Global Journal of Food Science and Technology

ISSN: XXXX-XXXX Vol. 2 (3), pp. 127-133, June, 2014. © Global Science Research Journals

Full Length Research Paper

Effect of whole wheat flour on the quality of wheat-baked bread

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Accepted 9th June, 2014

The use of whole wheat and white wheat flour blends in the production of functional breads was studied. Whole wheat flour was blended with white wheat flour at 10, 20, 30 and 40% substitution level while the 100% white wheat bread served as control. The proximate composition of the various flour blendsused for the preparation of the breads was determined using standard methods. The bread loaves were produced using the straight-dough procedure and were subsequently evaluated for their weight, loaf volume, specific volume and sensory attributes. Proximate analyses results showed an increase in the range of 1.86% for moisture, 1.43% for ash, 3.28% for protein, 1.92% for fat, 2.49% for crude fibre and a decrease in carbohydrates by 10.98% with increasing levels of whole wheat flour in the blends. There was also a decrease in bread volume, specific volume and an increase in weight by 216.31cm^3, 1.35g/cm^3 and 35.54g respectively, with progressive inclusion of the whole wheat flour. The sensory analysis results showed that replacement of white wheat flour with whole wheat flour up to 20% of substitution level produced acceptable bread which was comparable with the control in terms of the overall acceptability of the bread.

Keywords: whole wheat flour, white wheat flour, functional bread, sensory attributes,dietary fibre.

INTRODUCTION

Bread is an important staple food (Abdelghafor et al., 2011)and the most widely consumed bakery product (Aini and Maimon, 1996).It may be described as a fermented confectionary product produced mainly from white wheat flour, water, yeast and salt by a series of processes involving mixing, kneading, proofing, shaping and baking (Dewettinck et al., 2008; Banu et al., 2012).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 led to drastic reduction in the nutritional density and fibre content of white bread when compared to bread made from whole grain cereals (Maneju et al., 2011).Recently, consumers' awareness of the need to eat functional foods- foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements is increasing (Ndife and Abbo, 2009).Also, many people for medical reasons cannot eat "ordinary bread" and a growing number of people wish to make their bread more nutritious (Dewettincket al., 2008;Scade, 1975) therefore, the trend is to produce specialty breads, health breads or functional breads made from whole grain flour and other functional ingredients (Dewettinck et al., 2008). 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. Whole wheat flour has been shown by many researchers to be a rich source of these functional ingredients such as fibre, phytochemicals, minerals and 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).

Whole wheat bread is made from whole wheat flour produced by milling the entire wheat kernel. This implies

Table 1: Mixture contents of bread substituted with different levels of whole wheat flour

Ingredients	Weight in different samples				
	E0	E1	E2	E3	E4
White wheat flour	500g (100%)	450g (90%)	400g (80%)	350g (70%)	300g (60%)
Whole wheat flour	0g	50g (10%)	100g (20%)	150g (30%)	200g (40%)
Yeast	20g	20g	20g	20g	20g
Fat	30g	30g	30g	30g	30g
Sugar	30g	30g	30g	30g	30g
Salt	2.5g	2.5g	2.5g	2.5g	2.5g
Water	250ml	250ml	250ml	250ml	250ml

that the outer layers of the wheat kernel are retained (Banu *et al*., 2012).This is in contrast to white, refined flours, which contain only the endosperm (Catterall, 1998). Therefore the wholemeal flour provides good bread in terms of nutritional value and health benefits (Dewettinck*et al.*, 2008). Since the market of white flour bread is better than that of wholemeal flour bread, there is much interest in developing white breads rich in dietary fibre content (Maneju et al., 2011) and/or with high vitamins and minerals contents. Although white flour may in a process called food fortification have some micronutrients lost in processing added back, fortified white wheat flour does not, however, contain the macronutrients of the wheats' bran and germ like whole wheat flour does and is notably lacking in fibre. Fibre has long been known to aid digestive health and can help one lose or maintain weight because eating fibre-dense wheat bread helps one feel full.

Much effort has been made to enrich bakery products especially bread with non-wheat flour so as to increase the dietary fibre content, yet maintain the desirable eating qualities (Banu et al., 2012). The challenge is to create high fibre bread without the undesirable grainy texture. Whole wheat flour thus, provides a new source of fibre for utilization in bakery products. The aim of this research was to produce functional breads form whole wheat and white wheat flour blends and to compare the bread samples with bread produced from 100% white wheat flour.

MATERIALS AND METHODS

Materials

Wheat grains, white wheat flour and other ingredients for baking bread were purchased from a local market ("Eke-onuwa") at Owerri in Imo-State, Nigeria.

Methods

Preparation of whole Wheat Flour

Wheat grains were sorted for wholesomeness, washed with distilled water, sun dried for 24hrs and milled three times using attrition mill to obtain very fine flour. The bran and germ were not sieved out and therefore flour of 100% extraction rate was obtained.

Formulation of Blends

White wheat flour was blended with 10, 20, 30 and 40% whole wheat flour. A Cross-flow blender (The Patterson Kelly Co. Inc., Stroudsburg, PA) was operated for 1 h to produce homogenous blends. The flour samples in addition to 100% white wheat flour were stored at ambient temperature (29^{0}C ± 2^{0}C) in sealed polyethylene bags until required.

Proximate Analysis of Flour Samples

Moisture, ash, protein, fat, and crude fibre contents of the flour samples was determined by methods described by AOAC (1990). Available carbohydrate was determined by difference according to Onwuka (2005).

BREAD MAKING PROCESS

The one-stage method was used to prepare the dough using a laboratory mixer. All the ingredients and flour blends as shown in Table 1 were placed in the dough mixer and mixed thoroughly for approximately 5min. The dough was left in bowls to prove covered with damp clean muslin cloth for approximately 55min at room temperature (29°C). Two kneading's of 30 s each were afterwards performed at 60 and 120 min. The dough was then divided in two pieces which were moulded into a

Table 2: Results of proximate composition of flour blends

Flour samples	Parameters					
	Moisture (%)	**Ash (%)**	**Crude protein**	**Fat**	**Crude fibre**	**Carbohydrates**
E0	12.19 ±0.057	0.86 ±0.000	11.65 ±0.113	1.31 ±0.028	0.48 ±0.42	73.51 ±0.064
E1	12.25 ±0.057	1.28 ±0.028	11.98 ±0.184	1.53 ±0.057	0.75 ±0.42	72.21 ±0.014
E2	13.04 ±0.141	1.71 ±0.085	12.94 ±0.113	1.96 ±0.113	1.44 ±0.071	68.91 ±0.071
E3	13.62 ±0.127	2.13 ±0.113	13.88 ±0.240	2.90 ±0.000	1.78 ±0.169	65.69 ±0.198
E4	14.05 ±0.057	2.29 ±0.042	14.93 ±0.084	3.23 ±0.567	2.97 ±0.197	62.53 ±0.085

E0- 100% white wheat flour, control sample ; E1- sample with 10% whole wheat flour ; E2-sample with 20% whole wheat flour; E3- sample with 30% whole wheat flour, E4- sample with 40% whole wheat flour

loaf, placed in a loaf tin and further proved in a proving cabinet for 30 min at 30°C. The samples were introduced into the oven and baked at 180ºC for 35 min.

Determination of Weight, Loaf Volume and Specific Volume of Bread Loaf weight

After a 2 hour cooling on a cooling rack, loaf weight (W) of the bread samples was measured on digital scale.

Loaf Volume of Bread

Loaf volume of bread was measured using rapeseed replacement method (AACC, 2000). The loaf was put in a metallic container with known volume (VC). The container was topped up with rapeseed, the loaf was removed and the volume of the rapeseed was noted (VR). Loaf volume (VL) was then calculated according to the following formula:

VL (cm^3) = VC - VR

Specific volume of bread

Specific volume (VS) of bread was measured by using the following expression:

VS (cm^3/g) = VL/W

Sensory Evaluation of the Baked Product

The bread samples were subjected to sensory evaluation using ten panelists. Their preference of the samples was evaluated using the 9- point hedonic scalefor 1- extremely dislike and 9- like extremely (Ihekoronye and Ngoddy, 1985). The bread samples were evaluated for crust colour, crumb texture, taste and overall acceptability. During sensory evaluation, panellists were instructed to drink water or rinse their mouths to clear the palate after each evaluation. Sensory evaluation was done on the same day the breads were prepared.

Statistical Analysis

Values were obtained as the means ± standard deviation of three determinations. Data was analysed by analysis of variance (ANOVA) and Duncan's multiple-range test or *t*-test. Differences among samples were considered significant at P≤ 0.05 (Ihekoronye and Ngoddy, 1985).

RESULTS AND DISCUSSIONS

Proximate Composition of Flour Samples

Results of the proximate composition of the flour samples are shown in Table 2. The proximate values increased with increasing levels of whole wheat flour substitutions except for carbohydrate values which showed the reverse. The high carbohydrate content of 100% white wheat flour was as a result of the fact that it was processed from the endosperm which contains basically carbohydrates. This is in contrast to the whole wheat flour which has three nutrient-rich parts: the bran (the outer layers), the germ (the innermost area) and the endosperm (the starchy part in between).

The moisture contents of the flour samples increased with whole wheat flour substitution and the values ranged from12.19% to 14.05%. Banu et al. (2012) reported moisture contents of 11.3% and 11% for white flour and whole wheat flour respectively. Zlatica and Jolana (2010) reported moisture content of 11.4% for fine flour and 10.6% for whole meal flour. The differences in moisture content of the flour samples could be due to differences in storage and processing methods of the samples since they were not from the same source.Increase in moisture content has been associated with increase in fibre (Maneju et al., 2011). The range of values for moisture

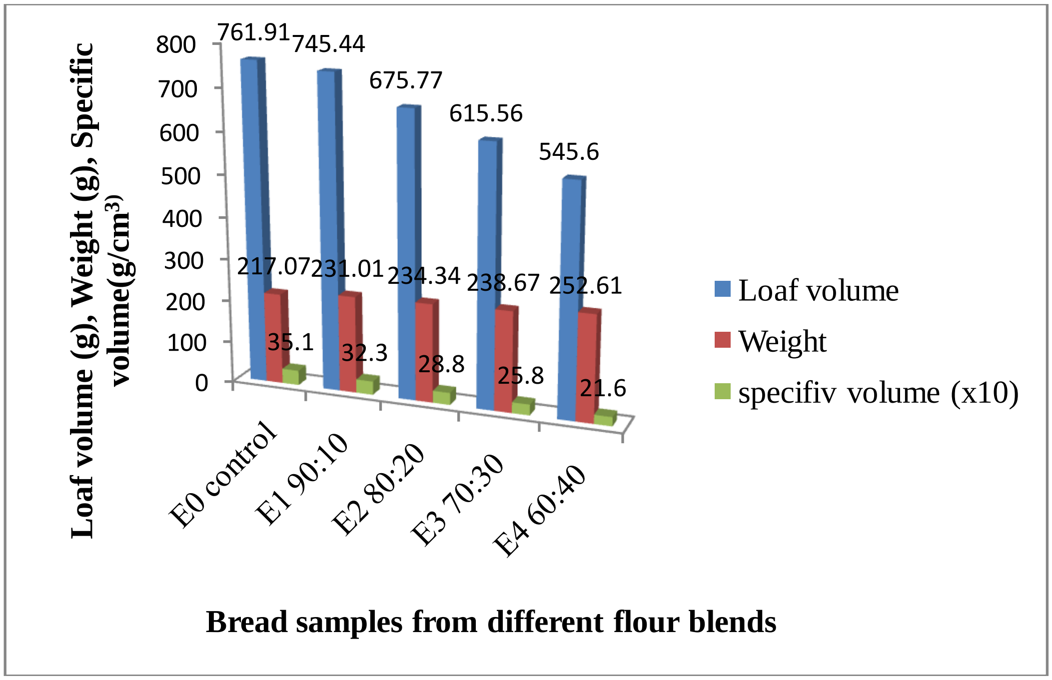

Figure 1: Results of loaf volume, weight and specific volume of breads from different blends of white wheat flour and whole wheat flour

content implied that the flour blends had good storage potential, since it was known that moisture and water activity of a product determine greatly its keeping quality (Ajani et al., 2012). These values were minimal and may not have adverse effect on the quality attributes of the product. High moisture content has been associated with short shelf life of a product as they encourage microbial proliferation that lead to spoilage (Ezeama, 2007).

There was also an increase in the protein content of the flour blends with whole wheat flour substitution in therange of 11.65% to 14.93%. Whole wheat flour contains more protein than white flour (Ziaulhaq et al. 2004) since it contains the macronutrients of the wheat's bran and germ (rich in fibre and protein).

The fat content of the flour blends increased from 1.31 to 3.23% with increased level of whole wheat flour substitution in the flour blends. Fat plays a significant role in the shelf life of food products and as such relatively high fat content could be undesirable in food products. This is because fat can promote rancidity in foods, leading to development of unpleasant and odorous compounds (Ihekoronye and Ngoddy, 1985).

The crude fibre content of the flour samples showed a percentage increase in the range of 0.48 to 2.97% asthe white wheat flour was substituted with whole wheat flour. This could be attributed to the high crude fibre content of the whole wheat flour. Crude fibre most likely from the bran of the whole wheat flour represents variable fraction of dietary fibre and includes mostly the lignin, cellulose and hemicelluloses components (Islam et al., 2007).The increased fibre content of the flour blends has several health benefits; it will aid in the digestion of the flour samples in the colon when they are processed into bread and reduce constipation often associated with bread produced from white wheat flour (Jideani and Onwubali, 2009). 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).

Ash content of the flour blends increased at higher whole wheat flour substitution.The same observation was made by Banu et al. (2012) who reported that addition of 3 to 30% wheat bran stream (WBS) to the white flour increased the ash content. Ash content in flour samples with 10%, 20%, 30% and 40% whole wheat flour increased by 0.42, 0.85, 1.27 and 1.43% respectively compared to the control. The significant increase in ash may be attributed to the increased amount of minerals such as calcium and iron at higher whole wheat flour substitution levels in the flour samples.The amount of minerals in flour increases with extraction rate and can be determined by burning a sample of the flour to ashes (Scade, 1975).

Results of Loaf Volumes, Weights and Specific Volumes

The results of loaf volume, weights and specific volumes are shown in Figure 1.

Table 3: Results of sensory evaluation

Bread samples	Crust color	Crumb texture	Taste	Overall acceptability
E0	6.40^{a}	6.10^{a}	6.99^{a}	6.40^{a}
E1	6.25^{a}	5.99^{a}	6.87^{a}	6.37^{a}
E2	5.85^{b}	5.87^{a}	6.79^{a}	6.35^{a}
E3	4.42^{c}	3.01^{b}	3.41^{b}	3.55^{b}
E4	3.36^{d}	2.44^{c}	2.32^{c}	2.53^{c}

E0- 100% white wheat flour bread, control sample ; E1- sample with 10% whole wheat flour ; E2-sample with 20% whole wheat flour; E3- sample with 30% whole wheat flour, E4- sample with 40% whole wheat flour
*Means in the same column bearing different superscripts are significantly different ($p \le 0.05$).

Loaf Volume

Loaf volume is an important indicator for identifying bread characteristics because it provided quantitative measurement of baking performance. Bread samples at higher whole wheat flour substitution levels elucidated lower loaf volume compared to the control. A pronounced decrease of loaf volume was exhibited in bread sample with 40% whole wheat flour. The significant decrease in loaf volume at higher whole wheat flour substitution levels was attributed to the gluten dilution effect (Krishnan et al., 1987), which was associated with the low protein network in the dough (Rosell et al., 2001) and indicated weak interaction between starch and gluten of flour (Oates, 2001). Substitution of whole wheat flour which contains dietary fibre (Pollard et al., 2002) and non- gluten networks into the bread formulation caused an adverse effect on carbon dioxide gas production and retention during dough proofing that exerted lower loaf volume.Gomez et al. (2003) 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. 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., 2003). Hence, gas cells in the dough at higher whole wheat flour substitution levels were not able to expand due to less gas retention.

Specific Volume of Bread

The specific volume of the bread samples decreased significantly at higher whole wheat flour substitution. Bread with 40% whole wheat flour had a substantial decrease in specific volume of 1.35g/cm^{3}compared to the control.A similar result was reported by Gomez et al.(2003) and Sullivan et al.(2011) who utilized wheat fibres and barley middlings. Banuet al. (2012) also reported decreased specific loaf volume and slice area in wheat bran stream containing breads. The lower value of specific volume was directly related to the lower loaf volume of the bread samples. The occurrence of lower loaf volume and specific volume was due to the higher amount of amylopectin which increased the water retention and decreased the gas retention (Lee et al., 2001) of loaf during baking, thus resulting in reduced loaf volume.

Weight

Weight of the bread samples increased at higher whole wheat flour substitution levels because of decrease in volume and specific volume. Bread with 40% whole wheat flour had the highest weight (252.61g).

Sensory Evaluation

The process by which bread quality is determined still relies heavily on subjective assessment (Cauvain, 1998b). Sensory evaluation results are shown in Table 3.

Crust Colour

The crust as applied here is the outside layer of the bread. It should be smooth and golden brown (Sanful, 2011).The score for crust color decreased significantly ($p \ge 0.05$) as whole wheat flour substitution level increased. However, no significant difference was observed for the control (E0) and bread sample that had 10% and 20% whole wheat flour (E1). Bread with 40% whole wheat flour had the lowest score for crust color indicating that crust color was not attractive at higher whole wheat flour substitution levels. The same observation was made by Sanful (2011) for Taro and Whole Wheat Flour Composite Bread.

Crumb Texture

Crumb texture was observed to reduce significantly with increased whole wheat flour substitution level. Texture is the quality of the bread that can be decided by touch, the degree to which it is rough or smooth, hard or soft. Hard crumb texture, caused by increased fibre from wheat bran substitution was reported by Eiman et al. (2008). The baking conditions (temperature and time variables), state of the bread components (such as fibres, starch, gluten etc.) and the amounts of absorbed water during dough mixing, all contribute to the final texture of breads (Gomez et al., 2003).Addition of whole wheat flour into the bread formulation resulted in coarser structure and increased the crumb pore size.The number of cells in a bread slice gives an indication of the amount of gas bubbles captured during proofing. Banu et al. (2012) reported that for quality bread usually a large number of small sized cells are desirable and they observed that the incorporation of wheat bran stream into the white flour leads to a more coarse structure of bread. Sullivan et al. (2011) explained that the low number of cells is as a result of gas escaping during proofing, suggesting a disruption of the gluten matrix in the dough. The control sample had a significantly higher score ($p \leq 0.05$) for crumb texture compared to the other samples. However, no significant difference for crumb texture ($p \geq 0.05$) was found between the control and bread sample with 10% and 20% whole wheat flour.

Taste

The taste of the bread refers to the sweet sensation caused in the mouth by contact with the bread due to the sweetening agent. The taste characteristics of bread are vital in determining the overall acceptability of the product. The taste diminished significantly as whole wheat flour substitution level increased. The control and bread samples with 10 and 20% whole wheat flour did not differ significantly ($p \leq 0.05$) in taste.

Overall Acceptability

The score for overall acceptability decreased significantly as whole wheat flour substitution level increased. The overall acceptance expresses how the consumers or panellists accept the product generally.The control received the highest score for overall acceptability followed by the 10% and 20% whole wheat flour breads. The bread with the highest whole wheat flour (40%) was unacceptable because it contained the lowest score for overall acceptability. Thus, bread substituted with up to 10% and 20% whole wheat flour were acceptable and these bread samples were comparable with the control in terms of the overall acceptability of the bread.The baking properties of whole wheat 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 product (Rodriguez et al., 2006).

CONCLUSION

Substitution of white wheat flour with whole wheat flour greatly improved the nutritional quality of bread. The bread samples would serve as functional food because of their high fibre content. However, further research work should be focused on how to improve the organoleptic qualities and hence acceptability of whole wheat flour enriched breads. Public enlightenment on the nutritional benefits of the whole wheat flour supplemented functional foods would help to improve their sensory acceptability. There is also the need to adjust the mixing ingredients and baking techniques in order to improve the bread qualities.

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