European Journal of Food Science and Technology
Vol.2, No.1, pp.19- 28, June 2014
Published by European Centre for Research Training and Development UK (www.ea-journals.org)

PRODUCTION AND QUALITY ASSESSMENT OF ENRICHED COOKIES FROM WHOLE WHEAT AND FULL FAT SOYA

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ABSTRACT: *The use of whole wheat and roasted full fat soybean flour blends in the production of whole meal cookies was studied. Enriched cookies were produced using whole wheat and soybean flour blends, in the ratios: 100:0%, 80:20%, 70:30% and 50:50%, and were labeled A, B, C and D respectively. Sample A served as control. The functional characteristics and proximate composition of the composite flours were determined. The nutritional compositions, microbial and sensory quality of the enriched cookies were evaluated. The results obtained showed superior physical quality by the enriched cookies. On dry weight basis, protein, fat, fiber, ash and energy increased from 8.75 to 24.65, 4.50 to 7.13, 3.29 to 5.73, 2.15 to 2.95% and 411to 578 g/cal. respectively, whereas carbohydrate decreased from 70.45 to 23.71% with increased substitution of soy-flour. The mineral contents also showed increased values for sodium, potassium, calcium, magnesium and iron in the enriched cookies. The viable microbial counts for the enriched cookies were very low (<1.5x101 cfu/g). There were no coliform and mould contaminations in all the samples. There were significant differences (p< 0.05) in sensory attributes analyzed. Samples C and D with 30% and 50% soy-flour substitution had the best overall acceptability ratings of 8.65 and 8.10 respectively*

KEYWORDS: Whole Wheat, Full Fat Soya, Enriched Cookies, Physico-Chemical Composition.

INTRODUCTION

Cookies, known in the United Kingdom as a type of biscuits but more generally referred to as “cookies” in USA is regarded as confection-food with low moisture content (Albert, 1999). Cookies are nutritive snacks obtained from single or composite dough which has been transformed into digestible and more appetizing products through the action of heat in the oven (Singh et al, 2000). Cookies are classified based on the ingredient composition and processing techniques (Albert, 1999).

Wheat is one of the most important staple food for humans (Akhtar et al., 2008). The kernel consists of the wheat germ and the endosperm, which is full of starch and protein (Mannay and Shadaksharaswany, 2005). Usually the whole grain is milled to leave just the endosperm for white flour, while the by-products of bran and germ are discarded. It has been shown that the whole grain is a concentrated source of essential nutritional components such as vitamins, minerals, protein, fat and fibre while the refined grain is mostly starch (Potter and Hotchkiss, 2006; Bakke and Vickers, 2007). Wheat therefore, is perhaps the most popular energy grain for the production of confectionary products, because of the unique properties of its protein (gluten) which combines strength and elasticity required to produce bread, cookies, cakes and pastries such as spaghetti, macaroni and noodles of desirable texture and flavour (Potter and Hotchkiss, 2006; Akhtar et al., 2008).

Soya bean is one of the most important oil and protein crops of the world (Alabi et al., 2007; Hegazy and Ibrahim, 2009)). It is an excellent source of protein because it contains all the essential amino acids, is very rich in minerals and is a good source of fat soluble vitamins (Alabi et al., 2007; Serrem et al., 2011). Moreover, phytochemicals like isoflavones, contained in soybeans are effective cancer-preventive agents for lowering risks of various cancers, is also involved in prevention of osteoporosis via its phytoestrogen effects and in the prevention of neovascularization in ocular conditions (Zhu et al., 2005). Hence soya is regarded as the richest in food value of all plant foods consumed in the world (Mannay and Shadaksharaswany, 2005; Giami and Bekebian, 2000; Ndife et al, 2011).

The need for strategic development in the use of inexpensive local resources in the production of staple foods has been promoted by organizations such as the Food and Agricultural Organization (FAO) and the United Nations refugee feeding programs (FAO/WHO, 1994; Awogbenja and Ndife, 2012). 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 (FAO/WHO, 1994). This is because 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 (Okoye and Okaka, 2009; Serrem et al., 2011).

Moreover, formulation of foods from low-lysine staples such as grains fortified with legumes has been proposed as a practical and sustainable approach to improving the protein nutritional value of foods for vulnerable people in developing countries (FAO/WHO, 1994; Zhu et al, 2005) and especially in famine and war situations where there is the need to provide a one stop whole meal with all the required nutritional components that will cater for dire nutritional needs of both the young and elderly victims.

The simplicity and ease of production makes cookies the best choice as excellent carriers of a blend of different and varied functional ingredients, without obvious detraction from the sensory quality and shelf stability of the resultant products, thus, cookies can be formulated into food a product that contains all the nutrients needed by the body (Albert, 1999).
Therefore, this study intends to produce whole meal enriched cookies of high energy, protein and fibre contents from flours obtained from whole wheat grain and roasted full fat soya bean and to evaluate the nutritional, microbial quality and sensory acceptance.

MATERIALS AND METHODS

The whole wheat grains 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 full fat 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.

Production of Cookies

The whole wheat flour was mixed with varying inclusions of 0, 20, 30 and 50% of the roasted full fat soy-flour and were labeled as samples A, B, C and D respectively. Sample A served as control. The composite flours were blended with other baking ingredients (Table 1) in a mixer, kneaded for 12 min with a kneading machine into consistent dough. The resulting dough was cut into uniform sizes and passed through a series of molding, shaping and stamping. The stamped dough were baked in the oven for 45 min at 260 ^{0}C, the products were allowed to cool and were subsequently packaged with a cellophane wrapper. All the enriched cookies were stored at room temperature, during the period of analytical investigation.

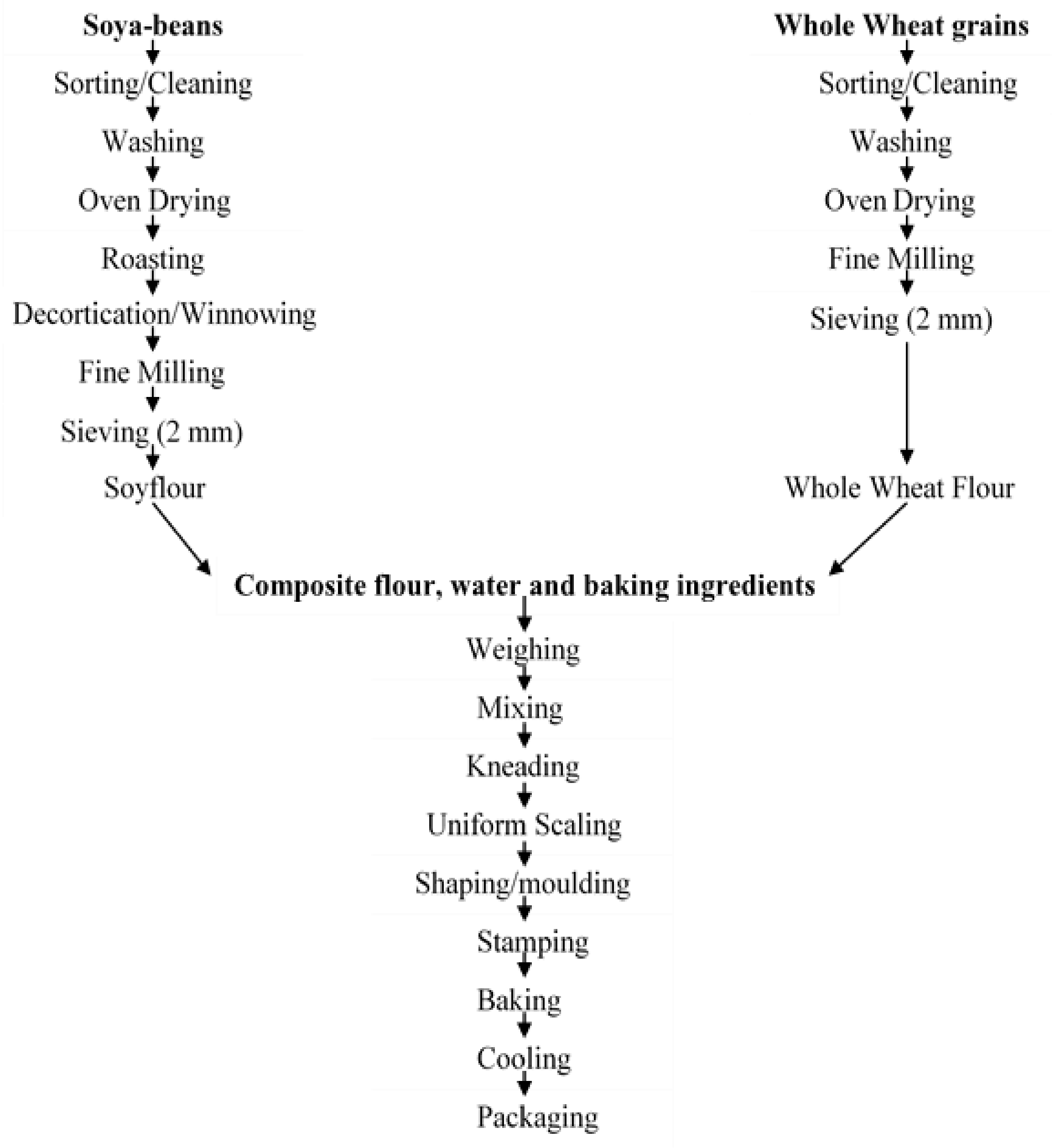

Figure 1. Flow chart for the production of enriched cookies.

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

	Cookie samples			
	A	**B**	**C**	**D**
Whole-wheat flour (g)	100	80	70	50
Soy-flour (g)	0	20	30	50
Salt	2	2	2	2
Sugar (g)	8	8	8	8
Sugar (g)	1	1	1	1
Water	119	119	119	119
Total dough weight (g)	130	130	130	130

Physico-chemical analysis

The cookies physical characteristics, such as: height, width, thickness were measured with digital vernier calipers with 0.01mm precision and the spread ratio calculated by the method described by (Ayo et al, 2007). While the functional properties of bulk density, water and oil absorption capacities and wet ability were determined (Onwuka, 2005) The determination of the chemical composition of the cookie samples viz: moisture content, ash, protein, fat, fiber, cabohydrate and Energy contents were determined by methods described by AOAC (1990).

Mineral Assay

The cookie samples were digested by the wet ashing method prior to mineral content determination using atomic absorption spectrophotometer for Ca, Mg, and Fe and Corning 400 flame photometer for K and Na (Abulude et al, 2007). While the phosphorus content was determined colorimetrically with Jenway 6100 spectrophotometer using the method described by Nielson (2003).

Microbiological analysis

The determination of the microbial quality (mesophilic aerobic bacteria, coliforms, yeasts and mold counts) of the products were performed by the method outlined in compendium of methods for the microbiological examination of foods (AMPH, 1992) with some modifications.

Sensory analysis

Sensory evaluation of the composite bread samples were carried out by 25 panelists on a 9 point hedonic scale for different parameters such as colour, aroma, taste, texture, crunchiness and overall acceptability as described by Iwe (2010).

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

Composite flour analysis

The results obtained from the functional characteristic and proximate analysis of the whole wheat flour and full fat soybean flour are shown in Tables 2 and 3. The functional properties of the composite flours showed increased bulk density with soy-flour substitution. The bulk density of flours is affected by their moisture contents (Onwuka, 2006).

The composite flours also showed increased resistance to water absorption with soy- flour substitution. The wet-ability, that is, the wetting time provides useful indication of the degree to which the composite flours are likely to mix with water and other water soluble ingredients (Onwuka, 2006). Sample D had the lowest water absorption capacity of 1.11g/g, while sample A (whole wheat flour) had the highest oil absorption capacity (0.68 g/g). The results were not different from that obtained from literatures (Potter and Hotchkiss, 2006). The chemical compositions of composite flours have been shown to affect both physico-chemical properties and nutritional quality of their products (Akhtar et al., 2008; Mashayekh et al., 2008).

Table 2: Results of functional properties analysis of composite flours

	Flour samples			
Parameters	**A**	**B**	**C**	**D**
Bulk Density (g/ml)	0.60±0.10	0.77±0.08	0.83±0.12	0.85±0.11
Wetability (g/sec)	10.10±0.42	13.20±0.39	15.20±0.40	16.15±0.45
Water absorption capacity (g/g)	1.36±0.20	1.31±0.25	1.27±0.22	1.11±0.28
Oil absorption capacity (g/g)	0.68±0.18	0.60±0.20	0.56±0.20	0.51±0.16

*Data are mean values of triplicate determination ± standard deviation

Table 3. Results for proximate analysis of composite flours.

	Flour samples	
Parameters	**Soybean flour**	**Whole wheat flour**
Moisture (%)	6.48±1.21	7.20±1.31
Crude protein (%)	37.50±2.22	12.85±2.25
Fat (%)	10.95±1.36	3.55±1.25
Crude fiber (%)	6.74±1.15	4.67±1.38
Ash (%)	2.26±0.76	1.70 ±0.80
Carbohydrate (%)	36.07±3.25	70.03±3.15

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

Physical characteristics

The result of the physical analysis of the cookies produced from whole wheat and soya bean flour blend obtained from table 3, shows that the width of the cookies samples A, B, C and D increased as a result of the level of soy-flour substitution. The reverse was observed for the thickness of the cookies. Sample A (whole wheat cookies) had the highest value of 4.80mm. Sample D recorded the highest for spread factor (87.22). The increased spread ratio observed in soy-flour substituted cookie samples was due to the difference in the particle sizes and characteristics of the constituent flours of soya and wheat (Agu et al, 2007). The spread factor is an indicator of biscuit and cookie quality.

Table 4: Result of physical evaluation of the enriched cookies.

	Cookie samples			
Parameters	**A**	**B**	**C**	**D**
Width (mm)	23.83±1.20	27.13±1.10	29.40±1.52	31.40±1.45
Thickness (mm)	4.80±0.50	4.40±0.65	4.50±0.55	3.60±0.60
Spread factor	49.28±2.21	61.66±2.50	65.33±2.32	87.22±2.20

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

Chemical analysis

Table 5 shows the results of the chemical composition of the enriched cookies. Cookies with increased soy-flour substitutions were found to be nutritionally superior (have higher proximate values for protein, fat, crude fibre content and mineral contents) to whole-wheat cookies (sample A).The moisture contents of the cookies decreased with soy flour substitution by a range of 9.85% to 7.24%. High moisture content has been associated with short shelf life of baked products, as they encourage microbial proliferation that lead to spoilage (Ezeama, 2007; Akhtar et al., 2008; Elleuch et al., 2011).

There was also an increase in the protein content of the cookies with soy-flour substitution in the range of 8.75% to 24.65%. This increase is as a result of substitution of whole-wheat flour (12.85% protein) with soya bean flour of 38.50% protein content (Table 3). Other studies have also reported a similar increase of protein content in soy-composite flours (Singh et al., 2000; Mashayekh et al. (2008). Protein is needed as building blocks for the body, necessary for growth and for the repair of damaged tissues (Wardlaw, 2004).

Table 5: Result of chemical analysis of the enriched cookies

	Cookie samples			
Parameters	**A**	**B**	**C**	**D**
Moisture (%)	9.85±1.52	8.30±1.55	7.56±1.48	7.24±1.56
Protein (%)	8.75±2.23	7.53±2.30	21.08±2.18	24.65±2.00
Fat (%)	4.50±0.30	5.27±0.32	6.10±0.33	7.13±0.30
Crude fiber (%)	3.29±1.35	4.55±1.40	5.05±1.43	5.73±1.38
Ash (%)	2.15±0.85	2.47±0.70	2.75±0.90	2.95±0.86
Carbohydrate (%)	70.45±3.15	37.35±3.40	29.62±3.81	23.71±3.62
Food energy value (kcal)	411.31±4.10	508.42±4.56	546.12±4.32	578.21±4.84

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

The fat content also increased from 4.50% to 7.13% in the cookies samples. Sample D had the highest percentage fat content compared to sample A (whole wheat cookies). Soy-bean (an oil seed) from which the soy-flour was produced must have contributed most of its oil content to the product. The high oil content of the cookies will affect the shelf stability (Potter and Hotchkiss, 2006). Fat is essential component of tissues and a veritable source for fat soluble vitamins (A, D, E and K). It is able to supply thrice the amount of energy required by the body (Wardlaw, 2004).

The ash content also increased from 2.15% to 2.95% in the cookies produced from soy-bean flour substitution. Ash is an indication of mineral contents of foods and has been shown by Alabi and Anuonye (2007) to be high in soy supplemented cereal meals. The crude fibre content of the cookies showed a percentage increase in the range of 3.29% to 5.73% as the whole-wheat flour was substituted with soy-bean flour. The high 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).

The increased fibre and the lower carbohydrate content of cookies have several health benefits, as it will aid digestion in the colon and reduce constipation often associated with products from refined grain flours (Slavin, 2005; Elleuch et al., 2011). The crude fibre contents of the cookies, was within the recommended range of not more than 6 g dietary fibre and other nonabsorbable carbohydrates per 100 g dry matter (FAO/WHO, 1994). Vitalis et al. (2009) reported that using whole wheat flour in combination with legumes in biscuit production resulted in improved nutritional and functional properties of the final products.

Sample A (whole wheat cookies) had the highest carbohydrate content (70.45%), while sample D had the highest energy value of 578.21 kcal. The energy value in sample A could be attributed to the higher lipid contents of soy enriched cookies. Similar trends were reported by Serem et al. (2011) in the fortification of wheat flours with defatted and non-defatted soy flour, respectively. This is highly desired especially in famine and war-torn locations were the next meal is not easy to come by. High-energy foods tend to have a protective effect in the optimal utilization of other nutrients (Wardlaw, 2004).

Mineral analysis

The mineral compositions of the cookie samples are shown in Table 6. Potassium is the most abundant element in all the cookie samples. The highest potassium content (460.82 mg/100g) was recorded in sample D (50% substitution).The mineral content of the cookie samples increased with soy-flour substitution for all the minerals analyzed, except for zinc. Sample A (whole wheat flour) had the highest content of zinc (4.38mg/100g).

High potassium and are low in sodium contents recorded by cookie samples is advantage reported to protect against arterial hypertension (Wardlaw, 2004). Inadequate intakes of micronutrients (Zinc and Iron) have been associated with severe malnutrition, increased disease conditions and mental impairment (Wardlaw, 2004; Mannay and Shadaksharaswany, 2005). The results from this study show that the cookie samples would contribute substantially to the recommended dietary requirements for minerals (Wardlaw, 2004).

Table 6: Result of mineral analysis of the enriched cookies

	Cookie samples (mg/100g)			
Parameters	**A**	**B**	**C**	**D**
Sodium	1.89±1.60	6.90±1.42	7.82±1.73	8.56±1.80
Calcium	30.48±0.51	52.36±0.65	55.85±0.75	65.26±0.84
Potassium	412.47±1.92	453.61±1.68	455.35±2.10	460.82±2.25
Magnesium	31.21±0.16	35.40±0.14	37.37±0.15	42.65± 0.18
Zinc	4.38±0.10	2.74±0.11	2.95±0.10	3.26±0.13
Iron	2.10±0.13	2.55±0.12	3.04±0.11	3.19±0.12

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

Microbial analysis

The results obtained from the microbial quality investigated are shown in Table 7. The results obtained for total aerobic counts were low in all the cookie samples (<1.5x10^2 cfu/g). Sample D (with 50% soy substitution) had the highest microbial counts of 1.0x10^1 cfu/g. The high oil content must have been responsible. The oil and fibre contents are critical to the survival of microbes and will ultimately affect the shelf stability and sensory quality of the cookie samples (Ezeama, 2007). There were no observable coliform and yeast/mould growths from all the cookie samples. This eliminates the possibility of faecal contamination in the different cookie samples, which is pointer to good production and handling practice. This could also be due to the dry nature of the cookie samples (Ezeama, 2007).

Table 7: Results of microbiological analysis of the enriched cookies

	Cookie samples (cfu/g)			
Parameters	**A**	**B**	**C**	**D**
Total Viable count	$1.5\pm0.10x10^1$	$1.3\pm0.21x10^1$	$1.3\pm0.13x10^1$	$1.0\pm0.11x10^1$
Total Coliform count	NG	NG	NG	NG
Yeast/mould	NG	NG	NG	NG

*Data are mean values of triplicate determination ± standard deviation; *NG (No observable growth);

Sensory analysis

Table 8 summarizes the results for the sensory evaluation and overall acceptability of the different cookie samples. The statistical analysis revealed that there were significant differences (p<0.05) among the cookie samples in the sensory attributes observed. Sample A (whole wheat) had the highest score (7.91), while sample C had the lowest score (6.75) for appearance. The appearance was based on the colour-appeal, the panelists showed preference for the lighter colour of sample A (whole wheat). Browning in the cookie samples could have been due to Maillard-type reactions (Potter and Hotchkiss, 2006) resulting from the presence of reducing sugars, proteins and amino acids and caramelization due to the effect of severe heating during processing (Mannay and Shadaksharaswany, 2005).

Table 8: Results of sensory evaluation of the enriched cookies

	Cookie samples			
Parameters	**A**	**B**	**C**	**D**
Appearance	7.91 ^{a}	7.70 ^{a}	6.75 ^{b}	7.18 ^{b}
Taste	6.15^{c}	6.90 ^{b}	6.75 ^{b}	8.35^{a}
Aroma	6.25c	7.11^{b}	7.93^{a}	8.33^{a}
Texture	6.53^{b}	6.84^{b}	8.10^{a}	7.87^{a}
Crunchiness	8.16^{a}	7.95^{a}	6.60^{b}	6.25^{b}
Overall acceptability	7.10^{b}	7.53^{b}	8.65^{a}	8.10^{a}

*Data are mean values of triplicate determination ± standard deviation. *Means within a row with different letters are significantly different at P<0.05.

The incorporation of full fat soybean flour into whole-wheat cookies resulted in better taste and aroma scores. Sample A had the lowest values of 6.15 and 7.11 for both taste and aroma, while sample D (50% full fat soy flour) had the highest scores of 8.35 and 8.33 for taste and aroma respectively. Most of the panelist appreciated the roasted flavour from the soy-flour which was attributed to the oil content. Serrem et al. (2011) reported that substitutions of defatted-soy-flour into wheat bread and biscuits were associated with beanny flavour, aroma and after taste. Beany flavours are commonly associated with food legumes (Okoye and Okaka, 2009).

The scores for texture (softness and smoothness) and crunchiness (chewability) of the cookie samples were affected by soybean flour substitution. The cookie with 30% soyflour substitution (sample C), had the best score (8.10) for texture (softness and smoothness), while the whole wheat cookie (sample A), had the highest score (8.16) for crunchiness (chewiness). Hard crumb that is associated with increased fiber was probably mellowed by the oil contents (Bakke and Vickers, 2007).

Cookie samples C and D had the best overall acceptability ratings of 8.65 and 8.10 respectively. The baking conditions (temperature and time variables); the state of the cookie constituents, such as fibre, starch, protein (gluten) weather damaged or undamaged and the amounts of absorbed water during dough mixing, will all contribute to the final outcome of the overall acceptability (Bakke and Vickers, 2007; Akhtar et al., 2008; Serrem et al., 2011).

CONCLUSION

In conclusion, enriched cookies with soy-flour substitutions were found to be nutritionally superior (have higher protein, fat, fibre energy and mineral content) to whole- wheat cookies. Thus, the enriched cookies can conveniently be regarded as a balanced whole meal. However there is the need to improve on the appearance (colour) and crunchiness of the enriched cookies in order to increase the overall organoleptic acceptance. The results also show that the cookies are safe for human consumption considering their low microbial content. However, further research work should be focused on the shelf stability of the enriched cookies, considering that high lipid content would make the cookies to be prone to rancidity.

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