38% and 8.72 to 13.26% for the blends, while 100% "garri" flour had 23.56 and 17.18% respectively. The %TNAA of the blends for which there was significant difference ($p < 0.05$), were 49.89, 41.14 and 51.21% for samples GSM-1, GSM-2 and GSM-3 respectively, which most probably indicated that the blends contained protein with equal amounts of both positively and negatively charged amino acids. There was extremely high, but negative correlation between %TAAA and %TBAA (r = -0.98), which indicated that as one increased, the will decrease. The TBCAA and %TBCAA of the blends were 8.49 – 9.14g/100 protein and 12.84 – 13.79%, suggesting low values of these parameters, which is in agreement with the observation of [68], that TBCAA are high in animal proteins like eggs, meat and dairy, but low in most plant protein, except legumes.

The slightly but significantly ($p < 0.05$) higher values of sample GSM-2 could be attributed to its slightly higher soy cake flour (24%). Branched-chain amino acids have been credited with the ability to build up muscle proteins, thereby helping to reduce muscle breakdown and prevent fatigue and muscle wasting [69]. The % Cys in TSAA contents of the blends were from 42.53% for sample GSM-1 to 48.85 for sample GSM-3, sample GSM-2 had a value of 45.82%, while 100% "garri" flour had a significantly

Table 6. Percentages of amino acid groups and amino acids in groups of 100%"Garri" powder and blends of 'Garri', soy cake and whole millet flours.

Samples/Parameters	GSM-1	GSM-2	GSM-3	CTL-1
% TEAA	35.01 ± 0.03^{b}	32.50 ± 0.02^{c}	30.50 ± 0.01^{d}	44.46 ± 0.03^{a}
% TNEAA	64.99 ± 0.04^{c}	67.50 ± 0.02^{b}	69.50 ± 0.03^{a}	55.54 ± 0.02^{d}
% TNAA	49.89 ± 0.01^{c}	51.14 ± 0.00^{b}	51.21 ± 0.02^{b}	55.61 ± 0.03^{a}
% TAAA	24.68 ± 0.01^{c}	24.19 ± 0.03^{b}	25.14 ± 0.03^{a}	3.36 ± 0.01^{d}
% TBAA	13.26 ± 0.00^{b}	10.64 ± 0.01^{c}	8.72 ± 0.00^{d}	17.18 ± 0.04^{a}
% TSAA	5.64 ± 0.02^{a}	5.59 ± 0.04^{a}	5.24 ± 0.02^{a}	4.21 ± 0.01^{b}
% TBCAA	12.84 ± 0.02^{c}	13.79 ± 0.00^{b}	12.96 ± 0.01^{c}	18.60 ± 0.02^{a}
% TArAA	10.03 ± 0.02^{a}	9.12 ± 0.03^{b}	9.75 ± 0.01^{a}	0.62 ± 0.02^{d}
% Cys in TSAA	42.53 ± 0.01^{d}	45.82 ± 0.00^{c}	48.85 ± 0.04^{b}	75.00 ± 0.02^{a}
% Tyr in TArAA	26.92 ± 0.00d	35.37 ± 0.03^{b}	38.18 ± 0.01^{a}	24.10 ± 0.02^{d}

Means of triplicate determinations are reported and expressed and values expressed as Mean ± s.d
Means with different superscripts along rows are significantly different ($p < 0.05$)
GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour.

($p < 0.05$) higher % Cys in TSAA value (75%), despite its generally low amino acid profile. The % Cys in TSAA of the samples were higher than the 37.8% reported for Garcina kola [30], almost similar to the 50.5% obtained by [70] for Anacardiumoccidentale and the 50% for plant sources generally, but lower than 67.09% reported for raw P. africana [67]. These results appeared at variance with the observation of [71], that vegetable proteins, especially legumes may contain substantially less Met than Cys. The relatively high % Cys in TSAA of the samples, which showed very large negative correlation between it and the %TSAA (r = -0.94), will be an advantage to the consumers, sinceit has been observed that Cysteine has the ability to substitute for Methionine, one of the common limiting essential amino acids in the diets of people, especially in many developing parts of the world [72].

In addition, cysteine is regarded as one the amino acids needed for the synthesis of glutathione [73], which can act as a reducing agent for synthesis of glutaredoxin in deoxyribonucleotide synthesis and also useful to remove toxic products of metabolism, especially peroxides, while synthesis of glutathione is often limited by availability of Cys [74]. There was significant difference ($p < 0.05$) among the samples for % Tyr in TArAA, with values ranging from 26.92% for sample GSM-1 to 38.18% for sample GSM-2, while sample GSM-3 had 33.35%. Phenylalanine (indispensable) and tyrosine (dispensable) amino acids, are considered important since they are both used in the synthesis of protein [75]. However, while phenylalanine must be obtained from foods, tyrosine can be synthesized from phenylalanine, which may results in its depletion as observed by [30], thereby reducing its contribution to protein synthesis.

It is expected that some portion of the relatively high amount of phenylalanine in the TArAA of the flour samples should be spared by the Tyr. Contrary to the very high, but negative correlation between % Cys in TSAA and %TSAA, the correlation between % Tyr in TArAA and % TArAA was just average (-0.55), but both correlations were negative, which suggested increase in the % of each amino acid as each respective amino acid group reduced.

Anti-oxidant properties

The anti-oxidant potentials of the flour blends and 100% "garri" flour are represented in Figure 1 at concentrations of 25, 50, 75, and 100µg/mL respectively.These results showed that as concentration increased, anti-oxidant properties also increased, most probably due to increase in the bioactive materials at higher concentrations. These results showed that the flour blends exhibited higher free radical scavenging and antioxidant potentials, compared to 100% "garri" flour, which had very low anti-oxidant properties. For instance, the Fe-chelating ability of the blends at 50µg/mL concentration ranged from 33.64% for sample GSM-3 to 41.09% for sample GSM-1, compared to 100% "garri" flour, which had Fe-chelating activity of 16.20%, while their potentials on free radicals against DPPH assay, also at 50µm/mL,were 50.43, 44.32 and 45.58% for samples GSM-1, GSM-2 and GSM-3 respectively, as against 15.58% for 100% "garri" flour. The high anti-oxidant potentials of the blends, compared to 100% "garri" flour could be attributed to the presence of soy cake and millet flours, both of which have been credited with bioactive components such as phytochemicals, fibre and protein, and high antioxidant activities [20, 76, 77].

Similar observations of improved anti-oxidant potentials of plant-based materials enriched with soy flour and fibre-rich materials have been reported [4, 58, 78]. The high anti-oxidant potentials of the blends will be beneficial to the potential consumers of "Eba" prepared from the blends, compared to that prepared from 100% "garri" flour, since the role of anti-oxidants in the management of many degenerative ailments like hypertension, diabetes and cancers has been well established [45, 79, 80]. Sample GSM-1 had higher ant-oxidant potentials for DPPH and hydroxyl radicals (OH-) at lower concentrations and for Nitric oxide (NO) radicals at higher concentrations (75 and 100µg/mL). This could most probably be due to its proportions of soy cake and millet flours, which most probably resulted in better protein complementation,

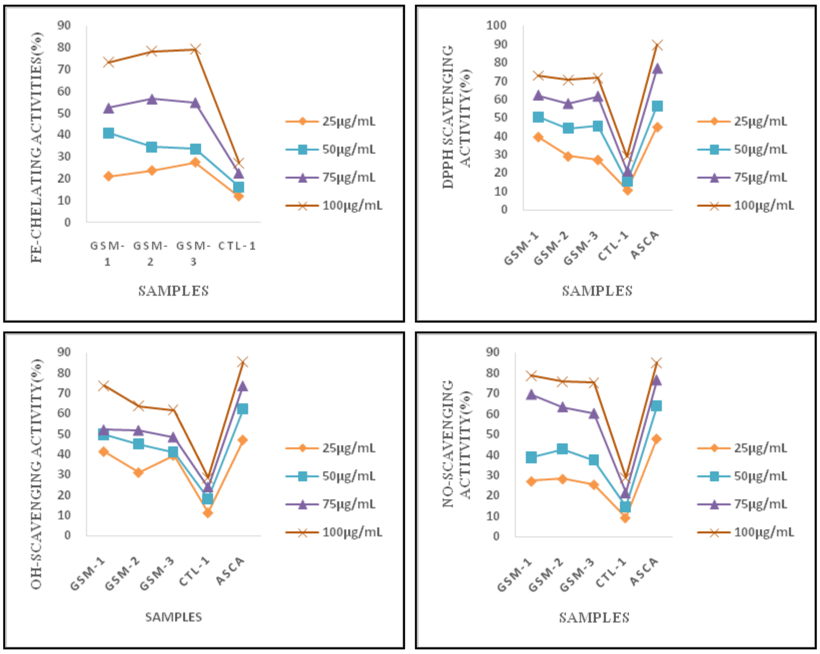

Figure 1. Anti-oxidant potentials of 100% "garri" flour and blends of "garri", soy cake and millet flours.

GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour.
ASCA = Ascorbic acid

Table 7. Mean scores of sensory attributes of dough meal samples from "Garri", powder and blends of 'Garri', soy cake and whole millet flours.

Samples/Parameters	GSM-1	GSM-2	GSM-3	CTL-1
Appearance	7.12 ± 0.33^{b}	6.70 ± 0.38^{b}	6.60 ± 0.41^{b}	7.85 ± 0.36^{a}
Aroma	6.84 ± 0.34^{b}	6.35 ± 0.50^{c}	6.95 ± 0.34^{b}	8.25 ± 0.36^{a}
Mouldability	6.95 ± 0.44^{b}	6.30 ± 0.47^{d}	6.50 ± 0.43^{c}	7.58 ± 0.35^{a}
Mouth feel	6.92 ± 0.35^{b}	6.65 ± 0.50^{c}	6.55 ± 0.41^{c}	7.45 ± 0.34^{a}
Taste	6.80 ± 0.33^{b}	6.45 ± 0.44^{c}	6.72 ± 0.44^{b}	7.92 ± 0.28^{a}
Texture	7.24 ± 0.31^{a}	6.85 ± 0.53^{b}	6.30 ± 0.42^{c}	7.28 ± 0.42^{a}
Overall Mean Scores	6.98 ± 0.30^{b}	6.55 ± 0.24^{c}	6.60 ± 0.14^{d}	7.72 ± 0.28^{a}

Means of triplicate determinations are reported and expressed and values expressed as Mean ± s.d
Means with different superscripts along rows are significantly different ($p < 0.05$)
GSM-1: = 56.00GRF : 22.00SCF : 22.00WMF: GSM-2: = 60.50GRF: 24.00 SCF: 15.50WMF:
GSM-3: = 58.25GRF : 22.38SCF : 19.37WMF: CTL-1 = 100% "Garri" flour
GRF= "Garri" flour; SCF = Soy cake flour; WMF = Whole millet flour.

and probably some effect of anti-oxidant properties.

Sensory attributes of dumplings prepared from selected blends

The mean scores of the sensory attributes of cooked dough meal "Eba" samples from the flour blends are presented in Table 7, which showed significant differences ($p < 0.05$) between "Eba" sample prepared from 100% "garri" flour and "Eba" samples from the blends, and also among samples from the blends for most sensory attributes measured. Good quality of "Eba", like for most dough meals, is related to appearance in term of shiny, absence of lumps and blemish, its taste such as cooked and sour taste, pleasant aroma, texture in relation to smoothness, non-stickiness, moderately elastic and properly mouldable [11]. Most of these attributes of dough meals, especially those relating to texture have been reported to be influenced by attributes of "garri" such as granularity, ease of reconstitution, degree of its powderiness, functional properties like water absorption, swelling and solubility, pasting properties, as well as proximate composition in terms of protein, fibre and carbohydrate contents as observed by [11, 16, 81]. "Eba" from 100% "garri" had significantly ($p < 0.05$) higher acceptability mean scores (> 7 out of maximum of 9), for all sensory attributes, including overall mean score (7.72), most probably because most of the panelists were familiar with the quality attributes of "Eba" from 100% "garri".

With respect to the blends, "Eba" from sample GSM-1 had significantly ($p < 0.05$) highest acceptability mean scores for most sensory parameters, particularly appearance, mouldability, mouthfeel, texture and overall mean score, even though other two samples had fairly high acceptability mean scores (> 6 out of maximum of 9). The relatively but significantly ($p < 0.05$) higher mean scores for sample GSM-1 for sensory attributes such as texture, mouldability and mouthfeel could most probably be due to its slightly higher fibre content (Table 2), compared to other two blends, which might had affected the functional properties of the blends, as discussed in a previous study [82]. It has been previously reported that fibre contents of food systems had bearings on bulking and consistency of their products [83, 84], which may have influenced some of the sensory attributes. The results obtained in this study are in agreement with the observations of [16] and [58] that the sensory properties of dough meal samples prepared from quality protein maize and plantain flours containing soy cake and fibre-rich plant sources were altered. The overall acceptability mean scores of "Eba" samples were in descending order of GSM-1 (6.98) > GSM-3 (6.60) > 6.55 (GSM-3), out of a maximum score of 9.0, which corresponded to moderately liked on the graduating scale used. Generally, sample GSM-1 had the highest acceptability mean scores for most sensory attributes.

Conclusion

This study showed that addition of spy cake and millet flours to "garri" significantly ($p < 0.05$) improved its nutritional compositions, especially in respect of protein, fibre, minerals and amino acid profiles, which will enhance the nutritional status of "Eba" prepared from the flour blends and consequently of the consumers. The anti-nutritional contents of the blends which increased from the addition of soy cake and millet flours had no adverse effect on the mineral bio-availability in the flour blends, and will provide health benefits to consumers. The anti-oxidant potentials of the flour blends will also provide additional health benefits to the consumers through scavenging of free radicals from the body. It is expected that "Eba" prepared from the flour blends will contribute significant fraction of the required daily allowance for each of the nutrients contained in the flour blends, compared to "Eba" prepared from 100% "garri". The flour blends produce "Eba" of high consumer acceptability mean scores for all sensory attributes, with sampleGSM-1 (56.00% "garri':22.00% Soy cake flour:22.00% Millet flour) receiving the highest consumer acceptability mean scores for most sensory parameters. This sample also had the best values for most parameters measures including minerals, amino acid profiles, protein quality indices as well as higher anti-oxidant potentials.This study has therefore established that "Eba" of good nutritional content, excellent anti-oxidant properties and high consumer acceptability can be produced fromblends of "garri", soy and millet flours. There is the need to evaluate the functional status of the flour blends. Consequently, further study will focus on the glycaemic index, anti-diabetic, anti-cholesterol potentials of the flour samples. Prospects of potentials of the flour blends to reduce blood sugar level, and possibility of their low glycaemic properties, will help in controlling and reducing the high incidence of diseased conditions such as diabetes, hypertension and obesity, thereby helping to reduce the use of synthetic drugs to control these ailments, and its consequent adverse effects.

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