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Effect of soy enrichment on bread quality

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Abstract

The effect of full-fat soybean flour and whole wheat on the proximate composition and morphogeometric properties of bread was studied. Soy bean flour was prepared by cleaning, soaking, boiling, drying and milling soy bean to required particle size. Composite of soybean and wheat flour were made in various proportions: 5:95, 10:90, 15:85 and 20:80 respectively with wheat flour serving as control. Proximate analysis was carried out on the composite flour samples using standard procedures. Bread loaves produced with composite flours and 100% wheat flour using the straight dough procedure were tested for chemical, morphogeometric properties, trypsin inhibitor activity and organoleptic characteristics by standard procedures. The ash, crude protein and crude fat content of the soy-enriched bread increased significantly ($p<0.05$) with increasing soy flour substitution. Crude fiber and carbohydrate decreased with increasing substitution of soybean flour. There were no significant differences ($p<0.05$) in the moisture content of the soy-enriched bread. Bread volume and weight loss decreased with increased addition of soy flour ($p<0.05$). Organoleptic test of the bread samples showed that they varied in terms of taste, crust colour, crumb colour, crumb texture, aroma; and general acceptability decreased with increasing soy substitution level. A substitution of wheat flour with 5% soy flour gave the bread with the best overall acceptability.

Introduction

Cereal-based food products are major sources of dietary energy that can meet the nutrient needs of people and further boost food security. In Nigeria, bread is a widely consumed cereal-based product produced from wheat flour. A huge amount of money is spent on wheat importation annually since it does not thrive well on Nigerian soils and climatic conditions (Bokanga, 1995). Hence, there is an alarming need to reduce the importation of wheat by exploring other sources of flour. The use of non-wheat flour in bread manufacture had been advocated by several researchers (Edema *et al.*, 2005; Shittu *et al.*, 2008; Mesfin and Shimelis, 2013). According to Edema *et al*. (2005) and Mesfin and Shimelis (2013) countries such as Ethiopia, France, Norway, India and Israel have developed their own bread specialties based on their available agricultural resources.

Consumption of soybean *(Glycine max)* has in recent years increased, since people are becoming more health conscious rather than just eating off the shelves and due to its availability and low cost. Soybean belongs to the family leguminosae and sub-family papillionnideae. It is a rich source of essential nutrients and contains a wide variety of chemical compounds that have potent bioavailability. Soybean flour contains about 35 - 45% protein (Kure *et al*., 1998),and is considered as an excellent source of high quality plant protein with all essential amino acids required for proper growth and maintenance of body (Dandago and Igwe, 2006). It is rich in lysine which is deficient in most cereals. In addition, it is high in vitamins and minerals, and has been shown to possess natural antioxidant which helps in lowering cholesterol level, preventing cancer (Wada *et al*., 2013) and cardiovascular disease (Burris *et al*., 2009), regulation of menopause and combat oxidative degradation and could also extend the shelf-life of its products. The use of soybean is limited by the presence of antinutritional factors such as trypsin inhibitors, tannins and phytic acid which may inhibit the availability of desired nutrients or reduce the nutritional value of soybean if not removed (Liener, 1981). Liener (1994) reported that trypsin inhibitors can be effectively inactivated by moist heat. Lasekan *et al*. (2004) suggested that an appropriate and convenient method of processing should be adopted in order to render soybean safe, palatable, digestible and nutritious. Many studies have recorded success with incorporating soy flour into staple food such as bakery product as a feasible means of increasing daily soy intake in people's diet (Kure *et al*., 1998; Murphy *et al*., 1999; Dhingra and Jood, 2002;

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Basman *et al.*, 2003). This study is therefore focussed on determining the effect of different levels of soy inclusion on the nutritional, morphogeometrical and organoleptic characteristics of bread with the aim of developing nutritionally rich and acceptable bread for the consumers.

Materials and Methods

Raw materials

Soybean seeds, instant dry yeast, salt and sugar were procured from an open market in Iwo, Osun State, Nigeria. Wheat flour was obtained from Dangote Flour Mills PLC, Apapa, Lagos.

Preparation of soy flour

Soybean seeds were cleaned to remove dirt and foreign material. The seed was then weighed and soaked in hot water for 1 hour to soften the hulls. The soybean seeds were then dehulled, boiled at 99°C for 20 - 25 minutes and dried in a cabinet dryer at 60°C for 72 hrs. The dried soybean seeds were cooled, milled, sieved with a 250 µm mesh, packed and stored in polyethylene bags until needed.

Formulation of composite flour

Wheat flour was substituted with full-fat soy flour at 5, 10, 15, and 20 percent inclusion level to obtain composite flour samples. 100% wheat flour served as the control.

Processing of bread

Composite bread was baked using the modified straight dough method of Onuegbu *et al.* (2013). Ingredients (wheat flour, soy flour, fat, water, instant dry yeast, sugar and salt) were mixed together in various proportions for 15 minutes. After mixing, the dough was kneaded, moulded, and shaped into greased pans for proofing. The dough was proofed in a proofing cabinet for 3 hours at 50°C and thereafter baked in a preheated electric oven at 200°C for 30 min. Bread samples were depanned, cooled, packed in polyethylene bags and stored at ambient temperature till subsequent analyses.

Physico-chemical analyses

Proximate analyses (moisture, crude protein, crude fat, crude fibre, ash) of the flour samples were determined by A.O.A.C. (2012) method. Trypsin inhibitor was determined by the method of Kakade *et al*. (1969). Morphogeometric analysis included loaf volume and loaf weight loss during baking. Loaf volume was determined by the seed displacement method as described by Giami *et al.* (2004). Loaf volume was calculated from the weight of seed displaced by the loaf and from the weight of a known volume of seeds. Weight loss (%) was calculated by subtracting the baked bread weight from the dough weight. Sensory evaluation of the composite bread samples was carried out using the descriptive method by 12 untrained panellist comprising students of the Department of Food Science and Technology, Bowen University. Questionnaires were presented to the panellists and the parameters evaluated were taste, crust colour, crumb colour, crumb texture, aroma and overall acceptability. All analyses were done in triplicates and data obtained were expressed as mean. Analysis of variance was performed to evaluate the data with significant level at $p<0.05$.

Results and Discussion

Physico-chemical properties

The effect of substituting wheat flour with full-fat soy flour on the proximate composition and trypsin inhibitor of bread is presented in Table 1. The increased substitution of wheat flour with soy flour affected the proximate composition of the composite bread loaves. The values for moisture, ash, protein, and fat, were lowest in wheat bread (sample A), which served as control and higher in samples substituted with soy flour. The values increased with increasing levels of inclusion of soy flour except for crude fiber and carbohydrate content. Increase in soy flour substitution significantly increased the ash content of the product. Sample A had the lowest ash content while samples D and E had the highest ash content. Increase in ash content of the soy substituted samples may be as a result of the ash content of the soy flour compared to the wheat flour.

Addition of full-fat soy flour significantly increased the protein content with increasing soy proportion. This increase is expected due to the substitution of wheat flour with full-fat soy flour which was higher in protein content. This observation is in agreement with the findings of Mashayekh *et al.* (2008) and Ndife *et al.* (2011) who reported an increase in protein content of bread with increasing substitution of soy flour. Alabi and Anuonye (2007) and Aly *et al*. (2012) also reported that legumes with high protein content used as composite flour resulted in an improved protein quality of cereal based products.

In terms of their crude fat content, the samples were significantly different ($p<0.05$) from each other. The fat content increased with increasing level of soy substitution. The high fat content of sample E was not unexpected since it had the highest level of soy

Table 1. Proximate Composition of Wheat and Composite Flour

Parameters	Level of Soy-substitution				
	Sample A	Sample B	Sample C	Sample D	Sample E
Carbohydrate (%)	66.43^{d}	64.17^{c}	61.13^{b}	61.03^{b}	57.60^{a}
Crude protein (%)	12.43^{a}	13.87^{b}	15.20^{c}	16.67^{d}	17.43^{e}
Crude fat (%)	5.17^{a}	5.93^{b}	6.17^{c}	7.37^{d}	8.73^{e}
Crude fiber (%)	2.97^{d}	2.77^{c}	2.73^{c}	2.53^{b}	2.40^{a}
Ash (%)	2.70^{a}	3.07^{b}	3.27^{c}	3.57^{d}	3.57^{d}
Moisture (%)	10.30^{b}	10.11^{ab}	10.30^{b}	10.03^{a}	10.27^{b}
TIA (mg/100g sample)	NAD	0.53^{a}	1.63^{b}	2.20^{c}	2.43^{d}

Numbers with the same superscript in the same row are not significantly different at 5% level of significance. *TIA: Trypsin inhibitor activity; NAD: No Activity Detected
Key
Sample A – 100% wheat flour
Sample B – Composite flour containing 95% wheat flour, 5% full–fat soy flour Sample C – Composite flour containing 90% wheat flour, 10% full–fat soy flour Sample D – Composite flour containing 85% wheat flour, 15% full–fat soy flour Sample E – Composite flour containing 80% wheat flour, 20% full–fat soy flour

flour substitution (20%) compared to other samples. This result is in agreement with that of Ndife *et al.* (2011) which reported an increase in fat content of bread made with composite flour containing soy flour. High fat content may improve food flavour and also play a vital role in the shelf stability.

The crude fibre content decreased significantly ($p<0.05$) with increasing substitution of soy flour. This could be attributed to the lower crude fibre content of the soy flour compared to the wheat flour. Sample A had the highest crude fibre content with sample E having the lowest. This result is contrary to the report of Mesfin and Shimelis, (2013), which showed an increase in fibre content of composite flour made from quality protein maize and soybean with a corresponding increase in the proportion of soybean flour. Ndife *et al*. (2011) also reported an increase in the crude fibre content of composite bread from whole wheat and soy flour.

The carbohydrate content decreased with increase in the proportion of soy flour, with Sample A containing the highest percentage of carbohydrate compared to the soy enriched samples. These results are in agreement with those obtained by Sanful and Darko (2010) and Aly *et al.* (2012). They established that complementation of wheat flour with legume flour such as soy flour or chickpea flour at different levels led to a decrease in carbohydrate content.

The Trypsin inhibitory activity (TIA) of the composite flour is shown in Table 1. The trypsin inhibitory activity increased significantly ($p<0.05$) as soy substitution increased. The control sample (A) had no trypsin inhibitory activity because wheat does not contain any trypsin inhibitor and it was not enriched with soy flour while sample E had the highest trypsin inhibitor content. The lethal dose of trypsin inhibitor in food is 2.5 g/kg (Imuwa *et al*., 2011). Though, trypsin inhibitor was present, the level was very low and will not cause significant distress to the gastric system of the consumer or malabsorption of protein in the body. The trypsin inhibitory activity could also be further reduced during baking.

Morphogeometrical analyses

The report of the morphological analyses is presented in Table 2. Loaf volume was significantly ($p<0.05$) affected during baking by the inclusion of soy flour. The control sample (A) had a higher loaf volume than other bread samples. This is in agreement with the study of Ribotta *et al*. (2008). Sample B had the highest volume compared to other soy enriched breads while sample E had the lowest volume indicating that the volume decrease was greater at higher soy flour substitution. The reduction in loaf volume could be as a result of higher soy substitution which caused a destabilization of the gluten network thus preventing the dough from exhibiting oven spring but causing the dough to collapse. Sluimer (2005) indicated that high amounts of fat in the formula can prevent bread from forming and make the dough to collapse during and after baking. Menjivar and Faridi (1994) associated the dough collapse during and after baking to be as a result of the competition between fat and the aqueous phase for the surface of the flour

Table 2. Morphogeometric Quality of Soy-Enriched Bread

Parameters	Level of Soy-substitution				
	Sample A	Sample B	Sample C	Sample D	Sample E
Loaf volume (cm^3)	4166.33^e	4083.33^d	3686.67^c	3020.00^b	2263.30^a
Weight loss (%)	8.17^e	7.70^c	7.87^d	7.00^b	2.95^a

*Numbers with the same superscript in the same row are not significantly different at 5% level of significance.

Table 3. Sensory Scores for Bread and Soy Enriched Bread

Sample	Taste	Crust Colour	Crumb Colour	Crumb Texture	Aroma	General Acceptability
A	1.00^a	1.29^a	1.43^a	3.43^{ab}	1.57^a	1.86^a
B	1.43^a	1.29^a	1.71^{ab}	3.00^{ab}	1.57^a	3.86^b
C	2.43^b	2.14^b	2.00^{ab}	2.43^a	2.43a^b	5.29^c
D	2.86^b	2.71^{bc}	2.29^{ab}	2.71^{ab}	2.71^{bc}	6.43^{cd}
E	3.00^b	3.00^c	2.38^b	3.57^b	3.57^c	7.57^d

Means with the same subscript in a column are not significantly different ($p > 0.005$) at 5% level of significance.
Taste: 1 = Characteristics bread taste; 2 = Slightly beany; 3 = Beany
Crust colour: 1 = Light brown; 2 = Brown; 3 = Dark brown
Crumb colour: 1 = White; 2 = Cream; 3 = Yellowish cream
Crumb texture: 1 = Very hard; 2 = Hard; 3 = Soft; 4 = Very soft
Aroma: 1 = Very peasant; 2 = Pleasant; 3 = Unpleasant; 4 = Very unpleasant
General Acceptability: 1 = like extremely 2 = like very much 3 = like moderately 4 = like slightly; 5 = neither like nor dislike; 6 = dislike slightly; 7 = dislike moderately; 8 = dislike very much; 9 = dislike extremely

particles during dough mixing. This may prevent the formulation of the gluten network when flour is covered by fat before it can be hydrated (Menjivar and Faridi, 1994). Shafali and Sudesh (2004) also found that when either full-fat or defatted soy flour was mixed with barley and wheat flours, these ingredients produced a decrease in loaf volume. Anil (2007) and Rehman *et al.* (2007) also reported that the addition of fibre and non-gluten protein reduced loaf volume. Fibre would diminish loaf volume due to the dilution of gluten and the interactions between gluten and fibre material (Chen *et al*., 1988) while foreign proteins would weaken and interrupt the gluten network (Ribotta *et al*., 2005).

Weight loss during baking in the bread samples decreased significantly as the soy-substitution increased. The control sample had the highest weight loss followed by sample B and the least in the sample E. This could be due to the presence of fat and non-gluten protein present in soy flour which traps water molecules hence preventing its evaporation and causing reduction in weight loss. Lorimer *et al.* (1991) reported that the addition of non – gluten proteins causes a diluting effect and consequent weakening of wheat dough. They further suggested net competition between the proteins and gluten for water molecules and the disruption of starch – protein complexes by the foreign proteins as factors that can also cause weakening of the dough thus causing weight reduction.

Sensory evaluation

The sensory assessment shown in Table 3 revealed significant differences in some of the parameters assessed. The composite bread had a beany taste with increasing soy flour substitution. Samples A and B were rated characteristics bread taste, sample C was rated as having a slightly beany taste, and samples D and E having a beany taste. Appearance score in terms of crust colour and crumb colour decreased significantly with increase in soy flour substitution due to the crust and crumb colour change. For crust colour, samples A and B were rated as light brown, sample C as brown, and samples D and E as dark brown. The brownish appearance of the bread crumb became more visible with increasing soy substitution. This could have been due to caramelization or/ and maillard reactions (Mohsen *et al*., 2009). For crumb colour, sample A was rated as white, samples B, C and D as cream, and sample E as yellowish – cream. The crumb texture of sample E was rated the highest and sample C the lowest. However, there was no significant difference between the various bread slices. The crumb texture for samples C and D were rated as being hard while samples A, B and

E were rated as being soft. Aroma score decreased significantly with increasing full-fat soy substitution levels. Samples A, B and C were rated as having pleasant aroma with no significant difference while sample D was rated as having unpleasant aroma, and sample E was rated as the poorest having a very unpleasant aroma ($p<0.05$). The aroma scores of sample D and E could be attributed to the beany flavour of soy flour. General acceptability was judged based on other evaluated organoleptic attributes. The control sample was the most acceptable while the sample containing 20% soy flour was the least acceptable. The 5% inclusion level was considered to be the most preferred soy substituted bread.

Conclusion

Soy enrichment of bread could be used to produce a nutrient dense food with proposed great health benefit. Out of the soy-bread samples (5%, 10%, 15% and 20%), the inclusion of 5% soy flour produced bread which was nutrient dense with morphogeometric characteristics similar to wheat bread and was more acceptable and preferred by the consumers. Soy flour inclusion at 5% level can therefore be advantageous due to the increased nutritional value and acceptable consumer attitude in sensory characteristics. The bread also had low level of anti-nutritients, making them safe for consumption. Therefore, it is recommended that the technology of using composite flour should be encouraged among food industries to make economic use of local raw materials in producing high quality food products rich in protein such as bread to boost food security and to improve the nutritional status of the nation.

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