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Quality assessment and sensory acceptability of bread produced from wheat, ground bean and sweet potato flour blends

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Abstract
The study was undertaken to evaluate the nutrient composition, physical and sensory properties of bread samples produced from wheat, ground bean and sweet potato flour blends. The ground beans and sweet potatoes were prepared into flours and used at varying replacement levels (5-25% and 5-25%) for wheat flour in the production of bread loaves with 100% wheat flour bread as control. The nutrient composition, physical and sensory properties of the bread samples were determined using standard methods. The moisture, crude protein, fat, crude fibre and ash contents of the bread samples increased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours from 7.53-8.03%, 9.06-14.52%, 3.12-4.68%, 3.42-5.15% and 2.41-3.04, respectively, while the carbohydrate and energy contents decreased from 74.46-64.58% and 362.16-358.52 KJ/100 g, respectively. The mineral composition of the bread samples also increased significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours from 76.32-102.33 mg/100 g (calcium), 86.33-106.76 mg/100 g (potassium), 43.17-70.79 mg / 100 g (phosphorus), 92.14-112.15 mg / 100 g (magnesium), 1.52-2.05 mg / 100 g (iron) and 2.13-2.98 mg/100 g (zinc), respectively. The thiamine, riboflavin, niacin, ascorbic acid, vitamin A and vitamin E contents of the bread samples increased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours from 42.17-59.19 mg/100 g, 62.31-80.69 mg/100 g, 24.15-47.57 mg/100 g, 12.15-12.15-12.73 mg/100 g, 18.32-47.33 mg/100 g and 15.31-43.67 mg/100 g, respectively. The physical properties (loaf volume, loaf height, loaf weight, oven spring and specific loaf volume) of the bread samples decreased significantly (p<0.05) with corresponding increase in the addition of ground bean and sweet potato flours from 310.21-115.41 cm^3, 6.82-3.84 cm; 410.21-246.31g, 458.15-407.94 cm and 0.76-0.26 cm^3/g, respectively. The sensory properties of the samples showed that the control sample (100% wheat flour bread) was the most acceptable to the panelists and also differed significantly (p<0.05) from the composite flour breads in colour, texture, taste and flavour. Although the 100% wheat flour bread (control) had better sensory and physical properties, it had the least values in nutrient contents compared to the composite flour bread loaves. However, the study showed that the nutrient contents of wheat flour breads could be improved by enriching wheat flour with ground bean and sweet potato flours at the levels of 5-25% and 5-25%, respectively in the production of bread loaves.

Keywords: Breads, production, quality evaluation, sensory acceptability, wheat flour, ground bean flour, sweet potato flour

Introduction
Bread is a staple food produced by baking dough of flour and water with the addition of other ingredients such as sugar, salt, milk, yeast and fat (Elisa *et al.*, 2017) [22]. Bread is also described as a fermented confectionary product that is produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Dewettinck *et al.*, 2008) [18]. They are ready-to-eat cereal-based foods that are commonly consumed in Nigeria and other countries of the world. They are convenient and inexpensive food products that contain digestive and dietary principles of vital importance (Kulkarmi and Deshponde, 2007) [53]. They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat from the oven (Olaoye *et al.*, 2007) [7]. The proportion of flour types and other ingredients vary widely in bread making in accordance with their mode of production. Non-cereal ingredients such as fruits used in bread making require the inclusion of additives to improve the flavour, texture, colour, shelf stability and ease of production. Most of these foods are however poor sources of protein and as such contribute to poor nutritional quality (Akpapunam and Darbe, 1994) [2].

Being a ready-to-eat convenient food product, it is therefore important to fortify bread and other snacks with vitamins and minerals and also enrich them with other protein sources derived from oilseeds and legumes (Elizabeth *et al.*, 1999) [19]. Although legumes are important part of traditional diets around the world, they are often neglected in typical Western diets. Legumes are inexpensive, nutrient-dense sources of protein that can be used to substitute dietary animal protein (Anderson *et al.,* 2009) [4]. Although, legumes are excellent sources of essential minerals, they are also rich in dietary fibre and other phytochemicals that may affect health.

Wheat is one of the dominant crops in temperate countries that is used as human food and livestock feed. The usefulness of wheat depends partly on it's adaptability and high yield potential as well as on the gluten protein fraction which confers the visco-elastic properties that allow the dough to be processed into bread, pasta, noodles and other food products (Browns *et al*., 2011) [14]. There are several advantages associated with the use of wheat in bread baking which makes it to serve as elastic, cohesive and adhesive agent. The presence of gluten also increases the protein content of the bread. Wheat also contributes essential amino acids, minerals and vitamins with beneficial phytochemicals and dietary fibre components to human grain products (Anderson *et al*., 2000) [5]. However, wheat products are also known to be responsible for a number of adverse reactions in humans which include gluten intolerance and allergies (Feldman, 2001) [25].

Ground bean is an underutilized leguminous crop which serves as a source of relatively cheap protein for rural dwellers (Broughton *et al.,* 2003) [13]. Ground bean seeds have high protein contents and are also rich in amino acids such as lysine and methionine than most of the other leguminous crops. Despite its nutritional attributes and its ability to grow on a marginal area, the crop still remains an underexploited grain legume.

Sweet potato is among the world's most important and underexploited tuber crop. It is commonly referred to as subsistence, food security or famine relief crop. Its uses have considerable diversified effect in developing countries (Adenuga, 2010) [1]. Sweet potatoes are good sources of vitamins C and E as well as dietary fibre, potassium and iron. They are low in fat and cholesterol contents. Sweet potato serves as an important source of protein for many rural populace and is also an important source of starch and other carbohydrates that are required by the human body (Onoja and Obizoba, 2009) [42]. However, the supplementation of cereal-based foods with legumes or tuber crops would not only improve the micro and macro-nutrient contents of the products, but will also enhance their quality. The objective of this study was to evaluate the quality characteristics and sensory acceptability of bread loaves produced from wheat, ground bean and sweet potato composite flours.

Materials and Methods

The wheat flour (*Triticum aestivum*), ground bean (*Kersingella geocarpa*) seeds and sweet potato (*Ipomoea batatas*) tubers used for the study were purchased from Ogbete Main Market, Enugu, Enugu State, Nigeria. The bakery materials (bakery fat, salt, yeast, sugar (sucrose) and flavouring agent used for the production of bread were also bought from the same market.

Preparation of Ground Bean Flour

The malted ground bean flour was prepared according to the method described by Eneche (2006) [23]. One kilogram me (1 kg) of ground bean seeds were cleaned thoroughly to remove dirt and other extraneous materials. The cleaned seeds were steeped in 2.5 litres of potable water in a plastic bowl at room temperature (30±2 °C) for 24 h with a change of water at intervals of 6 h to prevent microbial fermentation. After steeping, the seeds were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to disinfect the seeds. The seeds were then rinsed for three consecutive times with excess water, cast on a moistened jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The seeds were then spread on the jute bag and allowed to germinate in the germinating chamber at room temperature (30±2 °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 and the germinated seeds were collected, spread on the trays and dried in a tray 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 ground bean seeds were cleaned and rubbed in-between palms to remove the rootlets and shoots along with the hulls. The DE hulled malted seeds were milled in a hammer mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in a covered plastic container, labeled and stored in a refrigerator until needed for further use.

Preparation of Sweet Potato Flour

The sweet potato flour was prepared according to the method described by Alves (2012) [3]. The sweet potatoes were selected, cleaned, peeled and cut into 3cm × 1cm slices with a kitchen knife. The slices were placed into a stainless pot and blanched with 2 litres of potable water at 85^{o}C for 15 min on a hot plate. The blanched potato slices were drained, rinsed and dried in a tray dryer (Model EU 850D, UK) at 60^{o}C for 18 h with occasional stirring of the slices at intervals of 30 min to ensure uniform drying. The dried slices were milled in a hammer mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in a covered plastic container, labeled and kept in a refrigerator until needed for further use.

Formulation of Flour Blends

Wheat flour (WF), ground bean flour (GBF) and sweet potato flour (SPF) were thoroughly mixed together in the ratios of A-100:0:0, B-90:5:5, C-80:10:10, D-70:15:15, E-60:20:20 and F-50:25:25 in a Kenwood mixer (Model NX 908G, Britain, UK) to produce composite flours. The composite flours produced were individually packaged in covered plastic containers, labeled and kept in a refrigerator until needed for the production of bread loaves.

Preparation of Bread Samples

The bread loaves were prepared according to the straight dough development method described by Okaka (2009) [35]. The recipe used for the production of bread samples contained 100% flour, 60% fat, 40% sugar (sucrose), 20% dried yeast, 5% salt and 200 mL distilled water. During the bread making, all the ingredients with the exception of the yeast were thoroughly mixed together in a micro dough mixer (Model KSM 850G, USA). After that, the yeast was activated by putting 20 g of yeast in a sealed plastic container containing 30mL of warm distilled water, 25 g of sugar and 15 g of flour and allowed to rest at room temperature (30±2 °C) for 25 min to form the yeast-in-water dispersion. The dough produced was transferred into a plastic bowl and pierced carefully at the centre. The yeast-in-water dispersion was poured into the pierced hole and the dough containing the yeast-in-water dispersion was continuously kneaded manually for 10 min to introduce oxygen for rigorous fermentation and to facilitate the development of gluten. The kneaded dough was quietly divided and moulded manually into uniform shapes of similar sizes. The moulded dough's were placed separately into baking pans smeared with vegetable oil and covered with greased bread wrapper. The bread doughs were allowed to ferment at room temperature (30±2 °C) for 1 h. The fermented doughs were proofed at 40ºC in a cabinet proofer for 85 min and baked in an electric oven (Salva, USA) at 200 °C for 50 min. The bread loaves were removed from the oven, taken out of the baking pans and allowed to cool at ambient temperature for 1 h. The cooled bread samples were divided into two (2) lots. The first lot was wrapped with aluminum foils and used for sensory evaluation after 2 h. The second lot was packaged in low-density polyethylene bags and kept in a refrigerator until needed for analysis. The bread loaves produced from 100% wheat flour were used as control.

Proximate Analysis

The moisture, crude protein, ash, fat and crude fibre contents of the samples were determined according to the standard analytical methods of AOAC (2010) [6]. The carbohydrate was calculated by differences. 100% - (%Moisture + % Crude Protein + % Fat + % Ash + % Crude Fiber). The energy content was calculated by multiplying the percentage values of protein, fat and carbohydrate by the Atwater factors of 4, 9 and 4, respectively (AOAC, 2010) [6]. All determinations were carried out in triplicate samples.

Micronutrients Analyses

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 method of AOAC (2010) [6]. The potassium and iron contents of the bread loaves were determined by the use of a flame photometer (Model 405, Corning UK) according to the method described by Ndife *et al.* (2011) [32]. The phosphorus content was determined by the vanadomolybdate calorimetric method described by Yusufu *et al.* (2013) [1]. The niacin, ascorbic acid and folic acid contents of the samples were determined by the methods of AOAC (2010) [6]. The thiamine, riboflavin and vitamin A contents of the samples were determined according to the flour metric methods described by Onwuka (2005) [45]. All determinations were carried out in triplicate samples.

Evaluation of Physical Properties

The loaf volume and the specific loaf volume of the samples were determined according to the method described by Giami *et al.* (2004) [26]. The Loaf height was determined according to the method described by See *et al.* (2007) [48]. The loaf weight was determined by the use of sensitive electric weighing balance according to the method described by Giami *et al.* (2004) [26]. The oven spring was determined according to the method described by Oladunmoye *et al.* (2010) [38]. All determinations were carried out in triplicate samples.

Sensory Evaluation

The wheat and composite flour bread samples were cooled for 2 h after baking at room temperature (30±2 °C). The loaves were then sliced separately into smaller slices with the aid of a bread knife. The sensory test was conducted by a panel of twenty (20) semi-trained panelists comprising of staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The samples were evaluated for the attributes of crust colour, taste, texture, flavour and overall acceptability using a nine-point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Neta *et al.*, 2011) [33]. The sensory evaluation was carried out in the Food Processing and Preservation Laboratory of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The panelists were sitted in such a way that they could not see the rating of each other. The samples were randomly coded and served in plain coloured plastic plates and each assessor was provided with a cup of drinking water to rinse his/her mouth after testing each sample to avoid residual effect. The assessors were asked to taste and score the bread loaves based on their preference and acceptance of each of them.

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 at $p<0.05$.

Results and Discussion

Proximate Composition of Bread Samples

The proximate composition of the bread samples are presented in Table 1. The moisture content of the bread samples ranged from 7.53 to 8.03% with the control sample (100% wheat flour bread) and the sample substituted with 25% ground bean and 25% sweet potato flours having the least (7.53%) and highest (8.03%) moisture contents, respectively. The moisture content of the samples was observed to increase with increase in the addition of ground bean and sweet potato flours to the products. The observed increase in the moisture content of the samples could be attributed to higher water absorption capacities of ground bean-sweet potato composite flours compared to the wheat flour and this is in agreement with the report of Giami *et al.* (2004) [26] for wheat-toasted and boiled African bread fruit composite flours. High moisture content in foods encourages rapid growth of microorganisms. The low moisture content obtained in this study is advantageous in that it could lead to the reduction in microbial proliferation and extension of the shelf life of the products (Elkalifa-Elmoneim and Bernhardt, 2010) [20]. The protein content of the samples increased significantly ($p<0.05$) with increase in substitution of ground bean and sweet potato flours. The bread sample substituted with 25% ground bean and 25% sweet potato flours had the highest protein content (14.64%), while the control sample had the least protein content (9.06%). The observation is in agreement with the reports that ground beans and sweet potatoes are relatively high in protein contents than the wheat flour (Aremu *et al.*, 2011; Oluwalana *et al.*, 2012) [7, 40]. Protein plays a significant role in building and maintenance of body cells and tissues. It is also essential for the synthesis of enzymes and hormones needed for the development of the body (Okaka *et al.*, 2006) [36]. The fat content of the bread samples varied from 3.12 to 4.84%. The fat content of the samples increased significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours in the products. This increase could be attributed to the addition of ground bean flour which is relatively high in fat content. The values (3.12-4.84%) obtained in this study were lower than the fat content (4.12-5.46%) reported by Ndife *et al.* (2011) [32] for functional breads produced from whole wheat and soybean flour. Fat is important in the diets because it supplies essential fatty acids and facilitates the absorption of fat soluble vitamins in humans. It is also important in human diets because it is a high energy yielding nutrient (Michaelsen *et al.*, 2000) [32]. The crude fibre content of the bread samples increased from 3.42% in control sample to 5.15% for the sample substituted with 25% ground bean and 25% sweet potato flours. The control sample (100% wheat flour bread) had the least crude fibre content (3.42%), while the sample containing 25% ground bean and 25% sweet potato flours had the highest value (5.15%). The observed increase in crude fibre content could be attributed to the addition of high levels of ground bean and sweet potato flours to the sample. The observation is in agreement with the reports that ground beans and sweet potatoes are good sources of crude fibre (Chikwendu, 2007; Olaoye *et al.*, 2007) [17, 39]. Fibre plays a significant role in digestion and absorption of food in the human body. It also has a protective function against some diseases such as diabetes, high blood pressure and arteriosclerosis (Betancur-Ancona *et al.*, 2004) [12]. The ash content of the bread samples varied significantly (p<0.05) from each other with the control sample having the least value (2.41%), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest value (3.04%). The values (2.41-3.04%) obtained in this study were higher than the ash content (1.25-1.36%) of wheat-bean composite flour bread reported by Chikwendu *et al.* (2015) [16]. The high ash contents of the composite flour breads are clear indications of their high mineral contents. The carbohydrate content of the bread samples which varied from 64.58% to 74.46% decreased significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours in the products. The observed decrease showed that wheat flour serves as the major source of carbohydrate in bread. The result is in agreement with the report of Oluwalana *et al.* (2012) [40] for wheat-sweet potato composite flour breads. The energy content of the bread samples decreased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours to the products. The decrease in the energy content could be attributed to the low carbohydrate, protein and fat contents of the composite flours used for the production of the bread samples. The substitution of wheat flour with ground bean and sweet potato flours in bread making relatively improved the protein, ash, fat and crude fibre contents of the composite flour bread loaves compared to the wheat flour bread.

Table 1: Proximate composition (%) of bread loaves

Samples	% Substitution WF: GBF: SPF	Moisture	Protein	Ash	Crude fiber	Fat	Carbohydrate	Energy (KJ / 100 g)
A	100: 0: 0	$17.53^{e}\pm0.03$	$9.06^{f}\pm0.01$	$2.41^{f}\pm0.01$	$3.42^{f}\pm0.06$	$3.12^{f}\pm0.02$	$74.46^{a}\pm0.01$	$362.16^{a}\pm0.01$
B	90: 5: 5	$19.58^{d}\pm0.06$	$9.13^{e}\pm0.02$	$2.55^{e}\pm0.06$	$3.77^{e}\pm0.01$	$3.54^{e}\pm0.04$	$73.43^{b}\pm0.03$	$362.10^{b}\pm0.08$
C	80: 10: 10	$24.62^{c}\pm0.04$	$10.33^{d}\pm0.04$	$2.68^{d}\pm0.02$	$3.98^{d}\pm0.04$	$3.76^{d}\pm0.06$	$71.63^{c}\pm0.04$	$361.68^{c}\pm0.02$
D	70: 15: 15	$29.66^{c}\pm0.01$	$11.20^{c}\pm0.03$	$2.83^{c}\pm0.04$	$4.30^{c}\pm0.03$	$4.17^{c}\pm0.03$	$69.84^{d}\pm0.02$	$360.46^{d}\pm0.04$
E	60: 20: 20	$33.83^{b}\pm0.05$	$12.42^{b}\pm0.00$	$2.98^{b}\pm0.01$	$4.88^{b}\pm0.05$	$4.41^{b}\pm0.05$	$67.48^{e}\pm0.06$	$359.29^{e}\pm0.06$
F	50: 25: 25	$38.03^{a}\pm0.01$	$14.52^{a}\pm0.05$	$3.04^{a}\pm0.02$	$5.15^{a}\pm0.02$	$4.68^{a}\pm0.00$	$64.58^{f}\pm0.03$	$358.52^{f}\pm0.05$

Values are mean± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05). A- Bread made with 100% wheat flour. B- Bread made with 90% wheat flour, 5%ground bean flour and 5% sweet potato flour. C- Bread made with 80% wheat flour, 10% ground bean flour and 10% sweet potato flour. D- Bread made with 70% wheat flour, 15% ground bean flour and 15% sweet potato flour. E- Bread made with 60% wheat flour, 20% ground bean flour and 20% sweet potato flour. F- Bread made with 50% wheat flour, 25% ground bean flour and 25% sweet potato flour.
WF- Wheat Flour, GBF-Ground Bean Flour, SPF- Sweet Potato Flour

Mineral Composition of Bread Samples

The mineral composition of the bread samples are presented in Table 2. The calcium, potassium, phosphorus, magnesium, iron and zinc contents of the samples increased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours. The calcium content of the bread samples which ranged from 76.32-102.33 mg / 100 g increased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours. The control (100% wheat flour bread) had the least calcium content (76.32 mg / 100 g), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest value (102.33 mg / 100 g). The increase in calcium content is an indication that ground beans and sweet potatoes are good sources of calcium (Bampuori, 2007; Staniak *et al.*, 2014) [11, 52]. The values (76.32-102.33 mg / 100 g) obtained in this study were lower than the calcium content (163.43-177.33 mg / 100 g) of wheat-bean composite flour breads reported by Chikwendu *et al.* (2015) [16]. Calcium is important for proper development of bones and teeth in infants and young children (Okaka *et al.*, 2006) [36]. The potassium content of the bread samples which varied from 86.33 to 106.76mg/100g increased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours to the products. The control sample (100% wheat flour bread) had the least value (86.33 mg / 100 g), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest potassium content

(106.76 mg / 100 g). The values (86.33-106.76 mg / 100 g) obtained in this study were lower than the potassium content (177.56-188.40 mg / 100 g) reported by Onoja *et al.* (2014) [43] for breads made with blends of Orarudi (*Vigna sp.*) and wheat flour. Potassium is essential in blood clotting, muscle contraction and relaxation. The phosphorus content of the bread samples varied significantly (p<0.05) from 43.17 to 70.79 mg / 100 g with the control and the sample substituted with 25% ground bean and 25% sweet potato flours having the least (43.17 mg / 100 g) and highest (70.79 mg / 100 g) values, respectively. The increase in the phosphorus content of the composite flour breads is an indication that ground beans and sweet potatoes are good sources of phosphorus (Aremu *et al.*, 2006) [8]. Phosphorus is an important nutrient that plays a significant role in the formation of Adenosine Triphosphate (ATP) in the human body (Okaka *et al.*, 2006) [36]. The magnesium content of the bread samples which ranged from 92.14-112.15 mg / 100 g increased significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours. The control sample (100% wheat flour bread) had the least magnesium content (92.14mg/100g), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest value (112.15 mg / 100 g). The values (92.14-112.15 mg / 100 g) obtained in this study were higher than the magnesium content (24.07-57.12 mg / 100 g) of wheat-based bread substituted with legume, root, tuber and plantain flours reported by Onoja *et al.* (2011) [44]. Magnesium helps in reducing the incidence of migraine and heart attack in humans. The iron content of the bread samples which varied from 1.52 to2.05 mg / 100 g was found to increase with increase in the addition of ground bean and sweet potato flours to the products. The control sample (100% wheat flour bread) had the least iron content (1.52 mg / 100 g), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest value (2.05 mg / 100 g). The observed increase in iron content could be attributed to the addition of high amounts of ground bean and sweet potato flours which have high iron contents. Iron plays an important role in the prevention of anaemia in infants and young children. The zinc content of the bread samples ranged from 2.13 to 2.98 mg / 100 g with the control having the least value (2.13mg/100g), while the sample supplemented with 25% ground bean and 25% sweet potato flours had the highest zinc content (2.98 mg / 100 g). The zinc content of the bread samples was observed to increase steadily with increase in the addition of ground bean and sweet potato flours. Zinc supports normal growth and development during pregnancy, childhood and adolescence (Ravichandran *et al.*, 2010) [47]. The substitution of wheat flour with ground bean and sweet potato flours in the production of bread loaves greatly enhanced the mineral contents of the products.

Table 2: Mineral composition (mg/100g) of bread loaves

Samples % Substitution WF: GBF: SPF	Calcium	Potassium	Phosphorus	Magnesium	Iron	Zinc
A 100: 0: 0	76. 32^f±0.01	86.33^f±0.02	43.17^f±0.02	92.14^f±0.00	1.52^f±0.04	2.13^f±0.01
B 90: 5: 5	78.46^e±0.03	93.93^e±0.01	58.15^e±0.01	96.31^e±0.03	1.58^e±0.01	2.20^e±0.05
C 80: 10: 10	83.54^d±0.02	93.13^d±0.03	60.31^d±0.03	99.01^d±0.05	1.66^d±0.03	2.38^d±0.03
D 70: 15: 15	89.72^c±0.05	98.63^c±0.05	66.15^c±0.01	104.21^c±0.02	1.78^c±0.05	2.52^c±0.01
E 60: 20: 20	95.29^b±0.06	103.44^b±0.04	68.23^b±0.04	108.55^b±0.04	1.96^b±0.02	2.78^b±0.02
F 50: 25: 25	102.33^a±0.01	106.76^a ±0.03	70.79^a±0.01	112.15^a±0.03	2.05^a±0.01	2.98^a±0.04

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05) A- Bread made with 100% wheat flour. B- Bread made with 90% wheat flour, 5%ground bean flour and 5% sweet potato flour. C - Bread made with 80% wheat flour, 10% ground bean flour and 10% sweet potato flour. D- Bread made with 70% wheat flour, 15% ground bean flour and 15% sweet potato flour. E- Bread made with 60% wheat flour, 20% ground bean flour and 20% sweet potato flour. F- Bread made with 50% wheat flour, 25% ground bean flour and 25% sweet potato flour.
WF- Wheat Flour, GBF-Ground Bean Flour, SPF- Sweet Potato Flour

Vitamin Composition of Bread Samples

The vitamin composition of the bread samples are presented in Table 3. The thiamine, riboflavin, niacin, ascorbic acid, vitamin A and vitamin E contents of the bread samples increased sequentially with increase in substitution of ground bean and sweet potato flours in the products. The thiamine content of the bread samples varied from 42.17 to 59.19 mg / 100 g with the control and the sample substituted with 25% ground bean and 25% sweet potato flours having the least (42.17 mg / 100 g) and highest (59.19 mg / 100 g) values, respectively. The increase in thiamine content of the composite breads could be attributed to the addition of high proportions of ground bean and sweet potato flours to the samples. Ground beans and sweet potatoes have been reported to be good sources of thiamine (Lonsdale, 2006) [29]. Thiamine is essential for glucose metabolism, and it plays an important role in the proper functioning of the nerves, muscles and heart. The riboflavin content of the bread samples which ranged from 62.31 to 80.69 mg / 100 g increased significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours in the products. The control (100% wheat flour bread) had the least riboflavin content (62.31 mg / 100 g), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest value (80.69 mg / 100 g). The values (62.31-80.69 mg / 100 g) obtained in this study were higher than the riboflavin content (0.09-0.29) of wheat-bean composite flour breads reported by Chikwendu *et al.* (2015) [16]. Riboflavin helps in healthy maintenance of the eyes, nerves, muscles and skin. It is also necessary for growth and development in infants and young children. It is equally essential in the metabolism of protein, fat and carbohydrate in the body (Okwu, 2004) [37]. The niacin content of the bread samples ranged from 24.15 to 47.57 mg / 100 g. The sample substituted with 25% ground bean and 25% sweet potato flours had the highest niacin content (47.57 mg / 100 g), while the control sample (100% wheat flour bread) had the least value (24.15 mg / 100 g). The increase could be due to substitution effect which is an indication that ground beans and sweet potatoes are good sources of niacin (Hathorn *et al.*, 2008; Assogba *et al.*, 2015) [27, 9]. Niacin helps in maintenance of a healthy liver. It also acts as a component of the respiratory co-enzyme (NAD) that is responsible for tissue oxidation in human body. Niacin is also useful in lowering serum cholesterol and in reducing high blood pressure. It equally helps in the maintenance of nervous system. Poor bioavailability of niacin leads to the well-known niacin deficiency disease called pellagra (Campos-Vega *et al.*, 2010) [15]. The ascorbic acid content of the bread samples ranged from 12.15 to 12.74 mg / 100 g with the control having the least value (12.15 mg / 100 g), while the sample substituted with 255 ground bean and 25% sweet potato flours had the highest ascorbic acid content (12.74 m / 100 g). The observed increase could be attributed to the addition of high proportions of ground bean and sweet potato flours to the products. The observation is in agreement with the reports that ground beans and sweet potatoes are good sources of ascorbic acid (Oduro *et al.*, 2000; Oyetayo and Ajayi, 2005) [34, 46]. Ascorbic acid acts as an antioxidant, which helps in repair of worn-out tissues and in resistance of damaged cells and tissues to inflammation and oxidation. The vitamin A content of the bread samples increased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours to the products. The control sample (100% wheat flour bread) had the least value (18.32 mg / 100 g), while the sample substituted with 25% ground bean and 25% sweet potato flours had the highest vitamin A content (47.33mg/100g). The observed increase in the vitamin A content could be attributed to the addition of high amount of sweet potato flour in the sample and this is an indication that sweet potatoes are rich source of vitamin A. Vitamin A plays an important role in the maintenance of good sight. It also helps in the control and management of certain disease like cancer and diabetes in humans (Okaka *et al.*, 2006) [36]. The vitamin E content of the bread samples was found to increase with increase in substitution of ground bean and sweet potato flours from 15.31mg/100g for the control to 43.67mg/100g for the sample substituted with 25% ground bean and 25% sweet potato flours. The observed increase in the vitamin E content of the composite breads compared to the wheat flour bread is in agreement with the reports that ground beans and sweet potatoes are good sources of vitamin E (Oduro *et al.*, 2000; Aremu *et al.*, 2011) [36, 7]. Vitamin E is a potent chain–breaking antioxidant that inhibits the production of reactive oxygen species especially during the oxidation of fat and propagation of free radical reactions. The substitution of wheat flour with ground bean and sweet potato flours in the production of bread loaves greatly improved the vitamin contents of the samples.

Table 3: Vitamin composition (mg / 100 g) of bread loaves

Samples	% Substitution SF: AYBF: CF	Thiamine	Riboflavin	Niacin	Ascorbic acid	Vitamin A	Vitamin E
A	100: 0: 0	42.17^{f}±0.03	62.31^{f}±0.01	24.15^{f}±0.01	12.15^{e}±0.02	18.32^{f}±0.05	15.31^{f}±0.01
B	90: 5: 5	46.25^{e}±0.05	64.43^{e}±0.01	28.31^{e}±0.03	12.23^{d}±0.03	22.18^{e}±0.01	19.23^{e}±0.05
C	80: 10: 10	48.31^{d}±0.01	68.12^{d}±0.02	33.13^{d}±0.01	12.35^{c}±0.05	26.41^{d}±0.03	25.16^{d}±0.02
D	70: 15: 15	51.42^{c}±0.02	72.92^{c}±0.06	40.73^{c}±3.05	12.56^{b}±0.03	34.77^{c}±0.04	31.21^{c}±0.03
E	60: 20: 20	55.61^{b}±0.01	76.51^{b}±0.01	43.71^{b}±0.04	12.73^{a}±0.04	40.15^{b}±0.02	38.43^{b}±0.05
F	50: 25: 25	59.19^{a}±0.06	80.69^{a} ±0.04	46.57^{a}±0.02	12.74^{a}±0.01	47.33^{a}±0.01	43.67^{a}±0.04

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05). A- Bread made with 100% wheat flour. B- Bread made with 90% wheat flour, 5%ground bean flour and 5% sweet potato flour. C- Bread made with 80% wheat flour, 10% ground bean flour and 10% sweet potato flour. D- Bread made with 70% wheat flour, 15% ground bean flour and 15% sweet potato flour. E- Bread made with 60% wheat flour, 20% ground bean flour and 20% sweet potato flour. F- Bread made with 50% wheat flour, 25% ground bean flour and 25% sweet potato flour.
WF- Wheat Flour, GBF-Ground Bean Flour, SPF- Sweet Potato Flour

Physical Properties of Bread Samples

The physical properties of the bread samples are presented in Table 4. The loaf volume of the bread samples which ranged from 115.41 to 310.21 cm^3 was found to decrease significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours in the products. The control sample (100% wheat flour bread) had the highest loaf volume (310.21 cm^3), while the sample substituted with 25% ground bean and 25% sweet potato flours had the least value (115.41 cm^3). The decrease in the loaf volume could be attributed to the presence of little or no gluten in ground bean and sweet potato flours (Elleuch *et al.*, 2011) [21]. The loaf height of the bread samples decreased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours. The values (3.84 – 6.82 cm) obtained in this study were higher than the loaf height (2.54-5.68 cm) of wheat-sweet potato composite flour breads reported by Hathorn *et al.* (2008) [27]. The decrease in the loaf height could be attributed to increase in the amounts of ground bean and sweet potato flours added to the products. The result is in agreement with the findings of Malomo *et al.* (2012) [40] who reported similar decrease in loaf height of wheat flour breads substituted with bread fruit and breadnut flours. The loaf weight of the bread samples decreased significantly (p<0.05) with increase in substitution of ground bean and sweet potato flours. The decrease in the loaf weight could be attributed to decrease in carbondioxide retention capacity of composite flours compared to the wheat flour during fermentation and proofing operations (Shittu *et al*., 2007) [49]. The oven spring of the bread samples varied from 407.94 to 458.15 cm with the control sample (100% wheat flour bread) having the highest value (458.15 cm), while the sample substituted with 25% ground bean and 25% sweet potato flours had the least value (407.94 cm). The decrease in the oven spring of the composite bread samples could be attributed to the addition of high amounts of ground bean and sweet potato flours to the products which resulted in reduction of the gluten content of the wheat flour. The observation is in agreement with the report of Malomo *et al.* (2012) [40] for wheat-breadfruit-breadnut composite flour breads. The specific loaf volume of the bread samples which ranged from 0.26 to 0.76cm^3decreased significantly (p<0.05) with increase in the addition of ground bean and sweet potato flours to the products. The decrease in the specific loaf volume of the composite bread samples could be attributed to the absence of gluten protein in ground bean and sweet potato flours compared to the wheat flour which greatly affected their carbondioxide retention capacity during fermentation and proofing processes. The values (0.26-0.76 cm^3 / g) obtained in this study were lower than the specific loaf volume (1.20-3.86 cm^3 / g) of breads produced from blends of Orarudi' (*Vigna sp.*) and wheat flour reported by Onoja *et al.* (2011) [44]. The substitution of wheat flour with ground bean and sweet potato flours in the production of bread loaves generally reduced the physical properties of the products.

Table 4: Physical properties of bread loaves

Samples	% Substitution WF: GBF: SPF	Loaf Volume (cm^3)	Loaf Height (cm)	Loaf Weight (g)	Oven Spring(cm)	Specific Loaf Volume (cm^3/g)
A	100: 0: 0	$310.21^a \pm 0.02$	$6.82^a \pm 0.04$	$410.21^a \pm 0.01$	$458.15^a \pm 0.01$	$0.76^a \pm 0.05$
B	90: 5: 5	$282.15^b \pm 0.01$	$6.38^b \pm 0.02$	$398.52^b \pm 0.04$	$446.19^b \pm 0.02$	$0.68^b \pm 0.03$
C	80: 10: 10	$230.19^c \pm 0.03$	$5.86^c \pm 0.01$	$346.16^c \pm 0.01$	$434.31^c \pm 0.01$	$0.54^c \pm 0.01$
D	70: 15: 15	$210.31^d \pm 0.01$	$5.24^d \pm 0.03$	$318.31^d \pm 0.05$	$426.51^d \pm 0.03$	$0.44^d \pm 0.02$
E	60: 20: 20	$100.24^e \pm 0.05$	$4.78^e \pm 0.04$	$284.16^e \pm 0.01$	$418.21^e \pm 0.01$	$0.32^e \pm 0.00$
F	50: 25: 25	$115.41^f \pm 0.02$	$3.84^f \pm 0.01$	$246.31^f \pm 0.03$	$407.94^f \pm 0.07$	$0.26^f \pm 0.04$

Values are mean± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p< 0.05).A- Bread made with 100% wheat flour. B- Bread made with 90% wheat flour, 5%ground bean flour and 5% sweet potato flour. C- Bread made with 80% wheat flour, 10% ground bean flour and 10% sweet potato flour. D- Bread made with 70% wheat flour, 15% ground bean flour and 15% sweet potato flour. E- Bread made with 60% wheat flour, 20% ground bean flour and 20% sweet potato flour. F- Bread made with 50% wheat flour, 25% ground bean flour and 25% sweet potato flour.
WF- Wheat Flour, GBF-Ground Bean Flour, SPF- Sweet Potato Flour

Sensory properties of Bread Samples

The sensory properties of the bread samples are presented in Table 5. There were significant (p<0.05) differences between the control and composite bread samples in taste, texture, flavour, colour and overall acceptability. The result showed that the control sample (100% wheat flour bread) was the most acceptable to the judges followed by the sample substituted with 5% ground bean and 5% sweet potato flours. The increase in the addition of ground bean and sweet potato flours resulted in decrease in the acceptability of the composite bread samples as indicated by the low values of the samples in all the attributes evaluated. The colour of the composite bread samples was also affected by the addition of ground bean and sweet potato flours. The observed change in colour from light-brown in the control sample to darker-brown in the sample substituted with 25% ground bean and 25% sweet potato flours, could be attributed to Maillard browning reaction caused by the reaction between the amino acids of the proteins and added sugar and caramelization which are both influenced by the distribution of water (Fayle and Gerrard, 2002; Onimawo and Akubor, 2005) [24, 41]. Maillard reaction is reported to be related to temperature, time and presence of moisture (Ballolli *et al.*, 2014) [14]. Colour serves as an important consumer appeal factor for the initial acceptability of the baked product. The result of the sensory scores revealed that the panelists showed preference to the colour, taste, texture and flavour of the control sample (100% wheat flour bread) compared to the composite flour breads which differed significantly (p<0.05) from the control in all the parameters evaluated. However, the substitution of wheat flour with ground bean and sweet potato flours at the levels of 5-25% and 5-25%, respectively could be used in the production of good and organoleptically acceptable bread loaves because the composite flour bread samples were equally rated high in all the sensory attributes evaluated by the judges.

Table 5: Sensory properties of bread loaves

Samples	% Substitution WF:GBF:SPF	Colour	Texture	Taste	Flavour	Overall Acceptability
A	100: 0: 0	$7.45^a \pm 1.06$	$7.40^a \pm 1.02$	$7.65^a \pm 1.04$	$7.55^a \pm 1.02$	$7.85^a \pm 1.02$
B	90: 5: 5	$7.39^b \pm 1.01$	$7.35^b \pm 1.00$	$7.58^b \pm 0.03$	$7.45^b \pm 1.00$	$7.75^b \pm 1.03$
C	80: 10: 10	$7.25^c \pm 1.04$	$6.85^c \pm 1.02$	$7.45^c \pm 1.02$	$7.25^c \pm 1.05$	$6.35^c \pm 1.01$
D	70: 15: 15	$6.99^d \pm 1.03$	$6.60^d \pm 1.03$	$6.30^d \pm 1.03$	$6.40^d \pm 1.03$	$6.15^d \pm 1.04$
E	60: 20: 20	$6.50^e \pm 1.01$	$6.10^e \pm 1.02$	$5.70^e \pm 1.05$	$6.10^e \pm 1.06$	$5.40^e \pm 1.05$
F	50: 25: 25	$5.45^f \pm 0.04$	$5.70^f \pm 1.07$	$5.05^f \pm 1.03$	$5.70^f \pm 1.02$	$5.17^f \pm 1.03$

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).A- Bread made with 100% wheat flour. B- Bread made with 90% wheat flour, 5% ground bean flour and 5% sweet potato flour. C- Bread made with 80% wheat flour, 10% ground bean flour and 10% sweet potato flour. D- Bread made with 70% wheat flour, 15% ground bean flour and 15% sweet potato flour. E - Bread made with 60% wheat flour, 20% ground bean flour and 20% sweet potato flour. F- Bread made with 50% wheat flour, 25% ground bean flour and 25% sweet potato flour.
WF- Wheat Flour, GBF-Ground Bean Flour, SPF- Sweet Potato Flour

Conclusion

The study showed that the substitution of wheat flour with ground bean and sweet potato flours could be used to produce nutritious and organoleptically acceptable bread loaves. The production of bread from wheat, ground bean and sweet potato composite flours greatly improved the protein, ash, crude fibre, calcium, iron, phosphorus, magnesium, potassium and zinc contents of the composite flour breads. The thiamine, niacin, riboflavin, ascorbic acid, vitamin A and vitamin E contents of the composite breads also increased with increase in the addition of various proportions of ground bean and sweet potato flours to the products. The physical properties of the samples also showed that the loaf volume, loaf height, weight, oven spring and specific loaf volume of the composite breads decreased gradually with increase in substitution of ground bean and sweet potato flours in the products. The sensory properties of the samples equally showed similar decrease in the acceptability of composite bread loaves as the levels of substitution of ground bean and sweet potato flours increased. Generally, the control sample (100% wheat flour bread) was organoleptically the most acceptable compared to the composite flour bread loaves. However, the composite flour bread samples were equally rated high by the panelists but the sample substituted with 5% ground bean and 5% sweet potato flours were organoleptically more acceptable compared to the other test samples.

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