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Full Length Research Paper

Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends

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The use of whole wheat and soybean flour blends in the production of functional breads was studied. The flour blends of whole wheat and soybean were composites at replacement levels of 10, 20, 30 and 40% while the whole wheat flour bread (sample A) served as control. The proximate composition of the various flour blends used for the preparation of the breads were determined using standard methods. The bread loaves were produced using the straight-dough procedure and were subsequently evaluated for their nutritional composition and sensory attributes. The physico-chemical analyses results obtained showed an increase in the range of 11.0% for moisture, 4.37% for protein, 2.40% for fat, 2.35% for crude fibre, 0.85% for ash and a decrease in carbohydrate and energy contents by 20.92 and 44.60% respectively. There was also a decrease in bread volume and dough expansion by 64.50 and 13.0% respectively, with progressive inclusion of the soybean flour. The sensory analysis showed that there was no significant difference observed between the whole wheat bread and the soy bread samples in the sensory attributes of crust colour and crumb appearance, While significant difference ($p<0.05$) was observed in texture, flavour and overall preference respectively. It was concluded that a substitution of 10% soy flour into wheat flour gave the bread with the best overall quality acceptability.

Key words: Whole wheat, soybeans, composite flour, functional bread, physico-chemical composition, sensory attributes.

INTRODUCTION

Bread may be described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Dewettinck et al., 2008).

The consumption of bread and other baked goods such as biscuits, doughnuts and cakes produced from wheat flour is very popular, but the low protein content of wheat flour, which is the most vital ingredient used for the production of different kinds of baked goods has been major concern in its utilization (Young, 2001).

However, wheat is a good source of calories and other nutrients but its protein is of lower nutritional quality when compared to milk, soya bean, pea and lupin proteins as its protein is deficient in essential amino acids such as lysine and threonine (Bakke and Vickers, 2007; Dewettinck et al., 2008; Jideani and Onwubali, 2009). The use of white flour derived from the processing of whole wheat grain, which is aimed at improving the aesthetic value of white bread, has also led to the drastic reduction in the nutritional density and fibre content when compared to bread made from whole grain cereals (Maneju et al., 2011).

Recently, consumers' awareness of the need to eat high quality and healthy foods – known as functional foods, that is, foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements, is increasing (Ndife and Abbo, 2009). Therefore, the trend is to produce specialty breads made from whole grain flour and other functional ingredients known as health breads or functional foods (Dewettinck et al., 2008).

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Jideani and Onwubali (2009) reported that the development and consumption of such functional foods not only improves the nutritional status of the general population but also helps those suffering from degenerative diseases associated with today's changing life styles and environment. The whole wheat flour has been shown by many researchers to be a rich source of these functional ingredients such as fibre, phyto-chemicals, minerals, essential amino acids that are located in the bran and fat soluble vitamins contained in the germ of the whole wheat grain (Dewettinck et al., 2008).

Breads could be used as vehicle in the formulation of varying products with the increasing consumer demands for healthful food products. The enrichment of bread and other cereal based confections with legume flours particularly in regions where protein utilization is inadequate has long been recognized. This is because legume, nutritionally proteins are high in minerals, vitamins B and lysine, an essential limiting amino acid in most cereals (Jideani and Onwubali, 2009). Legumes can therefore complement cereals when blended at optimum ratio (Okoye and Okaka, 2009).

Formulation of foods from low-lysine staples fortified with legumes has been proposed as a practical and sustainable approach to improving the protein nutritional value of foods for young children in developing countries (FAO/WHO, 1994; Young, 2001). High protein soy breads form a popular carrier of nutrition to vulnerable groups like pregnant and nursing mothers, young and school children in reducing the incidence of malnutrition and at the same time encourage the farmers to grow more soybeans due to the increased utilization (Islam et al., 2007).

Soybean is one of the most important oil and protein crops of the world (Islam et al., 2007). Soybeans contain 30 to 45% protein with a good source of all indispensable amino acids (Serrem et al., 2011). The protein content of soybean is about 2 times of other pulses, 4 times of wheat, 6 times of rice grain, 4 times of egg and 12 times of milk. Soybean has 3% lecithin, which is helpful for brain development. It is also rich in calcium, phosphorous and Vitamins A, B, C and D, it has been referred to as "the protein hope of the future" (Islam et al., 2007).

Moreover, isoflavones contained in soybeans are effective cancer-preventive agents for lowering risks of various cancers (El Gharras, 2009). Evidence also points to the beneficial effects of soy isoflavones in the prevention of cardiovascular disease (El Gharras, 2009). Their potential health benefits of soy-isoflavones include prevention of osteoporosis via phytoestrogen effects of isoflavones, and prevention of neovascularization in ocular conditions (Zhu et al., 2005).

The need for strategic development and use of inexpensive local resources in the production of popular foods such as bread has been promoted by organizations such as the Food and Agricultural Organization (FAO), the International Institute for Tropical Agriculture (IITA), Nigeria and the Federal Institute for Industrial Research, Oshodi (FIIRO), Nigeria. This led to the initiation of the composite flour program, the objective of which was to seek ways of substituting flours, starches and protein concentrates from indigenous crops, for as much wheat as possible in baked products. Compositing with soy is expected to substantially improve the protein efficiency ratio (PER), *in-vitro* protein digestibility (IVPD), lysine score and isoflavone content in soy-composite formulations (Weiss, 2000; Okoye and Okaka, 2009; Serrem et al., 2011).

With increased awareness of a healthy lifestyle based on consumption of functional foods, breads containing whole grain, multi-grain or other functional ingredients especially from legumes will increasingly become more important in the bakery industry and in the emerging market (Dewettinck, 2008). The high protein content in the soy supplemented breads would be of nutritional importance in most developing countries, such as Nigeria, where many people can hardly afford high proteinous foods because of their expensive costs.

There is therefore the need to develop a different approach to offer the weary consumers the opportunity to feed on improved formulations with substantive health benefits from wheat-soy combinations (Gomez et al., 2003). A functional food, that combine many nutritional benefits of whole-wheat supplemented with soya beans has been proposed to cater for a set of clientele whose health has been compromised such as those suffering from protein-energy-malnutrition, diabetes and obesity (Young, 2001).

The objectives of this study therefore, were to formulate and develop functional breads from whole wheat flours composited with soy flour and to evaluate the products baking properties, nutritional, sensory quality and consumer overall acceptability.

MATERIALS AND METHODS

The whole wheat and soya beans used for this study were purchased from Kaduna Central market in Kaduna State of Northern Nigeria.

Preparation of composite flours

The whole wheat seeds and soya beans were cleaned from dirt by sorting out contaminants such as sands, sticks and leaves, and were later washed and oven dried. The soya beans were roasted and winnowed. Both the dried whole wheat and soya beans was later milled using attrition mill and sieved into fine flour of uniform particle size, by passing them through a 2 mm mesh sieve as shown in Figure 1.

Bread making

The whole wheat flour was then mixed, with varying inclusions of 0, 10, 20, 30 and 40% of the soy-flour. The composite flours were blended with other baking ingredients (Table 1) in a mixer, kneaded for 12 min into consistent dough and the resulting dough was

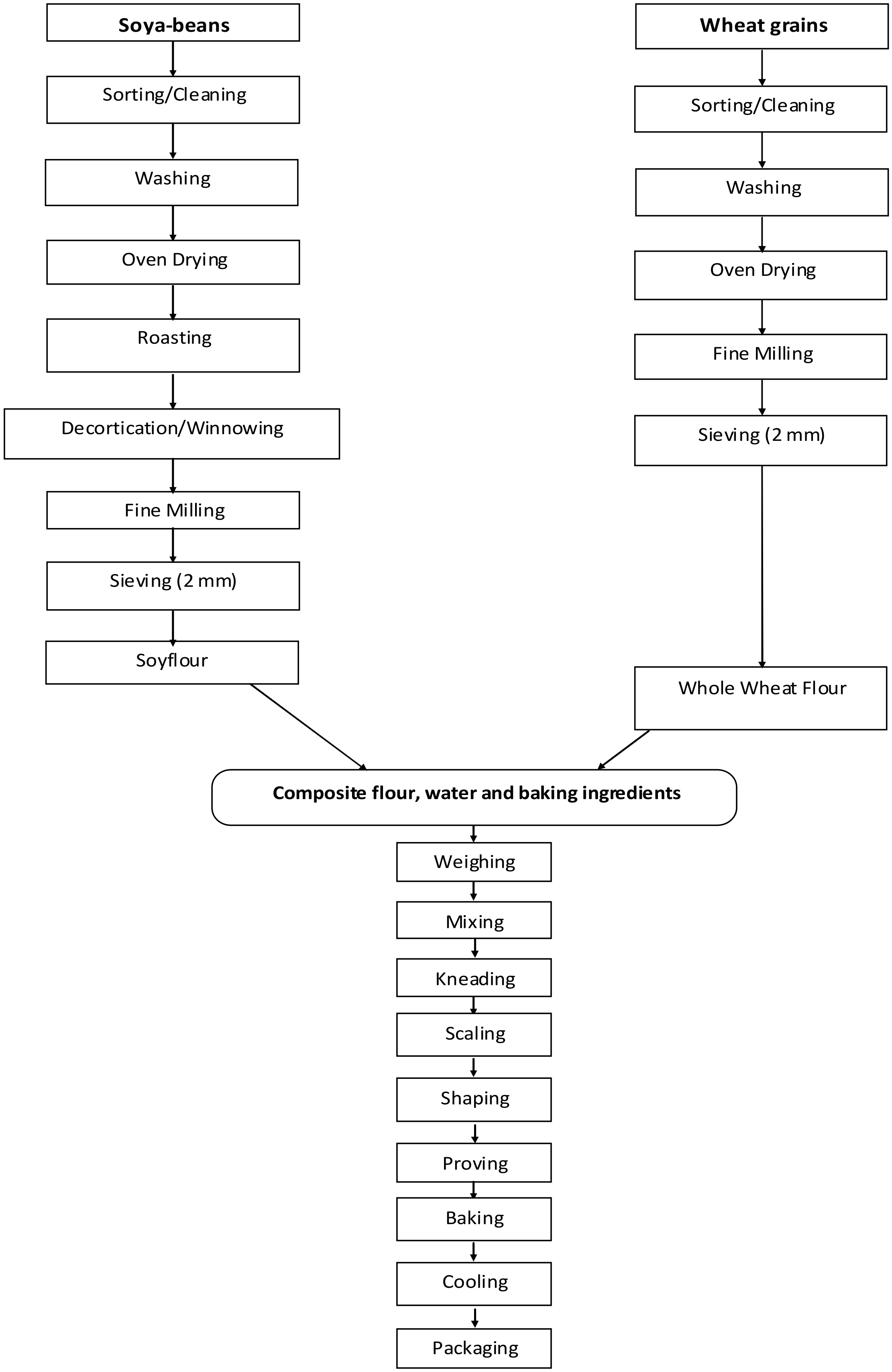

Figure 1. Flow chart for the production of functional composite bread.

Table 1. Formulation of Whole-wheat and soybean composite doughs.

Ingredients (%)	Samples				
	A	B	C	D	E
Whole-wheat flour (g)	100	90	80	70	60
Soy-flour (g)	0	10	20	30	40
Salt	2	2	2	2	2
Sugar (g)	6	6	6	6	6
Fat/Shortening (g)	4	4	4	4	4
Yeast powder (g)	2	2	2	2	2
Spices (g)	1	1	1	1	1
Water	65	65	65	65	65
Total dough weight (g)	180	180	180	180	180

Table 2. Proximate analysis results for composite flour samples.*

Parameters	Flour samples	
	Soybean flour	Whole wheat flour
Crude protein (%)	39.40±0.21	13.90±0.30
Moisture (%)	5.50±0.15	7.00±0.20
Crude fiber (%)	6.50±0.10	4.50±0.05
Ash (%)	2.50±0.35	1.50 ±0.25
Fat (%)	10.20±0.03	3.60±0.05
Carbohydrate (%)	35.90±0.25	69.50±0.15

*Data are mean values of triplicate determination ± standard deviation.

molded and placed in a pre-oiled baking bowl. The dough was proofed for 45 to 60 min at 35°C and 85% relative humidity and baked in a reel oven for 35 min at 217°C.

Physico-chemical analysis

The determination of the chemical composition of the bread samples viz: moisture content, ash content, protein content, fat content, crude fiber and content were determined by methods described by AOAC (1990). Carbohydrate was calculated by difference, and energy was calculated using Atwater conversion factors.

The bread characteristics, such as: the dough expansion, bread volume and bread specific volume were measured by the method described by Maneju et al. (2011). While the pH and brix of the composite bread samples were measured using the pH meter and refractometer as described by Jacobs (1999).

Sensory analysis

Sensory evaluation of the composite bread samples were carried out by 20 panelists on a 9 point hedonic scale for different parameters such as colour, aroma, taste, texture and overall acceptability as described by Ihekoronye and Ngoddy (1985).

Statistical analysis

The sensory evaluation data was statistically analyzed using the analysis of variance (ANOVA) and the Duncan Multiple range test with significance level at $p<0.05$ (Ihekoronye and Ngoddy, 1985).

RESULTS AND DISCUSSION

The results obtained from the proximate analysis of the whole wheat flour and soybean flour is shown in Table 2. The results were not different from that obtained from literatures (Weiss, 2000; Potter and Hotchkiss, 2006). The chemical composition of the composite flours have been shown to affect both physico-chemical properties and nutritional quality of their products (Dhingra and Jood, 2001; Akhtar et al., 2008; Mashayekh et al., 2008).

Physico-chemical analysis

The results obtained from the chemical analysis and the physical properties investigated are shown in Table 3. The increased supplementation of whole wheat flour with soy flour greatly affected the physico-chemical quality of composite bread.

The proximate values for moisture, ash, fat, crude fiber and protein, were lowest in whole wheat bread (sample A), which served as control and higher in other soya bean substituted samples. The proximate values increased with increasing levels of soya bean substitutions except for carbohydrate content and energy

Table 3. The results of the proximate analysis and physical characteristics of bread samples*

Parameters	Bread samples				
	A	B	C	D	E
Moisture (%)	28.50±0.13	33.00±0.15	36.00±0.16	37.50±0.10	39.50±0.15
Protein (%)	8.13±0.23	9.44±0.15	10.78±0.35	11.78±0.25	12.50±0.20
Fat (%)	4.00±0.03	4.50±0.02	4.74±0.05	5.56±0.03	6.40±0.05
Crude fiber (%)	3.30±0.05	4.10±0.15	4.60±0.10	5.00±0.15	5.60±0.20
Ash (%)	1.80±0.30	2.00±0.30	2.30±0.20	2.50±0.25	2.65±0.20
Carbohydrate (%)	54.27±0.15	46.96±0.20	41.58±0.15	37.66±0.20	33.35±0.25
Food energy value (Kcal)	285.60±0.35	266.10±0.25	252.10±0.30	247.80±0.25	241.00±0.35
Bread characteristics					
Bread volume (cm^3)	310±0.25	280±0.35	210±0.30	180±0.25	110±0.35
Dough expansion (cm)	460±0.20	430±0.30	405±0.25	400±0.35	400±0.30
Specific volume (cm^3/g)	0.78±0.10	0.70±0.20	0.53±0.15	0.45±0.10	0.28±0.15

*Data are mean values of triplicate determination ± standard deviation.

values which showed the reverse.

The carbohydrate content and energy values were highest in sample A (54.27% and 285.60 Kcal) and lowest in sample E (33.35% and 241.0 Kcal), respectively. The low carbohydrate and energy values were as result of the low fat content of the composite breads. Similar trends were reported by Serem et al. (2011) and Islam et al. (2007) in the fortification of wheat flours with defatted and non-defatted soy flour, respectively. The composite breads contained energy values in the range of 241 to 266 Kcal, and hence conformed to the (FAO/WHO, 1994) recommended minimum energy content of 1674 kJ/ 100 g.

The moisture contents of the composite breads increased with soy flour substitution by a range of 33.0 to 39.50%. Increase in moisture content has been associated with increase in fibre content (Akhtar et al., 2008; Elleuch et al., 2011; Maneju et al., 2011). High moisture content has been associated with short shelf life of composite breads as they encourage microbial proliferation that lead to spoilage (Ezeama, 2007).

There was also an increase in the protein content of the composite breads with soy-flour substitution in the range of 8.13 to 12.50%. This increase is as a result of substitution of whole-wheat flour (13.90% protein) with soya bean flour of 39.40% protein content (Table 2). Mashayekh et al. (2008) also reported increase in protein content of the bread as a result of the addition of soy flour. Other studies have also reported a similar increase of protein content in sorghum-soy composite flours (Singh et al., 2000; Awadelkareem et al., 2008). The fat content also increased from 0.5 to 2.4% in the composite breads produced from soy-bean flour substitution. Soy bean from which the soy-flour was produced from is an oil seed, must have contributed most of the oil content to the product. The high oil content of the composite bread ill affect the shelf stability (Weiss, 2000; Potter and Hotchkiss, 2006).

The crude fibre content of the composite bread showed a percentage increase in the range of 0.80 to 2.30% as the whole-wheat flour was substituted with soy bean flour. This could be attributed to the use of whole wheat flour and soy-flour, both of which had high crude fibre contents (3.5 and 6.5%, respectively).

The crude fibre most likely from the bran of the whole-wheat flour and the hull of soy beans, represents variable fraction of dietary fibre and includes mostly the lignin, cellulose and hemicelluloses components (Mannay and Shadaksharaswany, 2005; Islam et al., 2007).

The increased fibre and the lower carbohydrate content of composite breads have several health benefits, as it will aid in the digestion of the bread in the colon and reduce constipation often associated with bread produced from refined wheat flour (Jideani and Onwubali, 2009; Elleuch et al., 2011). According to well-documented studies, it is now accepted that dietary fibre plays a significant role in the prevention of several diseases such as; cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes (Slavin, 2005; Elleuch et al., 2011). The crude fibre contents of the composite breads, was within the recommended range of not more than 6 g dietary fibre and other non-absorbable carbohydrates per 100 g dry matter (FAO/WHO, 1994). Vitalis et al. (2009) reported that using whole grain raw materials and combining wheat flour with certain legumes and pseudocereals in biscuit production, resulted in improved nutritional and functional properties of the final product.

Bread characteristics

Results of the physical characteristics of composite bread samples containing different levels of soybean flour

Table 4. Sensory mean scores of bread samples.

Parameters	Bread samples				
	A	B	C	D	E
Crust colour	4.8^a	4.9^a	4.9^a	4.5^a	4.8^a
Crumb appearance	4.9^a	4.9^a	4.6^a	4.3^a	4.2^a
Texture	4.4^a	5.2^a	4.9^a	5.4^b	5.0^a
Flavour	5.5^a	4.4^b	4.3^b	4.0^b	2.0^c
Overall acceptability	4.4^a	4.4^a	4.1^b	4.0^b	3.8^c

*Means within a row with different letters are significantly different at P = 0.05

substitution as compared to the control is also shown in Table 3. The bread dough expansion and bread volume decreased by a range of 6.52 to 13.04% and 9.65 to 64.52%, respectively, as the level of substitution with soy bean flour increased. Albert (1997) and Gomez et al. (2002) reported that, the main problem of dietary fibre addition in baking is the important reduction of loaf volume and the different texture of the breads obtained. Increased supplementation of wheat flour with defatted and non-defatted soy-flour reduced loaf volume and specific volume drastically (Constandache, 2005; Rodriguez et al., 2006; Islam et al., 2007).

Dietary fibre additions, in general, had pronounced effects on dough properties yielding higher water absorption, mixing tolerance and tenacity, and smaller extensibility in comparison with those obtained without fibre addition (Gomez et al., 2002; Elleuch et al., 2011). The deleterious effects of addition of fiber 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 (Dewettinck et al., 2008; Eiman et al., 2008; Elleuch et al., 2011).

Sensory evaluation

Results of sensory evaluation of bread samples containing different level of soy-flour substitution as compared to the control is shown in Table 4.

The results of bread crust colour and crumb appearance did not show a consistent pattern for all the bread samples, and there was no significant difference in the bread samples and the control sample. The darker color of the crumbs of whole wheat bread and fortified breads and biscuits have been reported by several authors (Singh et al., 2000; Akhtar et al., 2008; Serrem et al., 2011). The brownish bread appearance could be directly related to the increase in fiber content (Hu et al., 2007). Moreover browing of the breads could also occur due to caramelization and maillard reactions, as the protein contributed by soybean flour must have reacted with sugar during the baking process (Dhingra and Jood, 2001; Mohsen et al., 2009).

The scores for texture (softness and chewiness) of the composite bread samples, increased with increase in soybean flour substitution, when compared to whole wheat bread (control sample A). The bread with 30% soy-flour substitution (sample D), had the best texture score. Hard crumb texture, caused by increased fiber from wheat bran substitution was reported by Eiman et al. (2008). The baking conditions (temperature and time variables); the state of the bread components, such as fibres, starch, protein (gluten) weather damaged or undamaged and the amounts of absorbed water during dough mixing, all contribute to the final texture of the breads (Gomez et al., 2003; Bakke and Vickers, 2007; Akhtar et al., 2008; Serrem et al., 2011).

The incorporation of soybean flour into whole-wheat bread resulted in poor flavour scores. The results showed a decrease in the scores as the whole-wheat flour was substituted with soy-flour. Sample E with 40% soy-flour recording the lowest value. Most of the panelist complained of beany flavour and aroma from the soy-flour in the composite breads. Serrem et al. (2011) reported that substitutions of defatted-soy-flour into wheat bread and biscuits were associated with the roasted soybean flavour, aroma and after taste. The beany flavour is commonly associated with food legumes (Okoye and Okaka, 2009). In soybeans, enzymatic break down by lipoxygenases or autoxidation of linoleic and linolenic acid produces hydroperoxides such as ketones, aldehydes and alcohols that may be responsible for the beany-flavour which discourages soy consumption (Mannay and Shadaksharaswany, 2005; Awadelkareem et al., 2008; Serrem et al., 2011).

The sensory evaluation also revealed that breads with soy-flour substitution up to 10% (sample B) were overall acceptable, even though normal bread was still preferred. 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 (Dewettinck et al., 2008; Jideani and Onwubali, 2009). Thus, different combinations of both synthetic and organic improvers such as malt flour, vital wheat gluten and ascorbic acid can be included in dough formulation to improve the baking and sensory qualities of the products

(Rodriguez et al., 2006; Elleuch et al., 2011).

Conclusion

In conclusion, composite breads with soy-flour substitutions were found to be nutritionally superior (have higher protein, fat and crude fibre content) to whole-wheat bread. However, the scores for organoleptic attributes like taste, aroma, texture (mouth feel), except for colour were generally inferior to that of whole-wheat bread. Therefore, the whole-wheat bread had better overall acceptability scores than the soy-composite breads.

The composite breads would serve as functional food because of the high fibre content. However, further research work should be focused on the phytochemical (isoflavone) content and how to improve the organoleptic qualities and hence acceptability of soy-enriched breads. Public enlightenment on the nutritional benefits of the soy-supplemented functional foods would help to improve the sensory acceptability of the soy supplemented bread. There is also the need to adjust the mixing ingredients and baking techniques in order to improve the composite bread qualities.

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