QUALITY EVALUATION OF FUNCTIONAL BREAD PRODUCED FROM BLENDS OF WHEAT AND *SOY-OKARA* FLOUR

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ABSTRACT

This present study evaluated the quality attributes of functional bread developed from the blends of wheat and *soy-okara* (SOF) flour. A completely randomized design which generated six (6) experimental runs based on different combinations of wheat (60–90%) and soy-okara (10–40%) flours was adopted for the production of functional bread. The flour blends were processed into bread and analyzed for sensory properties. The optimum flour combination in obtaining higher sensory acceptability was 85.34% WHF and 14.66% SOF with desirability function of 85% using numerical optimization techniques. The control (100% whole-wheat bread) and optimized bread produced were assessed for physicochemical, antioxidant properties and sensory qualities. The carbohydrate, calcium, phosphorus, and sodium of the optimized bread were significantly higher ($p<0.05$) than in the control sample having 58.14 and 75.14%, 128.80, and 75.60 mg/100 g, 68.18 and 63.77 and 13.83 ppm and 12.62 ppm respectively. The total flavonoid and phenolic contents of the control and optimized bread were significantly ($p<0.05$) different with values ranging from 92.77 to 114.86 mg/100 g and 66.43 to 57.51 mg/100 g respectively. A significant variation was observed in the sensory qualities between the control and optimized bread. The study revealed that the nutritional and antioxidant properties of the developed functional bread validate its potential health-promoting effects.

Keys: *Quality Evaluation, Functional Bread, Wheat, Soy-Okara, optimized bread*

Introduction

Bread as a baked product is a fermented and leavened confectionery product produced from wheat flour as the basic ingredient with the addition of other ingredients such as yeast, salt, sugar and water. It is known as an important source of carbohydrate in the food pyramid because it is capable of supplying all the nutrition needed by the body. It is one of the oldest and convenient foods widely consumed by the general populace in the world, cutting across all the socio-economic classes and it is acceptable to both children and adults. In Nigeria, it is reported that bread is widely consumed as the second most widely consumed non-indigenous staple food after rice (Nwakaegho *et al.*, 2017). The report indicated that about 6.2 billion loaves (or 5.2 million tons) of bread are supplied into the Nigerian market annually through domestic production in over 20,000 bakeries in Nigeria and through influx from neighboring countries (Nwakaegho *et al.*, 2017).
Wheat flour (*Triticum aestivum*) is the ancient and important flour used for bread making due to its unique baking qualities namely dough extensibility and viscoelasticity structure which is related to the presence of its constituent gluten protein (Grundas, 2003). However, bread made from refined wheat flour is characterized by low nutritional value and antioxidant potential as a result of milling processes

and would therefore be a notable dietary intervention requiring the incorporation of functional ingredients to improve its health benefits (Dziki *et al*., 2014). The development of functional bread using bioactive ingredients such as protein, dietary fiber and phenolic antioxidant and improving nutritional quality had been well studied (Dooshima *et al*., 2014; MikušováLucia *et al*., 2013).

Several kinds of research have established increased demand and consumption of functional bread because of its therapeutic benefits (De Escalada *et al*., 2007). Several reports confirmed that the development and consumption of such functional foods would not only improve the nutritional status of consumers but also help to prevent the risk of some degenerative diseases such as celiac disease which have been associated with modern lifestyles (Saleh *et al*., 2013; Olaiya *et al*., 2016). Therefore, bread can be considered an ideal matrix by which functionality could be delivered to consumers with appealing organoleptic properties.

The fortification of wheat-based products with other food sources is gradually gaining ground with a view of providing improved essential amino acid balance, combat protein calorie malnutrition and micronutrient deficiency. Fortification has also been employed to reduce total dependence on wheat flour which happens to be imported into countries that have unfavourable weather conditions for the cultivation of wheat. Several studies have been carried out with the view of enhancing the nutritional properties of pasta products by partially substituting wheat flour with legume, tubers, fruits and nuts flours.

Okara is a semi-solid residue obtained as a chaff from soymilk or *tofu* production. It is a bye-product previously regarded as agro-waste useful as animal feed or green-manure for farmers. Today, research has shown that okara is a pulpy, fiber-rich biomolecule, composed of cellulose, hemicellulose and lignin, as well as protein, lipids, vitamins, phytochemicals and phytosterols with modern usage (Pan *et al*., 2018; Porcel *et al*., 2017). It can be used directly in soups or salads. Okara is characterized by a light-yellow colour, mild and neutral flavour and low energy potential (2.78–3.28 kcal/g fresh matter) (Ostermann-Porcel *et al*., 2017a; Stanojevic *et al*., 2013). The dietary fiber and protein content in okara can prolong freshness of baked products which is based on their ability to retain water (Fendri *et al*., 2016). Thus, the aim of this study was to produce soy okara-enriched wheat-bread.

Material and methods

Raw materials

Market branded wheat (white) flour (*Triticum aestivum*), whole-wheat meal flour (market brand), and all other baking ingredients including granulated sugar (Dangote Group Nigeria), baking fat (topper margarine), instant dry yeast (STK Royal brand) and salt (Dangote Group, Nigeria) were procured from Ogbete main market Enugu, Enugu State, Nigeria.

Flour preparation

Soybean residue (okara) flour

The method described by Ibidapo *et al*. (2019) was adopted for soymilk processing. The soybean seeds *(Glycine max)* were thoroughly sorted, cleaned and washed in potable water. The cleaned beans were blanched in hot water for 30 min at 100 °C and thereafter de-hulled. The de-hulled cotyledons were wet-milled using ratio 1:5 (w/v). The slurry obtained was mixed and sieved using a clean muslin cloth to separate the milk and the sediment which was the pulpy residue called *okara*. The fresh pulpy *okara* was allowed to dry for 12 h in a cabinet dryer at 60 °C. The dried *okara* was pulverized into flour and stored in polyethylene pouch for further use.

Experimental design

A simplex-centroid mixture design (Design-Expert 6 (Stat-Ease Inc) was used to obtain different mixture ratio of the two flour components (wheat flour and *okara* flour) for the production of the composite functional bread. Wheat and *okara* flour were made into composite flour according to proportions in the mixture design matrix (Table 1) created with Design Expert 6.0.8 (Stat-Ease Inc). The portions of wheat and *okara* flours were thoroughly mixed in a high-speed laboratory mixer (Hobart mixer) to obtain homogenous blends which were consequently used for bread production. Wheat flour was well blended with okara as a protein source to produce individual mixtures containing 10, 20, 30 and 40% replacement levels. All samples were stored in airtight containers and kept at 4°C until required.

Table 1: Composition of the different formulations based on experimental design.

Experimental Run	Wheat flour	Soy-Okara flour
1	100	0.0
2	90	10.0
3	80	20.0
4	70	30.0
5	60	40.0

Optimum mixture combination for the formulation of functional bread

The generated 4 runs of flour mixture formulations were used to produce bread samples and sensory evaluation was conducted on the formulated bread samples using 9-point hedonic scale to measure its acceptability. The optimum levels of the mixture components for the functional bread were obtained using the numerical optimization technique. This technique searches the design space, using the models created during analysis to find factor settings that meet the defined goals. The numerical criteria were set to maximize the values for all the tested parameters. In order to obtain an optimum sample, a multiple response method called desirability function was applied. The predicted optimum formulation satisfying the optimization criteria was obtained as 85.34% WHF and 14.66% SOF with desirability function of 85%. The selected mixture component was reformulated to produce optimized bread with higher sensorial acceptability. The selected optimized bread was thereafter compared with a control sample (whole-wheat bread), which was produced using whole meal flour (Honeywell brand).

Bread preparation

The straight-dough method by (Chauhan *et al*., 1992) was used to prepare five different samples of bread, of which four were having varying amounts of wheat and *soy-okara* flours. The sample with 100% wheat flour served as the control. All the ingredients (flour, salt, sugar, yeast and water etc.) were mixed thoroughly to form the dough. The dough was adequately kneaded to smooth consistently, divided into equal sized pieces, moulded and transferred into clean baking pans that have its inside walls smeared with vegetable oil. The dough was allowed to proof at ambient temperature and then baked at 220ºC for 45 min and thereafter cooled.

Proximate Composition of the Bread Samples

The moisture content, ash, crude fibre, crude protein and fat content of the bread produced from wheat, water yam and brown hamburger bean were determined using the method of AOAC (2010). Total carbohydrate was calculated by difference. The caloric value was determined using the Atwater factors of protein (4), fat (9), and carbohydrate (4). These factors were used to multiply the values determined for the stated nutrients and the sum total of the multiplied values recorded.

Determination of Micronutrient Composition

The vitamins (B-complexes, A, C) and some mineral elements (Ca, K, Na, Mg, Fe, Zn and P) were determined by the method of AOAC (2010) using the Atomic Absorption Spectrophotometer (AA 800 Perkin-Elmer Germany).

Physical Properties of Bread Loaves

The physical properties of bread loaves were determined by the method of AACC (2000). Bread loaves were weighed after baking using the electronic weighing balance and the loaf weights were recorded in grams. The bread loaf height was measured by using a measuring ruler. The loaf volume was determined using the Rape seed displacement method. The specific volume was calculated as loaf volume divided by loaf weight (cm^3/g).

Determination of antioxidant properties

Measurement of radical scavenging activity using 1, 1-diphenyl-2-picrylhydrazyl (DPPH)

The free radical scavenging effect of the bread extract was determined using the DPPH free radical method as described by Ojewunmi *et al.* (2013). The activity of the test sample was determined by the level of reduction of DPPH radical which indicated its level of inhibition which increased with an increasing percentage of the free radical inhibition. DPPH free radical scavenging activity was expressed as the percentage of scavenging activity and studied at five different concentrations (20 μg/ml, 40 μg/ml, 60 μg/ml, 80 μg/ml and 100 μg/ml). The scavenging effect was calculated using the expression: % inhibition = $[A_0 - A_1] / A_0 \times 100$

Where:

A_0 is the absorption of the blank sample and

A_1 is the absorption of the extract Ascorbic acid was used as a standard.

Determination of total flavonoid content

The total flavonoid content of the extract was estimated using aluminum chloride method as described by Chang *et al.* (2002) using ascorbic acid as the reference standard and the total flavonoid content was expressed as mg ascorbic acid /g of extract.

Determination of total phenolic content

The amount of total phenol was determined using the analytical procedure described by Slinkard and Singleton (1977) in which Folin-Ciocalteau reagents were used with Gallic acid as a standard phenolic compound.

Sensory evaluation

The bread samples were presented to a 10-member panel of Judges that comprised of the students and staff of the Department of Food Science and Technology, Enugu State University of Science and Technology (ESUT) Enugu, Enugu State, Nigeria. The samples were assessed for crust appearance, crumb colour, crumb texture, aroma, and overall acceptability using a nine-point hedonic scale, where 9 indicated "liked extremely" and 1 indicated "dislike extremely" according to Ihekoronye and Ngody (1985).

Statistical analysis

The data generated were subjected to one-way analysis of variance (ANOVA) using Special Package for Social Science (SPSS Version 20) software. Duncan's New multiple range test was used to separate significant difference at $p<0.05$.

RESULTS AND DISCUSSION

Table 2: Preliminary Sensory Properties of Composite Bread Samples

Samples	Crumb Appearance	Crumb Colour	Flavour	Taste	Mouthfeel	Overall Acceptability
A	$7.60^{a}\pm0.10$	$8.10^{a}\pm0.10$	$7.45^{a}\pm0.3$	$8.40^{a}\pm0.3$	$8.30^{a}\pm0.1$	$8.05^{a}\pm0.3$
B	$6.50^{b}\pm0.2$	$6.75^{b}\pm0.2$	$6.15^{b}\pm0.1$	$6.20^{b}\pm0.4$	$6.45^{b}\pm0.1$	$6.05^{b}\pm0.3$
C	$5.40^{c}\pm0.2$	$5.80^{c}\pm0.2$	$5.75^{c}\pm0.3$	$5.80^{c}\pm0.2$	$5.75^{c}\pm0.4$	$5.75^{c}\pm0.07$
D	$5.30^{d}\pm0.2$	$5.40^{d}\pm0.2$	$5.65^{d}\pm0.2$	$5.60^{d}\pm0.3$	$5.30^{d}\pm0.4$	$5.50^{d}\pm0.1$
E	$5.25^{e}\pm0.07$	$5.20^{e}\pm0.07$	$5.10^{e}\pm0.3$	$5.55^{e}\pm0.2$	$5.10^{e}\pm0.4$	$5.40^{e}\pm0.4$
F	$5.10^{f}\pm0.05$	$5.05^{f}\pm0.05$	$5.00^{f}\pm0.4$	$5.40^{f}\pm0.2$	$5.05^{f}\pm0.4$	$5.10^{f}\pm0.2$

Values are expressed as mean ± standard deviation. Values with different superscript within the column are significantly different (p<0.05).
100:0 = 100% wheat flour; 90:10 = 90% wheat flour and 10% soy-okara; 80:20 = 80% wheat flour and 20% soy-okara; 70:30 soy-okara and 60:40 = 60% wheat flour and 40% soy-okara.

Preliminary Sensory Properties of Bread Samples from the Composite Blends

The sensory evaluation of the composite bread samples was presented in Table 2. Mean sensory scores of the bread samples is shown in Table 2. Appearance is an important attribute of food because it evokes the initial acceptance or rejection, which influences the reactions or impression of a consumer (Molnar, 2019). The values obtained for the appearance of the different bread samples ranged from 5.10 to 7.60. Significant (p<0.05) differences were observed among the samples. The scores for the appearance showed that as the sample E with the highest inclusion of soy-okara has the least score from the panelists. This is probably due to the high fibre content of the soy-okara flour which resulted in samples that lacked a smooth appearance.
The crumb colour ranged from 5.05 to 8.10. There was significant difference (p<0.05) among the samples in terms of colour. Addition of soy-okara flour reduced the colour of the bread samples. Despite the high nutritionally quality of soy-okara flour, its flours colour could not compete favourably with whole-wheat in bread products of its fibrous nature that prolongs baking time. Similar results were reported by Olanipekun *et al.* (2018) who pointed out that the incorporation of other types of flours in the manufacture of wheat bread affects the organoleptic properties of the breads produced. Colour is a key parameter in evaluating a well prepared and baked food products.

The flavour of a food is described as the delicate yet complicated interplay of taste and smell that gives each person a pleasant or unpleasant sensory experience, although, the appearance of the meal elicits initial reaction, it is the taste that eventually decides whether a consumer accepts or rejects it (Akubor and Badifu, 2014). The flavour scores of the bread samples ranged from 5.00 to 7.45. There was a significant difference (p<0.05) among the samples in terms of flavour such that the control sample (100% wheat bread) had the highest score (8.45) while sample E (60% wheat flour and 40% soy-okara flour) had the least score (5.00). Thus, the samples with reduced soy-okara flour were preferred. Maillard reaction takes place during baking, the sugars react with the amino acids to produce a high pleasant and detectable aroma.

According to Meilgaard *et al.* (2017), some factors influence taste perception, these factors include, age, hunger, health condition, adaptation to a given taste and medium. The taste scores of the bread samples ranged from 5.40 to 8.40. There was a significant difference ($p<0.05$) among the samples such that the highest taste score was observed in bread made with 100% wheat. This is quite explainable because wheat has been the major flour for bread making therefore influencing the sensory judgment of the panelists and also due to individual preferences and the afore-mentioned factors. Taste is the desirable quality of the foods. This is also where the judges sample the food orally.

The physical feeling in the mouth created by food or drink is referred to as mouthfeel, which can also be termed texture (Mouristen and Styrbeak, 2017). Mouthfeel involves; graininess, heaviness and slipperiness among other feelings. The values obtained for the mouthfeel of the bread samples increases from 5.05 to 8.30. There was significant difference ($p<0.05$) among the samples in terms of texture such that the control sample (100% wheat bread) had the highest score (8.30). The texture of the bread samples talks about the physical feel of the food. This defines the smoothness or roughness of the food when eaten. The texture scores have shown that high amount of soy-okara flour (up to 15% each) in bread products will affect the texture of the bread. However, very pleasant texture was observed in the breads obtained with an incorporation rate of soy-okara flour up to 10% each. The same remarks were reported by Ouazib (2017) during the evaluation of the effect of the partial substitution of wheat flour by chickpea flour on bread quality.

Overall acceptability (OA) scores ranged from 5.10 to 8.05. There was significant difference ($P<0.05$) among the samples such the control sample (100% wheat bread) had the highest score (8.35). The 100% whole wheat bread was scored highest and most preferred than all the other substituted samples. This is based on the fact that wheat has been the major flour for bread making therefore influencing the sensory judgment of the panelists. High overall acceptability values indicates that the product has good chances of being patronized by consumers when launched in the market. Generally, the result of the sensory evaluation has shown that delicious and appealing bread samples can be obtained with an incorporation rate of soy-okara flour up to 15% each.

Table 3: Proximate composition of control and optimized bread.

Parameters	Control sample (%)	Optimized sample (%)
Moisture content	25.65 ± 0.01	27.18 ± 0.02
Crude protein	9.33 ± 0.03	14.64 ± 0.02
Crude fat	3.68 ± 0.02	5.72 ± 0.01
Crude fibre	3.32 ± 0.03	7.87 ± 0.0
Ash	1.99 ± 0.03	2.41 ± 0.02
Carbohydrate	75.14 ± 0.0	58.14 ± 0.03
Energy (kCal/100g)	281.65 ± 0.02	266.55 ± 0.02

Results are expressed as means ± standard deviation (SD) of the triplicate determinations. * Significantly different ($p \leq 0.05$).

Proximate composition

The optimized bread recorded significantly ($p \leq 0.05$) higher moisture content (27.18%) than the control bread sample (25.65%) as indicated in Table 3. It was observed that there was greater retention of moisture in the optimized bread sample than in the control sample. This increased moisture content might probably be due to the formation of strong hydrogen bonding between the hydroxyl groups of fibre structure and the free water molecules which contributed to increased water retention of the product (Boulos *et al.*, 2000). Crude protein was detected to be significantly increased in the optimized bread (14.64%) compared to the control bread sample (9.33%). Increased protein in the optimized bread sample than the control sample could be attributable to the significant quantity of protein in *okara* flour. This result is in agreement with the study conducted by Wickramarathna and Arampath (2003). The total dietary fiber content obtained for the control sample (3.32%) was significantly lower ($p < 0.05$) than the optimized bread sample (7.87%). This increased dietary fiber content in the optimized bread is due to the significant quantity of soluble and insoluble dietary fiber in *okara*. This suggests that the optimized bread could be considered as functional bread as it contained significantly higher dietary fiber. Studies have shown that consumption of high dietary fiber foods has been associated with some physiological benefits such as weight management, gut and digestive health, hypochlesterolemic and anticancer effects as well as high satiety value and lipid metabolism (Jiefen *et al.*, 2019). Results obtained revealed significantly higher values of chemical composition in the optimized bread compared with the control sample except for carbohydrates and the energy values.

Table 4: Mineral element composition of control and optimized bread.

Mineral (mg/100g)	Control bread	Optimized bread
Calcium	75.60 ± 0.0	128.80 ± 0.01
Magnesium	35.25 ± 0.02	34.05 ± 0.0
Zinc	0.56 ± 0.01	0.81 ± 0.01
Phosphorus	63.77 ± 0.02	68.18 ± 0.01
Sodium (ppm)	12.62 ± 0.01	13.83 ± 0.00
Potassium (ppm)	27.95 ± 0.0	23.92 ± 0.03

Results are expressed as means ± standard deviation (SD) of the triplicate determinations. *Significantly different ($p \leq 0.05$).

Mineral composition

The mineral profile of the control and optimized bread samples is displayed in Table 4. Results obtained indicated a significantly ($p > 0.05$) higher content of calcium in the optimized bread 128.80 mg/100 g than in the control sample. The sodium content of the optimized sample differed significantly ($p \leq 0.05$) compared to the control bread sample. Results showed that the optimized bread had significantly higher ($p > 0.05$) phosphorus content 68.18 ± 0.06 mg/100 g than the control sample (63.77 mg/100 g). Conversely, the potassium content of the control bread sample was significantly ($p < 0.05$) higher (69.88 mg/100 g) than the optimized sample which is 59.79 mg/100 g. The significantly higher calcium, phosphorus, and sodium content of the optimized bread than the control sample can be linked to the fact that raw *okara* had the highest concentration of these elements. A similar observation was reported by Dhingra and Jood (2001) who obtained calcium content of 40 mg/100 g, in 10% soy-okara flour inclusion wheat bread. It was observed that the magnesium content of the control sample (35.25 mg/100 g) was greater than the optimized (34.05 mg/100 g) but not statistically different. Also, it was observed that both the control and optimized bread samples were significantly rich in magnesium and potassium. Magnesium helps in maintaining a healthy heartbeat while potassium is a principal intracellular cation in body tissues which helps in regulating fluid balance and nerve signals. Hence, bread that is rich in magnesium could be an asset for cardiovascular health.

Physical characteristics

The loaf weight, volume and specific loaf volume of control and optimized bread samples were depicted in Table 5. Significant differences ($p < 0.05$) existed in both the loaf volume and specific loaf volume of the optimized bread sample compared with the control. The values are 1104.65 and 968.40 cm^3 respectively while the specific loaf volume is 4.01 and 3.46 cm^3/g respectively. The loaf volume and specific volume decreased significantly ($p < 0.05$) in the optimized bread and this might probably be due to dilution of gluten with the non-gluten protein of *okara* thereby reducing the bread volume which was as a result of reduced carbon dioxide gas formation and retention during dough fermentation (Igbabul *et al.*, 2014).

Table 5: Physical characteristics of control and optimized bread.

Parameters	Control sample	Optimized sample
Loaf weight (g)	268.66 ± 0.47	266.33 ± 1.25
Loaf volume(cm^3)	1104.65 ± 07.14	968.40 ± 1.79
Specific loaf volume (cm^3/g)	4.01 ± 0.17	3.46 ± 0.03

Results are expressed as means ± standard deviation (SD) of the triplicate determinations.
*Significantly different ($p \leq 0.05$).

Antioxidant properties of the control and optimized bread samples

The percentage scavenging activity of the control and optimized samples ranged from 34.08 to 70.74 and 23.63 to 78.34% respectively, while the standard (ascorbic acid) showed significantly highest (p<0.05) percentage radical scavenging activity ranging from 48.42 to 85.20%. The optimized bread showed a higher percentage of DPPH free radical scavenging activity (78.34%) than the control bread (70.74%) at 100 µg/ml. This compared favorably with reference standard ascorbic acid. Higher DPPH value indicates higher antioxidant activity. This high DPPH scavenging activity recorded in the optimized bread may be attributed to the presence of phenolic and flavonoids compounds and some Maillard reaction products produced during baking. The finding aligned with the study of Musarat *et al.* (2016) who reported increased DPPH radical scavenging activity of cookies produced from wheat and water chestnut flour blends.

The optimized bread exhibited significantly higher ($p < 0.05$) total flavonoid content (114.86 mg/100 g) than the control sample having 92.77 mg/100 g as depicted in Table 6. On the other hand, the control sample recorded a significant ($p < 0.05$) higher total phenolic content of 66.43 mg/100 g than the optimized sample of 57.51 mg/100 g. This implied that the higher flavonoid content of the optimized sample can be linked to higher antioxidant activity as measured by DPPH radical scavenging activity. This obtained result agreed with Mikušová *et al.* (2013) who observed higher antioxidant activity in terms of flavonoid and dietary fiber contents of designed functional bread. Phytochemical evaluation studies have shown that phenolic compounds had been implicated in the reduction of cardiovascular diseases and the prevention of other degenerative diseases as well as contributing to antioxidant properties (Nambiar *et al.*, 2012; Taylor *et al.*, 2015). Antioxidant activity is considered a critical factor among others in determining the health-promoting effects of food materials.

Table 6: Antioxidant properties of control and optimized bread.

Antioxidant property (mg/100g)	Control sample	Optimized sample
Total Flavonoid content	92.77 ± 0.03	114.86 ±0.01
Total Phenolic Content	66.43 ± 0.02	57.51 ±0.0
Total Antioxidant capacity	52.44 ± 0.01	60.53 ± 0.04

Results are expressed as means ± standard deviation (SD) of the triplicate determinations. *Significantly different ($p \leq 0.05$).

Table 7: Sensory properties of control and optimized bread

Samples	Crumb Appearance	Crumb Colour	Flavour	Taste	Mouthfeel	Overall Acceptability
Control bread	$7.60^a \pm 0.10$	$8.10^a \pm 0.10$	$7.45^a \pm 0.3$	$8.40^a \pm 0.3$	$8.30^a \pm 0.1$	$8.05^a \pm 0.3$
Optimized bread	$7.10^b \pm 0.2$	$7.45^b \pm 0.2$	$7.85^b \pm 0.1$	$6.20^b \pm 0.4$	$6.85^b \pm 0.1$	$7.05^b \pm 0.3$

Results are expressed as means ± standard deviation (SD) of the 10-panalist score. *Significantly different ($p \leq 0.05$).

Sensory profiling of control and optimized bread

The sensory property of the control and optimized bread samples is shown in Table 7. The results obtained showed that there were significant differences ($p > 0.05$) in the sensory properties of the test bread samples.
A significant variation ($p<0.05$) was observed in the sweetness and denseness intensity between the control and optimized bread.
The values obtained for the appearance between the control and optimized bread ranged from 7.10 to 7.60. Significant (p<0.05) differences were observed among the samples. The scores for the appearance showed that optimized bread competes favourably with the control sample.
The crumb colour ranged from 7.45 to 8.10. There was significant difference (p<0.05) among the samples in terms of colour. Addition of soy-okara flour did not impact much changes in the colour ratings.

The flavour scores of the bread samples ranged from 7.45 to 7.45. There was a significant difference (p<0.05) among the samples in terms of flavour such that the optimized bread sample scored higher (7.85) than the control bread. Thus, the optimized bread sample was preferred.

The taste scores of the bread samples ranged from 6.20 to 8.40. There was a significant difference (p<0.05) among the samples such that the highest taste score was observed in control bread sample. The reduced sweetness intensity obtained in the optimized bread might be due to the higher protein content in which the *okara* protein reacted with the sugar in the bread to form Maillard reaction products, thus decreasing the level of sweetness. Additionally, the higher fiber content might contribute to reduced sweetness scores in that there might have been interaction between sucrose and *okara* fiber in the bread causing the sweetness to be masked thereby reducing its ability to elicit a sweet taste.

The values obtained for the mouthfeel of the bread samples increases from 6.85 to 8.30. There was significant difference (p<0.05) among the samples in terms of texture such that the control sample had the highest score (8.30). The texture of the bread samples talks about the physical feel of the food. However, very pleasant texture was observed in the optimized bread obtained with an incorporation rate of soy-okara flour. The same remarks were reported by Ouazib (2017) during the evaluation of the effect of the partial substitution of wheat flour by chickpea flour on bread quality.

Overall acceptability (OA) scores ranged from 7.05 to 8.05. There was significant difference (P<0.05) among the samples such the control sample (100% wheat bread) had the highest score (8.05). The 100% whole wheat bread was scored highest and most preferred than the optimized bread. This is based on the fact that wheat has been the major flour for bread making therefore influencing the sensory judgment of the panelists. Generally, the result of the sensory evaluation has shown that delicious and appealing bread samples can be obtained with an optimized formulation.

Conclusions

The present research study has revealed that acceptable functional bread could be produced from blends of wheat and *soy-okara* flour using simplex centroid mixture design. The functional bread possessed increased protein, calcium, magnesium, phosphorus, and sodium contents than the control sample. Therefore, these significant nutritional qualities and antioxidant properties possessed by the functional bread substantiate its potential health-promoting effects.

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