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PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF WHEAT-SOYBEAN COMPOSITE FLOUR BREADS

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The proximate composition, physical and sensory properties of breads supplemented with soybean flour were investigated. Soybean flour was prepared and used at varying replacement levels (10-40%) for wheat flour in the production of wheat-soybean composite flour breads with 100% wheat flour bread loaves as control. The proximate, physical and sensory properties of the bread samples were determined using standard methods. The crude protein, fat, crude fibre and ash contents of the bread samples increased significantly ($p<0.05$) with increase in soybean flour substitution from 8.48-39.07%, 8.09-12.04%, 4.23-6.32%, 3.40-5.70% and 1.83-2.68%, respectively, while the carbohydrate content decreased from 53.92-34.40%. The physical properties of the bread samples decreased significantly ($p<0.05$) with increase in substitution with soybean flour from 310.00-110.00 cm^3 (loaf volume), 7.16-3.85 cm (loaf height), 397.00-393.00 g (loaf weight), 460.00-400.00 cm (oven spring) and 0.78-0.28 cm^3/g (specific loaf volume), respectively. The level of likeness of the sensory attributes: taste, texture, flavour, crust colour and overall acceptability of the wheat-soybean composite bread samples reduced gradually with increased substitution of soybean flour. However, the study showed that the nutrient content, physical and sensory properties of wheat flour bread could be improved by substituting wheat flour with soybean flour at the levels of 10-30%, thus providing an alternative means of diversifying the use of non-wheat flour in bread production.

Keywords: Bread, Wheat flour, Soybean flour, Proximate composition, Physical quality, Sensory properties

INTRODUCTION

In developing countries, legumes have high acceptability and utilization due to their importance as good sources of dietary protein. Legumes are consumed worldwide, especially in developing and under developed countries where the consumption of animal protein may be limited as a result of economic, social, religious or cultural factors (Okoye and Obi, 2017). However, the use of legumes as protein source is limited by the presence of anti-nutrients or toxic substances which interfere with digestive processes and prevent efficient utilization of their proteins. To improve the nutritional quality and organoleptic acceptability of leguminous seeds, the anti-nutrients such as protease inhibitors, haemagglutinins, saponins, oxalates, phytates, lectins and flatulence factors which are naturally present in them can be reduced or inactivated by the use of simple processing techniques such as wet cooking, soaking in water, roasting, germination, autoclaving, steam blanching, microwave treatment, fermentation and dehulling (Aremu *et al.*, 2011; and Okorie, 2013).

Soybean (*Glycine max)* is one of the well known and utilized legumes that serves as a good source of plant protein that can be used to improve the nutritional status of people in developing countries, especially the poor and low income earners because of its high protein content (Jideani and Onwubali, 2009). The seeds of soybean are relatively high

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in protein, fat, vitamins and minerals. Soybean is also rich in calcium, iron, potassium and phosphorus. It is the only vegetable source of protein that contains all the essential amino acids (Edema *et al.,* 2005).

Soybean seeds can be processed into paste, flour, protein isolates and concentrates that can be used for the preparation of different types of baked products (Mohsen *et al.,* 2009). Soybean protein is limiting in essential sulphur containing amino acids (methionine, cystine, etc.) but is rich in lysine. Hence, soybean could form a good supplement to wheat flour which is low in lysine.

Wheat is the most popular cereal grain that is consumed worldwide. It is the leading crop due to the elastic property of gluten which is essentially used for the production of a variety of baked products such as bread, biscuits, cookies, doughnuts and cakes of which bread is the most common among them (See *et al.,* 2007). The low protein content of wheat flour has been of great concern to food scientists and nutritionists in recent times. The desire to fortify or supplement bread and other baked products with plant proteins derived from legumes or pulses has received considerable attention. This is because legume proteins have low levels of sulphur containing amino acids (methionine and cystine) but are high in lysine and tryptophan, which are essential limiting amino acids in most cereals (Dewettinck *et al.,* 2008).

Bread is one of the oldest bakery products, that is made and eaten in most countries around the world. It may be described as a fermented confectionery product that is produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Okaka, 2005). Due to the high demand and cost of wheat flour, strong initiatives are taken toward the provision of alternative source of flour. It is therefore of economic advantage if the importation of wheat flour can be reduced by substitution with other locally available nutrient dense food crops. This led to the whole idea of composite flour.

Composite flour is a mixture of different flours from cereals, legumes, oilseeds, root and tuber crops, fruits or other raw materials that is created to satisfy specific functional characteristics and nutrient composition. FAO (2001) reported that the replacement of wheat flour with 20% non-wheat flour for the production of baked products would result in an estimated savings in foreign exchange of twenty million US dollars for developing countries. Soybean flour can be used in composite with other flours for the preparation of baked and fried products such as bread, biscuits, doughnuts, cakes, sausages and burns. The use of non-conventional flours, such as, soybean flour to supplement wheat flour in the production of bread and other baked products would help to increase farmers income by adding value to the products, increase the protein intake of their consumers, reduce wheat importation and support food diversification and security. The objective of this study therefore was to develop and evaluate the proximate composition, physical and sensory properties of wheat breads supplemented with soybean flour.

MATERIALS AND METHODS

The brown soybean seeds (*Glycine max)* used for the study were purchased from Ogbete Main Market, Enugu, Enugu State, Nigeria. Commercial wheat flour and other ingredients (fat, sugar (sucrose), salt, milk and yeast) used for the production of bread were bought from the same market.

Preparation of Boiled Soybean Flour

The boiled soybean flour was prepared according to the method of Okoye *et al.* (2016). One kilogramme (1 kg) of soybean seeds were sorted to remove dirt and other extraneous materials. The sorted seeds were thoroughly cleaned and soaked in 3.5 litres of potable water at room temperature (29$\pm$2 °C) for 12 h with a change of water at every 4 h to prevent fermentation. The soaked seeds were drained, rinsed and dehulled manually by rubbing them in-between palms to remove the hulls. The dehulled seeds were rinsed, put into a stainless pot and boiled with 2.5 litres of potable water at 100 °C for 30 min on a hot plate. The boiled seeds were drained, spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60 °C for 16 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried seeds were milled in a hammer mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in a sealed plastic container, labeled and stored in a freezer until needed for further use.

Formulation of Flour Blends

Wheat Flour (WF) was blended together with Soybean Flour (SF) at different graded proportions of A-100:0, B-90:10, C-80:20, D-70:30 and E-60:40 in a Kenwood mixer (Mini-Processor, Model A 90 LD, Thom Emi Kenwood Small Appliance Ltd., Hampshire, UK) to produce composite flours. The composite flours produced were separately packaged in sealed plastic containers, labeled and stored in a freezer until needed for further use.

Preparation of Bread Samples

The bread samples were prepared using the straight dough development method of Mashayekh *et al.* (2008). The recipe used for the preparation of the bread loaves contained 100% flour, 60% fat, 40% sugar (sucrose), 15% dried yeast, 5% salt, 5% vanilla flavour and 200 mL distilled water. During preparation, all the ingredients with the exception of the yeast were thoroughly mixed together in a heavy-duty dough mixer (Kitchen Aid–KSM 900, USA) to obtain hard consistent dough. After that, the yeast was activated by putting 15 g of the yeast in a sealed plastic container containing 25 mL of warm distilled water, 20g of sugar and 10 g of flour and allowed to rest at room temperature (29$\pm$2 °C) for 25 min to form the yeast-in-water dispersion. The dough produced was transfered 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 repeatedly kneaded manually for 10 min to introduce oxygen for vigorous fermentation and to encourage the development of gluten. The kneaded dough was thoroughly divided and moulded manually into uniform shapes of similar sizes. The moulded doughs 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 (29±2 °C) for 1 h. The fermented doughs were proofed at 40^0C in a cabinet proofer for 90 min and baked in an electric oven (Salva, USA) at 220 °C for 40 °C. The loaves were removed from the oven, taken out of the pans and allowed to cool at ambient temperature for 1 h. The cooled bread loaves 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 samples produced from 100% wheat flour were used as control.

Proximate Analysis

The moisture, protein, carbohydrate, fat, crude fibre and ash contents of standard and composite breads were determined in triplicate using standard analytical methods (AOAC, 2006). Moisture content was determined by drying 5 g of the milled breads at 130 °C for 1 h in an air oven (Sanyo Gallenkamp, Weiss Technik, West Midlands, Uk). The ash content was determined gravimetrically after incineration in a muffle furnace at 550 °C for 24 h. Crude fibre content was determined by difference after the incineration of the fitter paper containing the insoluable materials from the hydrolysis and washing of moisture-free defatted sample (1 g). Fat was determined by exhaustive extraction of 1 g of the sample with petroleum ether in a Soxhlet extraction unit (Gerhardt, Bonn, Germany). Protein was determined by Kjeldahl method. After distillation and titration, the nitrogen was corrected using a factor of 6.25. Carbohydrate was calculated by difference on dry sample weight by subtracting the summation of the percentage of moisture, protein, fat and ash contents from 100%.

Physical Analysis

The loaf volume of standard and composite flour breads were determined by the method of Giami *et al.* (2004). Loaf weight was determined using electronic balance and the specific loaf volume was calculated as (loaf volume/loaf weight). The oven spring was determined by seed displacement method of Oladunmoye *et al.* (2010). Loaf height was determined by the method of See *et al.* (2007). All assays were carried out in triplicates.

Sensory Evaluation

The wheat and composite flour bread samples were cooled for 2 h after baking at room temperature (29$\pm$2 °C). The loaves were then sliced separately into small slices with the aid of a bread knife. The sensory test was conducted by a panel of twenty (20) semi-trained consumer taste 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*., 2007). The sensory evaluation was carried out in the Food Research 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 evaluate and score the bread loaves based on their degree of preference and acceptance of each product.

Statistical Analysis

The data generated in this research work were subjected to one-way analysis of variance (ANOVA) using SPSS, version 17.0 software. Means were separated by the use of Duncan's New Multiple Range Test (DNMRT) at p<0.05 and the results were expressed as mean±standard deviation of triplicate determinations.

RESULTS AND DISCUSSION

Proximate Composition of Wheat-Soybean Composite Bread Samples

The proximate composition of the bread samples are presented in Table 1. The moisture content of the bread samples ranged from 28.48 to 39.04% with the control sample (100% wheat flour bread) and the sample substituted with 40% soybean flour having the least and highest moisture contents, respectively. The moisture content of the samples was observed to increase with increased substitution of soybean flour. High moisture content has been known to encourage microbial proliferation and spoilage of foods through increased enzymatic action (Edema *et al.*, 2005; and Ezeama, 2007). The values obtained in this study were higher than the moisture content (21.07-23.67%) of wheat breads supplemented with stabilized undefatted rice bran reported by Ameh *et al.* (2013). The protein content of the samples increased significantly (p<0.05) with increase in substitution with soybean flour. The wheat flour bread substituted with 40% soybean flour had the highest protein content (12.40%) and this is in agreement with the report that soybean is a good source of protein (Dandago and Igwe, 2006). Protein helps primarily in building and maintenance of body cells and tissues (Mashayekh *et al.*, 2008). The fat content of the bread samples ranged from 4.23% to 6.32%. The fat content of the samples increased proportionally with increased substitution of soybean flour in the products. This increase could be due to the fact that soybean has high fat content. Fat is important in the diets because it supplies essential fatty acids and facilitates the absorption of fat soluble vitamins in humans (Okaka *et al.*, 2006; and Okoye and Ene, 2018). The crude fibre content of the samples increased significantly (p<0.05) from 3.40 to 5.70% with increased level of soybean flour supplementation. This observation is in agreement with the report of Mohen *et al.* (2009) that soybean is a good source of crude fibre. Crude fibre plays an important role in the prevention of many diseases of the digestive tract. It has been also reported that the intake of more fibre results in increase in faecal bulk and reduction in plasma cholesterol (Okaka *et al.*, 2008). The ash content of the bread samples increased sequentially with increased substitution of soybean flour in the products. The ash content (1.83-2.68%) reported in this study was lower than the ash content (4.17-6.46) of wheat flour bread produced using different yeast isolates reported by Balarabe *et al.* (2017). The ash content of a food material is used as an index for estimating the amount of minerals present in the food product (Sharma and Chauhan, 2002). The carbohydrate content of the samples decreased significantly (p<0.05) with increase in soybean flour substitution. The addition of soybean flour to wheat flour generally caused reduction in total carbohydrate content of the bread and this is an indication that the bread flour (wheat flour) is the major source of carbohydrate in bread. This result is similar to the report of Jideani and Onwubali (2009) for wheat-sprouted soybean composite flour breads.

The substitution of wheat flour with soybean flour in the production of bread loaves greatly enhanced the protein, ash, fat and crude fibre contents of composite flour breads.

Table 1: Proximate Composition (%) of Wheat-Soybean Composite Bread Samples

Sample ID	% Substitution WF:SF	Moisture	Protein N x 6.25	Fat	Crude Fibre	Ash	Carbohydrate
A	100:0	$28.48^e \pm 0.03$	$8.09^e \pm 0.08$	$4.23^e \pm 0.25$	$3.40^e \pm 0.10$	$1.83^e \pm 0.06$	$53.92^e \pm 0.34$
B	90:10	$32.50^d \pm 0.50$	$9.46^d \pm 0.03$	$4.73^d \pm 0.23$	$4.20^d \pm 0.08$	$2.10^d \pm 0.10$	$47.22^b \pm 0.22$
C	80:20	$35.50^c \pm 0.50$	$10.76^c \pm 0.02$	$4.94^c \pm 0.21$	$4.70^c \pm 0.05$	$2.32^c \pm 0.03$	$42.10^c \pm 0.18$
D	70:30	$37.17^b \pm 0.29$	$11.51^b \pm 0.04$	$5.50^b \pm 0.06$	$5.10^b \pm 0.10$	$2.50^b \pm 0.05$	$38.75^d \pm 0.97$
E	60:40	$39.07^a \pm 0.29$	$12.40^a \pm 0.10$	$6.32^a \pm 0.08$	$5.70^a \pm 0.09$	$2.68^a \pm 0.03$	$34.30^e \pm 0.83$

Note: Values are mean±standard deviation of triplicate determinations. Means in the same column with different letters are significantly different (p<0.05); WF – Wheat Flour, SF – Boiled Soybean flour.

Physical Properties of Wheat-Soybean Composite Bread Samples

The physical properties of the bread samples are presented in Table 2. The loaf volume of the samples decreased significantly ($p<0.05$) with increased substitution of soybean flour from 310.00 to 110.00 cm^3. The decrease may be attributed to the higher level of gluten present in wheat flour compared to composite blends which could not be properly stretched by carbon dioxide (CO_2) gas during fermentation and proofing (Elleuch *et al.*, 2011). The loaf height of composite bread was generally lower than that of 100% wheat flour bread (control). The loaf height was observed to decrease significantly ($p<0.05$) with increased supplementation of soybean flour from 7.16 to 3.85 cm. The observation is in agreement with the report of See *et al.* (2007) for breads supplemented with pumpkin flour. In addition, the result also revealed that the increase in the proportion of composite flour generally affected the shape and height of the breads, thereby resulting in more flat products. This is in accordance with the findings of Malomo *et al.* (2012) who reported similar trend on wheat flour bread substituted with bread fruit and breadnut flours. The loaf weight of the samples varied between 393.00 and 397.00 g for the bread sample substituted with 40% soybean flour and the control (100% wheat flour bread). The increase in loaf weight of wheat flour bread could be due to increase in carbon dioxide retention capacity of wheat flour compared to the composite blends during fermentation and proofing (Shittu *et al.*, 2007). The oven spring of the bread loaves ranged from 400.00 to 460.00 cm with the control sample and the composite flour bread substituted with 40% soybean flour having the highest and least values, respectively. The reduction in the gluten content of composite blends resulted in a tremendous decrease in oven spring of composite flour breads. The observation is in close agreement with the report of Akobundu *et al.* (1988) for non-wheat composite flour breads. The specific loaf volume of the samples decreased significantly ($p<0.05$) with increased substitution of soybean flour from 0.78 to 0.28 cm^3/g. The decrease could be attributed to reduction in the amount of gluten present in composite blends compared to wheat flour which ultimately affected their carbon dioxide retention capacity during fermentation and proofing. According to Green and Bovell-Benjamin (2004), bulky bread is desirable to hungry consumers because it is stomach filling and satisfying.

Sensory Properties of Wheat-Soybean Composite Bread Samples

The sensory properties of the bread samples are presented in Table 3. There were significant ($p<0.05$) differences between the control and the composite flour breads in taste, texture, flavour, crust colour and overall acceptability. Overall acceptability was determined on the basis of quality scores obtained from the evaluation of taste, texture, flavour and crust colour. It is evident from the result that the control sample (100% wheat flour bread) was the most acceptable to the judges followed by wheat-soybean composite flour breads with 10, 20, 30 and 40% soybean flour supplementation, respectively. This could be attributed to the fact that people have been used to the quality attributes in the control sample (100% wheat flour bread). The colour of the bread also was significantly ($p<0.05$) affected by the addition of soybean flour. The change in colour occurred from light-brown (control) to darker brown (composite flour bread with 40% soybean flour). This condition could be attributed to Maillard browning reaction caused by the reaction between the amino acids of the proteins and the

Table 2: Physical Properties of Wheat-Soybean Composite Bread Samples

Sample ID	% Substitution WF: SF	Loaf Volume (cm^3)	Loaf Height (cm)	Loaf Weight (cm)	Oven Spring (cm)	Specific Loaf Volume (cm^3/g)
A	100:0	$310.00^a \pm 1.00$	$7.16^a \pm 0.14$	$397.00^a \pm 0.00$	$460.00^a \pm 1.00$	$0.78^a \pm 0.00$
B	90:10	$280.00^b \pm 0.00$	$6.10^b \pm 0.00$	$396.00^b \pm 0.00$	$430.00^b \pm 1.00$	$0.70^b \pm 0.00$
C	80:20	$210.00^c \pm 1.00$	$5.50^c \pm 0.20$	$395.00^b \pm 0.00$	$405.00^c \pm 1.00$	$0.53^c \pm 0.00$
D	70:30	$180.00^d \pm 0.00$	$4.50^d \pm 0.23$	$394.00^b \pm 0.00$	$402.00^d \pm 0.00$	$0.45^d \pm 0.00$
E	60:40	$110.00^e \pm 1.00$	$3.85^e \pm 0.33$	$393.00^c \pm 0.00$	$400.00^e \pm 0.00$	$0.28^e \pm 0.00$

Note: Values are mean±standard deviation of triplicate determinations. Means in the same column with different letters are significantly different ($p< 0.05$); WF – Wheat Flour, SF – Boiled soybean flour.

Table 3: Sensory Properties of Wheat-Soybean Composite Bread Samples

Sample ID	% Substitution WF:SF	Taste	Texture	Flavour	Crust Colour	Overall Acceptability
A	100:0	$7.80^{a}\pm1.11$	$7.30^{a}\pm1.17$	$7.90^{a}\pm1.28$	$7.95^{a}\pm1.28$	$7.80^{a}\pm0.95$
B	90:10	$7.45^{b}\pm1.50$	$7.50^{b}\pm1.50$	$6.80^{b}\pm1.70$	$6.90^{b}\pm1.07$	$6.64^{b}\pm1.23$
C	80:20	$6.00^{c}\pm1.34$	$5.35^{c}\pm1.60$	$5.70^{c}\pm1.38$	$6.20^{c}\pm1.32$	$6.10^{c}\pm1.5$
D	70:30	$4.35^{d}\pm1.63$	$4.75^{d}\pm1.45$	$4.70^{d}\pm1.46$	$4.95^{d}\pm1.27$	$4.65^{d}\pm1.25$
E	60:40	$3.20^{e}\pm1.51$	$3.05^{e}\pm1.43$	$3.15^{e}\pm1.42$	$3.75^{e}\pm1.33$	$3.75^{e}\pm1.33$

Note: Values are mean±standard deviation of twenty (20) semi-trained judges. Means in the same column with different letters are significantly different (p< 0.05); WF – Wheat Flour, SF – Boiled soybean flour.

added sugar (Fayle and Gerrard, 2002) and caramelization which are influenced by the distribution of water and the reaction of added sugars and amino acids (Onimawo and Akubor, 2005). According to Ballolli *et al.* (2014), Maillard reaction is related to temperature, time and the presence of water (moisture). Colour appeared to be a very important criterion for the initial acceptability of the baked product by the consumer. Moreover, as the development of colour occurs classically during the later stages of baking, it can be used to determine the completion of the baking process. The scores of sensory evaluation (Table 3) indicated that the consumer preferred the crust colour of the control sample compared to the composite flour breads as they were significantly different (p<0.05) from the control. The overall acceptability of all the composite flour breads was significantly (p<0.05) less than the 100% wheat flour bread. However, the substitution of wheat flour with soybean flour in the production of bread produced good and acceptable results.

CONCLUSION

Acceptable and nutritious breads were produced from composite flours of wheat and soybean. Although, the 100% wheat flour bread (control) was organoleptically more acceptable, the composite flour bread samples were more nutritious. The supplementation of wheat flour with soybean flour drastically improved the protein, fat, crude fibre and ash contents of the composite bread samples compared to the 100% wheat bread. With the present cost of wheat flour, it is advantageous to diligently explore the possibility of using wheat /soybean composite flours for the commercial production of bread. This will equally reduce the cost of production since soybean is relatively cheap and readily available in different parts of Nigeria and other sub-Saharan African countries.

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