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Physical, nutritional and sensory qualities of bread samples made with wheat and black sesame (*Sesamum indicum* Linn) flours

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Abstract

The study was conducted to determine the effect of sesame flour supplementation on the physical, nutritional and sensory quality of bread. Black variety sesame seeds were soaked, dehulled, oven dried and sieved to produce sesame flour (SF). The wheat flour (WF) was substituted with SF at 0, 5, 10, 15 and 20%. The proximate composition of wheat and sesame flours and bread samples were determined using standard procedures. The physical characteristics (specific volume and oven spring) and sensory attributes were determined in the control and supplemented breads. Increasing the substitution from 5% to 20% SF significantly ($p \leq 0.05$) increased the protein, fat, ash and crude fibre of the supplemented bread samples, while there were significant decrease ($p \leq 0.05$) in carbohydrate and energy values. Physical properties showed less specific loaf volume and oven spring with increased sesame flour replacement. The sensory analysis showed significant differences between 100% wheat bread and sesame supplemented samples in all the determined sensory attributes. It was concluded that a substitution of 5% sesame flour into wheat flour gave the bread with the best overall quality acceptability.

Introduction

Bread is described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of operations including mixing, kneading, proofing, shaping and baking (Dewettinck *et al.*, 2008). The consumption of bread and other baked foods such as biscuits, doughnuts and cakes produced from wheat flour is very popular in Nigeria, but the low protein content of wheat flour, which is the most vital ingredient used for their production has been major concern (Young, 2001). In developing countries where the supply of animal protein is inadequate to meet the rapid population growth, considerable interests have been shown in supplementing wheat flour with high-protein, high-lysine material (especially legume and oilseed flours, protein concentrates, and isolates) to increase the protein content and improve the essential amino acid balance of flour-based baked products (Young, 2001). In Nigeria, there is a wide varieties of oil crops in various parts of the country ranging from largely known and highly utilized ones like soya bean, palm kernel and groundnut, to underutilized ones like walnut, locust bean, African oil bean and sesame seed.

Sesame (*Sesamum indicum* Linn) is a major oil crop in the world. Globally, the total crop area under sesame production is about 6 million hectares. Sixty-six percent of this is concentrated in Asia, twenty five percent of world sesame is planted in Africa (mainly Nigeria, Ethiopia and Sudan) and 8% in America, Venezuela, Mexico, Guatemala and Columbia) as reported by FIIR (1990). Nigeria is the fifth largest producer of sesame seed in the world with an estimated production of 120,000 metric tonnes annually (NCRI, 2003). It is found predominantly in Benue, Nasarawa and Jigawa States while other important areas of production are found in Yobe, Kano, Katsina, Kogi, Gombe and Plateau States.

There are basically two varieties of sesame majorly produced in Nigeria and these include white and black sesame seeds. The white variety sesame seeds are majorly consumed in Nigeria and used in the bakery while black sesame seed is almost entirely exported with minimal processing limited to cleaning and drying. However, black sesame seed has better nutritional advantage compared to white variety (Makinde and Akinoso, 2013). The fat, protein, ash and crude fibre contents of black sesame seeds showed the seeds to be rich in these nutrients (Ensminger *et al.*, 1994). Black sesame seeds also contain better quality of oil and are also suited for medicinal purposes to cure several human diseases (Leung, 2008). It is also exceptionally richer in iron, magnesium, manganese, calcium and Vitamins B1 and B2 (Makinde and Akinoso, 2013). Moreover, it contains higher levels of lignans, including unique content of sesamin, which are phytoestrogens with antioxidant and anti-cancer properties compared to

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the more common white variety (Moazzami *et al*., 2006). Evidence also points to the fact that black sesame flour contain significantly lower anti-nutrient (majorly phytate and oxalate) than white sesame (Makinde and Akinoso, 2013). Black sesame also has a stronger, earthier and nuttier taste than the white seed (Uhl, 2000). The functional properties of proteins from black sesame flour, such as excellent water retention and fat-binding capacity (Gandhi and Taimini, 2009); also justify the use of this sesame variety in different food formulation.

The realization of the nutritional advantage of black sesame seed is worthy of investigation in various food applications with the aim of providing relative inexpensive protein source for supporting proper growth and development. Very little research has been done to promote black sesame flour use in food formulations, hence supplementation of wheat flour with sesame flour can serve as a practical and sustainable approach to increase its utilization and at large reduce the incidence of malnutrition among vulnerable groups in Nigeria. To further the utilization of black sesame flour, the current study was designed to evaluate the effect of black sesame flour supplementation in physical, nutritional and sensory properties of bread.

Materials and Methods

Collection of seed

Black sesame seed (NCRI-97-28) variety was collected from National Cereal Research Institute, Badegi, Nigeria and transported to the laboratory in an airtight polyethylene bag and stored under cool dry storage (4°C) condition until needed.

Preparation of black sesame Flour

The sesame seeds were cleaned to remove extraneous materials and soaked in water (1: 5 w/v) for 4 h at 29 ± 2°C according to the method reported by Mohamed *et al.* (2007). The ruptured seed coats were then removed by rubbing with palms and washed with water. The dehulled seeds were dried in air oven at 105°C for 12 h, then milled and sieved (Wiley mill, 30 mesh) to obtain raw sesame flour.

Preparation of the Blends

Wheat flour was supplemented with sesame flours at 0, 5, 10, 15 and 20%. Each treatment was mixed thoroughly by sieving three times to achieve uniformity in flour blends.

Preparation of Bread

Bread samples were produced using the recipes on Table 1. The ingredients were mixed for 5 min in a mixer (Kitchen Aid-KSM 900, USA). This was followed by a rest period of about 15 min in order to relieve residual stress that occurred during mixing. The dough was moulded into cylindrical shape to fit into a 0.2-mm thick aluminium container. The dough was prepared, proofed in pre-oiled baking pans for 45 min at 35°C and RH, 85% and then introduced into the oven after it had attained and maintained baking temperature (about 265°C) for 45 min according to the method of Oladunmoye *et al.* (2010).

Table 1. Recipe used for bread dough preparation

Ingredient	Control	5%	10%	15%	20%
Wheat flour (g)	300	275	250	225	200
Sesame flour (g)	-	25	50	75	100
Water (ml)	100	112.5	125	137.5	140
Sugar (g)	20	20	20	20	20
Yeast (g)	10	10	10	10	10
Salt (g)	7.5	7.5	7.5	7.5	7.5
Shortening (g)	17.5	17.5	17.5	17.5	17.5

Proximate composition analysis

The proximate composition (moisture, crude protein, crude fat, ash and fibre) of the wheat flour, sesame flour and bread samples were determined using standard procedures (AOAC, 2005). Carbohydrate content was determined by difference. Energy content was calculated by multiplying protein, fat and carbohydrate contents by factors of 4, 9 and 4, respectively. For each type of bread, three loaves were frozen in home freezer, dried and ground into a coarse powder (60 mesh size) before analysis. All analyses were carried out in triplicate.

Physical characteristics of Bread

Physical characteristics of bread samples such as oven spring, loaf weight, loaf volume, specific loaf volume and colour were evaluated.

Oven spring. Oven spring was estimated from the difference in height of dough before and after baking.

Loaf weight. Loaf weight was measured 30 minutes after the loaves were removed from the oven using a laboratory scale (CE- 410I, Camry Emperors, China) and the readings recorded in grams

Loaf volume. Loaf volume was measured using the rapeseed displacement method as modified by Giami *et al.* (2004) as follows: A box of fixed dimensions (23.00 x 14.30 x 17.00 cm) of internal volume 5591.30 cm^3 was put in a tray, half filled with sorghum grains, shaken vigorously 4 times, then filled till slightly overfilled so that overspill fell into the tray. The box was shaken again twice, and then a straight edge was used to press across the top of the box once to give a level surface. The seeds were decanted from the box into a receptacle and weighed. The procedure was repeated three times and the mean value for seed weight was noted (C g).

A weighed loaf was placed in the box and weighed seeds (3500 g) were used to fill the box and levelled off as before. The overspill was weighed and from the weight obtained the weight of seeds around the loaf and volume of seed displaced by the loaf were calculated using the following equations:

Seeds displaced by loaf (L) = C g + overspill weight – 3500 g.

$$\text{Volume of loaf (V)} = \frac{L \times 5591.30\ cm^3}{C}$$

Specific volume. The specific loaf volume was determined by dividing the loaf volume by its corresponding loaf weight (cm^3/g) as described by Araki *et al*. (2009).

Colour Measurement. Crust and crumb colour were measured using Konica Minolta Spectrophotometer CR- 410 (Japan). Samples were cut into cubes of 2 x 2 x 2 cm and placed in the colorimeter. The colour attributes Hunter L, a and b values were recorded using the Spectramagic software version 2.11, 1998. L^* defines lightness, a^* denotes the red/green value and b^* the yellow/blue value. The L^* axis has the following boundaries: L = 100 (white or total reflection) and L = 0 (black or total absorption). Along the* axis, a colour measurement movement in the -a direction depicts a shift toward green; +a movement depicts a shift toward red. Along the b^* axis, -b movement represents a shift towards blue; +b shows a shift towards yellow. Three measurements were taken from each sample.

Sensory evaluation

Loaves of bread produced from the control and treatment flours were subjected to sensory evaluation. The 25-member panel comprised a broad cross section of adult population (students and staff) of the Bowen University, with panellists spread across a wide range of age, education and income groups. Loaves of bread were prepared a day ahead of sensory evaluation and stored at room temperature. The bread samples were presented in random order and panellists were asked to evaluate each loaf for crust and crumb colour, aroma, taste, mouth feel and overall acceptability. A 9-point hedonic scale was used where 1 = dislike extremely to 9 = like extremely. A score of 5 or below was considered a limit of acceptability for all sensory attributes tested.

Statistical analysis

All data were subjected to Analysis of Variance (ANOVA) with the SPSS version 15.00 Software. The means of the results were compared using Turkey's test and the statistical significance was defined as $P \leq 0.05$.

Results and Discussions

Proximate composition of flours and bread samples

The proximate composition of wheat flour (WF) and sesame flour (SF) are given in Table 2. The protein, fat and ash value for the flours were 15.4, 2.8 and 0.67% and 26.8, 47.7 and 4.62%, respectively. In general, sesame flour indicated higher levels of protein, ash, crude fibre and fat compared to wheat flour. These results are comparable with previous reports (Mepba *et al*., 2007; Kanu, 2011). The proximate composition of the bread samples are given in Table 3. The increased supplementation of wheat flour with sesame flour significantly affected the chemical quality of composite bread. The values for moisture, protein, fat, fibre and ash increased with increasing levels of sesame supplementation except for carbohydrate and energy contents. There was an increase in the protein content of the composite bread samples with sesame-flour supplementation in the range of 10.3 to 14.8% compared to the control (9.2%). This is because the WF has lower protein content than the SF. The fat content also increased from a value of 3.7% (control) to a range of 5.8-10.0% in composite bread samples produced from sesame flour supplementation.

The observed significant ($p \leq 0.05$) differences in fat content between the control and supplemented bread samples is attributed to the higher fat content in SF. Hence, increasing levels of SF incorporation in the bread resulted in enhancement of protein and fat content due to the declining amount of wheat flour in the formulation. The crude fibre and ash contents of the composite bread samples showed a percentage increase as the level of supplementation with sesame flour increased. This is direct effect of high content of cellulose, hemicelluloses and lignin in SF. In contrast, supplementation of wheat flour with SF showed reduction in carbohydrate content of the composite bread samples. The carbohydrate content was highest in the control (53.90%) and lowest in sample containing 25% sesame flour (32.46%) This indicated that wheat flour was the main contributor to the carbohydrate content in the bread. The composite bread samples contained energy values in the range of 276 to 280 Kcal. The higher energy values of the wheat bread compared to composite bread samples could be attributed to higher carbohydrate content of the wheat flour.

Physical characteristics of bread samples

Results of the physical characteristics of composite bread samples containing different levels of sesame flour supplementation as compared to the control are

Table 2. Proximate composition of wheat and sesame flour samples

Parameters	Flour samples	
	Wheat flour	Sesame flour
Moisture (%)	4.83 ± 0.15^{a}	4.81 ± 0.27^{a}
Crude protein (%)	15.40 ± 0.21^{a}	26.79 ± 0.32^{b}
Crude fibre (%)	0.34 ± 0.10^{a}	6.41 ± 0.05^{b}
Ash (%)	0.67 ± 0.35^{a}	4.62 ± 0.21^{b}
Fat (%)	2.84 ± 0.03^{a}	47.73 ± 0.07^{b}
Carbohydrate (%)	75.90 ± 0.25^{b}	9.65 ± 0.05^{a}
Energy (kcal/100 g)	390.76 ± 0.62^{a}	575.33 ± 0.75^{b}

Data are mean values of triplicate determination ± standard deviation

Table 3. Proximate composition of bread samples

Composition (%)	Sesame Flour Substitution (%)				
Protein	9.21 ± 0.05^{a}	10.31 ± 0.04^{b}	12.65 ± 0.31^{c}	13.83 ± 0.06^{d}	14.77 ± 0.05^{e}
Fat	3.72 ± 0.25^{a}	5.83 ± 0.72^{b}	7.14 ± 0.08^{c}	8.97 ± 0.26^{d}	10.04 ± 0.11^{e}
Ash	1.63 ± 0.03^{a}	2.03 ± 0.02^{b}	2.68 ± 0.01^{c}	2.76 ± 0.03^{d}	2.85 ± 0.04^{e}
Crude fibre	3.28 ± 0.05^{a}	4.22 ± 0.03^{b}	4.79 ± 0.06^{c}	5.43 ± 0.34^{d}	5.64 ± 0.02^{e}
Carbohydrate	53.90 ± 0.24^{e}	46.66 ± 0.20^{d}	40.48 ± 0.15^{c}	35.40 ± 0.22^{b}	32.46 ± 0.09^{a}
Energy (kcal/100 g)	285.92^{e}	280.35^{d}	276.78^{a}	277.65^{b}	279.28^{c}

Mean in a row with similar superscript are not significant different at $P \leq 0.05$

given Table 4. The loaf weight of the composite bread samples ranged from 227.25 to 240.20 g. The loaf weights of all SF based bread were significantly ($p < 0.05$) higher than the 100% wheat bread. In contrast, increased supplementation with SF reduced the oven spring, loaf volume and specific volume drastically.

The loaf volume and specific volume and oven spring values of the composite bread samples ranged from 643.70 to 768.1cm^3, 2.68 to 3.38 cm^3/g and 0.45 to 1.02, respectively which were significantly different from the control. The observed increase in weight of composite bread samples is as a result of less retention of carbondioxide gas in the blended dough, hence providing dense bread texture (Rao and Hemamalini, 1991). On the other hand, the less oven spring, loaf volume and specific volume of the composite breads resulted from the dilution effects on gluten with addition of SF to the wheat flour. The gluten fraction is responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide generated by yeast during fermentation. When gluten coagulates under the influence of heat during baking, it serves as the framework of the loaf, which becomes relatively rigid and does not collapse. Moreover, increase in fibre content of composite flour arising from SF addition may have pronounced effects on dough properties yielding higher water absorption, mixing tolerance and tenacity, and smaller extensibility in comparison with those obtained without fibre addition (Elleuch *et al*., 2011). Similarly, the adverse effects of addition of fibre on dough structure and loaf volume have been suggested to be due to the dilution of gluten network, which in turn impairs gas retention rather than gas production (Elleuch *et al*., 2011).Therefore, based on the findings of this study, a limit of 5% supplementation level with wheat flour in bread making is necessary to produced acceptable bread with weight and volume characteristics comparable to 100% wheat bread. Reductions in volume and quality as a result of blending wheat flour with more than 5% legume and oilseed flours and protein concentrates have been reported for sunflower (Yue *et al*., 1991), quinoa (Chauhan *et al*., 1992) and soybean (Ndife *et al*., 2011).

Table 4. Physical characteristics of bread samples

Characteristics	Sesame Flour Substitution (%)				
Oven Spring	1.13 ± 0.02^{e}	1.02 ± 0.03^{d}	0.98 ± 0.01^{c}	0.50 ± 0.02^{b}	0.45 ± 0.01^{a}
Weight (g)	214.45 ± 1.14^{a}	227.25 ± 0.09^{b}	232.95 ± 2.11^{c}	235.45 ± 1.17^{d}	240.20 ± 2.01^{e}
Volume (cm^3)	945.30 ± 0.16^{e}	768.10 ± 0.25^{d}	$708.121.10^{c}$	661.50 ± 0.83^{b}	643.70 ± 0.76^{a}
Specific volume (cm^3/g)	4.45 ± 0.03^{e}	3.38 ± 0.02^{d}	3.04 ± 0.02^{c}	2.81 ± 0.14^{b}	2.68 ± 0.08^{a}
Hunter colour difference					
Crust					
L	$61.84^{e} \pm 0.58$	$53.74^{d} \pm 0.36$	$51.53^{c} \pm 0.08$	$40.52^{b} \pm 0.88$	$35.13^{a} \pm 0.07$
a_L	$12.07^{a} \pm 0.03$	$18.53^{b} \pm 0.53$	$19.36^{c} \pm 0.45$	$21.93^{d} \pm 0.10$	$27.34^{e} \pm 0.01$
b_L	$18.31^{a} \pm 0.02$	$23.76^{b} \pm 0.40$	$24.90^{c} \pm 0.51$	$27.07^{d} \pm 0.45$	$33.32^{e} \pm 0.06$
Crumb					
L	$83.44^{e} \pm 0.59$	$62.01^{e} \pm 0.80$	$61.31^{e} \pm 0.95$	$55.41^{e} \pm 0.66$	$49.76^{e} \pm 0.12$
a_L	$-1.33^{a} \pm 0.01$	$1.06^{b} \pm 0.04$	$1.17^{c} \pm 0.02$	$1.66^{d} \pm 0.01$	$1.78^{e} \pm 0.15$
b_L	$14.45^{a} \pm 0.05$	$15.43^{a} \pm 0.27$	$15.57^{a} \pm 0.22$	$16.64^{a} \pm 0.21$	$22.79^{b} \pm 9.26$

Values in the same column with different superscript are significantly different ($p < 0.05$).

Table 5. Sensory scores of the bread samples

Parameter	Sesame Flour Substitution (%)				
	0	5	10	15	20
Crumb colour	8.59^{e}	7.15^{d}	6.30^{c}	5.70^{b}	4.80^{a}
Taste	8.05^{e}	7.20^{d}	6.30^{c}	5.65^{b}	4.65^{a}
Mouth feel	8.25^{e}	7.65^{d}	6.95^{c}	6.20^{b}	5.30^{a}
Overall acceptability	8.30^{e}	7.70^{d}	6.70^{c}	5.90^{b}	4.80^{a}

Values in the same column with different superscript are significantly different ($p < 0.05$).

The colour of the bread crust showed a significant decrease ($p < 0.05$) in L values of supplemented bread while there was significant increase in a (redness) and b(yellowness) values with increasing levels of SF. The colour became darker as the SF level increased because of the Maillard browning reaction caused by the reaction between wheat proteins and the added sugar and caramelization which are influenced by the distribution of water and the reaction of added sugars and amino acids (Kent and Evers, 1994). Colour is 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 judge completion of the baking process. Surface colour depends both on the physico-chemical characteristics of the raw dough (i.e. water content, pH, reducing sugars and amino acid content) and on the operating conditions applied during baking (i.e. temperature, air speed, relative humidity, modes of heat transfer) according to Zanoni *et al.* (1995). Similarly, it was observed that the crumb colour significantly ($p < 0.05$) increased in redness (a value) and yellowness (b value) but decreased in L value with higher percentage of SF supplementation. This might be attributed to the colour imparted by the black sesame flour. In general, L (lightness) was higher in the crumb compared to crust; however, a (redness) and b (yellowness) values in crust were higher than crumb which indicates the browning effect in agreement with values reported by Jusoh *et al.* (2012).

Sensory evaluation of bread

Sensory characteristics of composite bread samples containing different levels of SF supplementation as compared to the control are given in Table 5. The results of evaluation of crust colour showed significant difference in the composite bread samples and the control. It is evident from the results that bread prepared from 100% wheat flour had highest score (8.62) followed by bread prepared from 95% WF and 5% SF (7.41). Breads prepared from 90:10, 85:15 and 80:20 WF to SF combinations were fairly rated by panellists with respect to crust colour. Crust colour is very important parameter in judging properly baked bread that not only reflect the suitability of raw material used for the preparation but also provides information about the formation and quality of the product. Darkness in the crust colour of the composite bread was observed as the level of the supplementation of SF increased which may be attributed to the black colour of the black variety sesame flour. Similar effect (darkness) on colour was observed when wheat flour was substituted with different levels of sunflower protein isolate for the production of biscuits (Claughton and Pearce, 1989).

The supplementation of SF into wheat bread resulted in significant decrease in crumb colour scores. The results indicated that the bread prepared from 100% wheat flour was scored significantly ($P < 0.05$) highest (8.59) for crumb colour while bread with 20% SF had the lowest value (4.80). From the results, quality score for the taste of the breads ranged from 4.65 to 8.05. The highest (8.05) significant value ($P < 0.05$) for the quality score of the bread prepared from 100% WF followed by bread prepared from 95% WF and 5% SF. This could be due to the bitter taste of some inherent compounds in SF particularly at high temperature as reported by Ayo *et al*. (2010).

Mouth feel was significantly affected with the increase in the level of SF. Bread prepared from 100% wheat flour had highest score (8.25) while lowest score was obtained in the bread prepared from 20% SF (5.30). The baking conditions (temperature and time variables); the state of the bread components, such as fibre, starch, protein (gluten) weather damaged or undamaged and the amounts of absorbed water during dough mixing, all contribute to the final mouth feel of the bread (Serrem *et al*., 2011). The results show that level of supplementation significantly affected the overall acceptability of the bread samples. Bread prepared from 100% wheat flour had maximum score (8.30) compared to score (7.70) recorded for the bread prepared with 95% WF and 5% SF. Breads prepared from higher level of supplementation with SF were fairly rated by judges with respect to overall acceptability. In general, the baking properties of composite flour are often impaired as well as the organoleptic attributes of the products, because of the dilution of the gluten content (Jideani and Onwubali, 2009).

Conclusions

Composite bread samples with black variety sesame flour supplementation were found to be nutritionally superior (higher protein, fat and crude fibre) to all wheat bread. However, supplementation of wheat flour with sesame flour significantly affected loaf volume, specific volume as well as the oven spring. Supplementation of 5% sesame flour into wheat flour gave the bread with the best overall sensory acceptability

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