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*Corresponding author: D.S. Ikuomola,
Department of Food Science and
Technology, Joseph Ayo Babalola
University, Ikeji- Arakeji, Ilesa, Osun
State, Nigeria
E-mail: mercyo2001@yahoo.com

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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Quality assessment of cookies produced from wheat flour and malted barley (*Hordeum vulgare*) bran blends

D.S. Ikuomola^{1*}, O.L. Otutu¹ and D.D. Oluniran¹

Abstract: Cookies quality produced from blends of wheat flour (WF) and malted barley bran (MBB) at different ratios of 100/0, 95/5, 90/10, 80/20 and 50/50% was investigated. The proximate, physical and sensory properties of the cookie samples were evaluated using standard laboratory procedures. Cookies with 100% wheat flour (WF) serves as a reference sample. The data generated were statistically analyzed by one way analysis of variance (ANOVA) using SPSS (version 16). The proximate results of the cookies showed an increase in protein (11.21–15.64%), ash (1.41–1.88%), fat (29.86–32.36%), crude fibre (1.32–6.38%) as well as decrease in moisture content (4.06–3.34%), carbohydrate (52.79–40.05%) and energy value (525.02–509.98 kcal/100 g) as the substitution level of MBB increases. The physical properties of the cookies; weight (16.32–20.00 g), diameter (50.2–57.3 mm), thickness (6.30–6.60 mm), spread ratio (7.97–8.68) increased while the breaking strength (169.33–290.26 g) decreased as the levels of MBB increased. However, the sensory results showed that the cookies varied in colour (7.1–8.4), taste (4.1–7.6), flavour (4.3–8.3), crispiness (5.2–8.2) and overall acceptability (5.4–8.8). The reference sample had the highest sensory scores for all the attributes except for colour and crispiness, while cookies with 5 and 10% malted barley bran incorporation had

ABOUT THE AUTHORS

O.L. Otutu is a Senior Lecturer in the Department of Food Science and Technology, Joseph Ayo Babalola University, Ikeji Arakeji Nigeria. He has published a lot of papers in the area of Food Chemistry and Processing in Journals of repute both locally and internationally.

D.D. Oluniran is a young scientist with a BSc Degree in Food Science and Technology from Joseph Ayo Babalola University Ikeji Arakeji Nigeria.

PUBLIC INTEREST STATEMENT

Cookies are confectionary products widely consumed by all age group and ideal for nutrient availability, palatability and convenience. The consumption of food rich in whole grains and cereal brans have been reported to have several health benefits, such as; reduction of obesity, diabetes and cardiovascular diseases. Malted Barley Bran (MBB) merits a detailed investigation for its suitability in cookies production, owing to the presence of soluble fibres (pectin and gum), minerals, nutrients and phytochemicals. This perspective article describes some of the chemical, physical and sensory attributes associated with the cookies produced from wheat flour and MBB. Clearly depicted are the increased fibre and ash contents, weight and thickness with reduced breaking strength as a result of the increasing substitution level with MBB. The consumer acceptability of the cookies at 5% MBB level with desirable attributes could serve as a vehicle for essential nutrients to the populace and also reduce over-dependence on expensive wheat imports in Nigeria.

the highest score for crispiness and colour respectively. Based on the parameters analyzed, 5% malted barley bran incorporation could be utilized for cookies production owing to its baking potential characteristics. In conclusion, the high protein, ash and fibre contents of the cookies made with malted barley bran flour substitution is very important as this could make a significant contribution to the nutrient intake by consumers who are likely to be children.

Subjects: Environment & Agriculture; Bioscience; Food Science & Technology; Engineering & Technology

Keywords: cookies; malted barley bran (MBB); wheat flour (WF); proximate composition; sensory evaluation and physical characteristics

1. Introduction

Cookies are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven Anozie, China, and Beleya (2014). They are ready-to-eat, conveniences and inexpensive food product, containing digestive and dietary principle of vital importance Olaoye, Onilude, and Oladoye (2007). Cookies contribute valuable quantities of iron, calcium, protein, calorie, fibre and some of the B-vitamins to our diet and daily food requirement. Biscuits are important baked product in human diet, which are usually consumed with beverage and also used as weaning foods for infants (Ferial & Azza, 2011). The major ingredients are flour, fat, sugar, salt and water. These are mixed together with other minor ingredients (baking powder, skimmed milk, emulsifier and sodium meta-bisulphite) to form dough containing a gluten network (Akinwande, Ade- Omowaye, Olaniyan, & Akintaro, 2008). Soft wheat flour has been the major ingredient used in the production of biscuit and other pastry products, but they can also be made with non-wheat flours such as sorghum, maize, pearl millet, plantain, acha grain, bambara-nuts etc. One such locally available resource is malted barley bran.

The bran of malted barley (*Hordeum vulgare*) is a by-product of the brewing industry, which is a potentially valuable resource for industrial exploitation owing to its high source of protein, minerals and fibre. It is usually discarded or used as feed for animals. Malted barley bran consists mainly of the husk, with significant quantity of fibre content. It is considered as a good source of dietary fibre which could be of importance in the food industry, particularly baking. Supplementation of wheat flour with malted barley bran could therefore enhance the nutritional quality of baked products and makes more varieties to be available in the market.

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; Food and Agricultural Organization (FAO) and the United Nations Refugee feeding programs (Awogbenja & Ndife, 2012; FAO/WHO, 1994). However, this resulted to the initiation of the composite flour program, the aim 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/UNU Expert Consultation, 1994)

In Nigeria, reliance on wheat flour in the bakery industries has over the years restricted the use of other cereals and tuber crops available for domestic use. In recent years, government has through intensive collaboration with research institutes encouraged the use of composite flours in the production of bread and related food products such as cookies. This initiative enhanced the use of flours from roots and tubers (cassava, sweet potato, cocoyam), bread-fruit, plantains oilseeds (soybeans), legumes (bambara groundnut), fluted pumpkin seeds, maize, amaranth seeds and other underutilized crops that are good sources of flour. The adoption of these locally produced flours in the bakery industry increased the utilization of indigenous crops cultivated in Nigeria and also reduces the cost of bakery products (Ayo & Gaffa, 2002).

However, the increasing phenomenon of urbanization coupled with growing number of working mothers, have profoundly contributed to the popularity and increased consumption of snack foods Gernah, Senger, and Audu (2010). In addition, the consumption of baked products by human coupled with the escalating cost of wheat importation and difficulty in cultivating wheat in the tropics has focused attention on the need to explore the use of alternative local flours as supplements or substitutes for wheat flour in the baking industry. Many researchers have worked extensively on composite flour for the production of biscuits, buns, cakes and bread. Composite flour refers to the mixture of different concentrations of non-wheat flours from cereals, legumes, roots and tubers or mixture of flours other than wheat flour. Composite flours are advantageous, owing to the fact that the inherent deficiencies of essential amino acids in wheat flour (lysine, tryptophan and threonine) are supplemented from other sources.

Composite flour are better utilized for cookies production rather than for bread because of their ready-to eat form, relatively prolonged shelf-life, wide consumption and good eating quality. Cookies based on rye, barley, rice, maize, acha, amaranth and oat flour have been reported by several researchers. Protein enrichment studies on cookies have been carried out using brewer's spent grain (Gernah et al., 2010) and some legumes, which are generally good source of proteins. Supplementation of wheat flour with different proportions of bambara groundnut flour for biscuit production had also been investigated (Ferial & Azza, 2011). Despite the inherent potentials of malted barley bran, there is paucity of information on its incorporation in many food formulations.

The thrust of this study, therefore, was to produce and assess the chemical, physical and sensory properties of wheat cookies, improved with malted barley bran at different substitution levels.

2. Materials and methods

2.1. Source of materials

Dangote wheat flour, Dangote granulated sugar, powdered milk, Simas baking fat, salt and royal baking powder were procured from Ilesa market, Osun state, Nigeria. Malted barley bran (dried form) was obtained from Nigeria Brewery, Apapa, Lagos state, Nigeria. The chemicals used were of analytical grade.

2.2. Formulation of composite flour

The composite flour was prepared by replacing wheat flour (WF) with malted barley bran (MBB) at 0, 5, 10, 20 and 50% and were labeled as samples; T_0 , T_1 , T_2 , T_3 and T_4 respectively as shown in Table 1. Sample T_0 with 100% WF served as a reference sample. The malted barley bran was sorted to remove whole barley grains and then winnowed to remove stones and other foreign materials. The winnowed materials were oven dried at 45°C for 30 min and milled with the aid of a Kenwood Chef blender (Model: PT N0.77551) to form fine particle size (2 μ m) prior to its use. The wheat flour and malted barley bran flour were weighed separately with the aid of a digital electronic weighing balance (Metra, model TL 600) at different proportions.

Table 1. Formulation of wheat flour and malted barley bran blends

Sample code	Wheat flour (%)	Malted barley bran (%)
T_0	100	0
T_1	95	5
T_2	90	10
T_3	80	20
T_4	50	50

2.3. Production of cookies

The essential ingredients for the production of cookies and their various proportions are shown in Table 2. Powdered milk, fat, baking powder, salt and sugar were the same for all the proportions. After weighing, the fat was manually mixed vigorously with sugar for 10 min to form cream, wheat flour and malted barley bran flour blends at different levels were then added with other ingredients (milk and baking powder). The mixing was properly carried out and the method described by Akinwande et al. (2008) was followed to produce the cookies.

The flow chart for the production of cookies from wheat flour and malted barley bran flour blends is shown in Figure 1. All the experiments were conducted in duplicates and at random, the cookies were picked for subjective and objective evaluation.

2.4. Determination of proximate compositions of the cookies

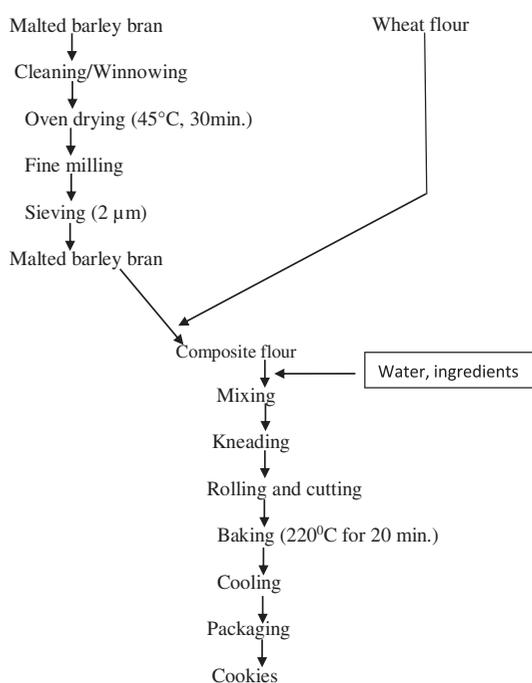
Cookies were analyzed for moisture, protein, fat, crude fibre and ash contents according to the methods described in Association of Official Analytical Chemists [AOAC] (2005). The total carbohydrate (CHO) was calculated by difference method as: $CHO = (\%moisture + \%protein + \%fat + \%ash)$. Food energy value (kcal/100 g) was determined according to the method of Marero et al. (1998) using the factor $(4 \times \%Protein) + (4 \times \%Carbohydrate) + (9 \times \%Fat)$.

Table 2. Recipes for Wheat – malted barley bran cookie samples

Sample code	Wheat flour (%)	Malted BARLEY bran (%)	Sugar (g)	Fat (g)	Baking powder (g)	Milk (g)	Salt (g)
T ₀	100	0	120	250	4.0	10	1
T ₁	95	5	120	250	4.0	10	1
T ₂	90	10	120	250	4.0	10	1
T ₃	80	20	120	250	4.0	10	1
T ₄	50	50	120	250	4.0	10	1

Figure 1. Production of cookies from Wheat flour -Malted barley bran blends.

Source: Adopted from self observation.



2.5. Determination of physical characteristics of the cookies

2.5.1. Weight

The weight of the cookies was determined according to the method of Ayo, Ayo, Nkama, and Adeworie (2007). The weights of cookie samples were determined with the aid of a weighing balance (model) immediately after cooling.

2.5.2. Diameter

The diameter (D) of the cookies was determined according to the method of AACC (2000). Four cookies were placed edge to edge and their total diameter was measured with the aid of a ruler. The cookies were rotated at angles of 90° for duplicate reading. The experiment was repeated twice and average diameter was recorded in millimeter.

2.5.3. Thickness

The thickness of the cookies was determined according to the method of Ayo et al. (2007). The cookies thickness was measured with the aid of a digital vernier caliper with 0.01 mm precision.

2.5.4. Spread ratio

Spread ratio of the cookie samples was determined according to the method of Gomez, Obliana, Martins, Madzavamuse, and Monyo (1997). For spread ratio, two rows of four well formed cookies were made and the height measured. They were arranged horizontally edge to edge and the sum of their diameters measured. The spread ratio was calculated as diameter divided by height, using the formula below;

$$SF = \frac{D \times CF \times 10}{T}$$

Where, CF is a correction factor at constant atmospheric pressure. It has a value of 1.0 in this case (AACC, 2000).

2.5.5. Breaking strength

The breaking strength was determined according to the method described by Okaka and Isiehs (1997). Cookies of known thickness (0.4 cm) were placed centrally between two parallel metal bars (3 cm apart) and weights were applied until the cookies snapped. The least weight that caused the breaking of the cookies was regarded as the break strength of the cookies.

2.6. Sensory evaluation of the cookies

Sensory evaluation of the cookies was carried out according to the method described by Retapol and Hooker (2006). A panel of twenty members consisting of students and members of staff in Food Science and Technology Department, Joseph Ayo Babalola University, Nigeria, was chosen based on their familiarity and experience with wheat-based cookies for sensory evaluation. Cookies produced from each flour blend, along with the reference sample were presented in coded form on white plastic plates and were randomly presented to the panelists. The panelists were provided with portable water to rinse their mouth between evaluations. However, a questionnaire describing the quality attributes (colour, taste, flavour, crispiness and overall acceptability) of the cookies was given to each panelist. The panelist assigned scores for each parameter as against the maximum score of 9. Each sensory attribute was rated on a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely).

2.7. Statistical analysis

Data obtained were subjected to appropriate statistical analysis (ANOVA) using a statistical package for the Social Sciences, SPSS (version 16). Mean separation was done using Duncan multiple range test and significance difference was accepted at 5% confidence level.

3. Results and discussion

3.1. Effect of malted barley bran on the proximate compositions of cookie samples

The results of the effect of malted barley bran on the proximate compositions of cookies are presented in Table 3.

The moisture content (%) of the cookies ranged between 3.34 and 4.06. The reference sample (T_0) had the least value while cookie sample (T_1) had the highest value. However, increased substitution level with MBB caused significant ($p < 0.05$) reduction in the moisture content values. The moisture content of the cookies was low enough (<10%) to reduce the chances of spoilage by micro-organisms and consequently guarantee good storage stability (Ayo et al., 2007). The findings showed that the moisture content of the cookie samples decreased with increasing substitution levels with MBB. On the contrary, Gernah et al. (2010) reported higher moisture content (5.20–9.30%) for cookies made from wheat-brewers spent grain flour blends. According to Adebowale, Adegoke, Sanni, Adegunwa, and Fetuga (2012), baked foods: cake, cookies and bread with high moisture content encourages bacterial, yeast and mould growth that could lead to spoilage. However, cookies should therefore have low moisture for safe storage and inhibition of microbial growth that could affect their quality.

Ash content of the cookies ranged from 1.41 to 1.88% for the reference sample (T_0) and cookie sample (T_4) respectively. The addition of MBB significantly ($p < 0.05$) increased the ash content of the cookies progressively. Ash content of a food material is an indication of the mineral constituents present. It is the inorganic residue remaining after the removal of water and organic matter by heating in the presence of oxidizing agent (Sanni, Adebowale, Olayiwola, & Maziya-Dixon, 2008). It aids the metabolism of other compounds such as fat, protein and carbohydrate (Okaka & Ene, 2005). The high ash content indicates high levels of minerals in the composite cookie samples. This suggests that cookies from the composite flour blends will provide more minerals to the consumers than the reference sample. Omeire and Ohambele (2010) observed a similar trend of increasing ash content (1.65–2.20%) in cookies produced from wheat-defatted cashew nut flours. Gernah et al. (2010) also reported a similar findings that cookies produced from wheat-brewers spent grain flour blends had high ash content (1.85–2.89%).

The protein content of the cookies ranged from 11.21 to 15.64%; cookie sample (T_4) had the highest protein content (15.64%) while the reference sample (T_0) had the lowest (11.21%). Addition of MBB caused significant ($p < 0.05$) increase in the protein content of the cookies. The observed increase could be attributed to the significant quantity of protein (12.5%) in barley bran (Satinder, Sativa, & Nagi, 2011). The findings conforms with the report of Omeire and Ohambele (2010) for the increasing trend of protein content (8.54–17.72%) in cookies produced from wheat-defatted cashew nut flour blends, but lower than the protein content (10.62–28.12%) of cookies made from

Table 3. Proximate compositions and energy values of cookie samples from wheat flour -malted barley bran blends

Sample code	Proximate compositions (%) of cookies						Energy value (kcal/100 g)
	Moisture	Ash	Protein	Fat	Crude fibre	Carbohydrate	
T_0	3.34 ^e	1.41 ^e	11.21 ^e	29.86 ^d	1.32 ^e	52.79 ^a	525.02 ^a
T_1	4.06 ^a	1.53 ^d	11.86 ^d	30.76 ^c	3.41 ^d	48.41 ^b	517.79 ^b
T_2	3.78 ^b	1.62 ^c	13.17 ^c	30.76 ^c	4.24 ^c	46.43 ^c	515.24 ^c
T_3	3.75 ^c	1.75 ^b	14.68 ^b	30.78 ^b	5.48 ^b	43.56 ^d	509.98 ^e
T_4	3.69 ^d	1.88 ^a	15.64 ^a	32.36 ^a	6.38 ^a	40.05 ^e	514.00 ^d

Notes: Mean values with different subscripts on the same column are significantly different ($p < 0.05$) from each other; WF–Wheat flour; MBB–malted Barley Bran; T_0 –100% WF–0% MBB; T_1 –95% WF–5% MBB; T_2 –90% WF–10% MBB; T_3 –80% WF–20% MBB; T_4 –50% WF–50% MBB.

wheat-brewers spent grain (Gernah et al., 2010). Olaoye, Onilude, and Idowu (2006) also observed an increase in the protein content with corresponding increase in the proportion of soy flour supplementation in bread produced from composite flour of wheat, plantain and soybean. The findings agreed with Adebowale et al. (2012) report who observed an increased trend in the protein content (7.06–11.84%) of cookies made from sorghum-wheat flour blends.

The fat content (%) of the cookies ranged between 29.86 and 32.36%. Cookie sample (T_4) had the highest fat content (32.36%) while the reference sample (T_0) had the least value (29.86%). The fat content of the cookies increased significantly ($p < 0.05$) as the substitution level increased from 5 to 50% with malted barley bran. The finding agrees with Omeire and Ohambele (2010) and Gernah et al. (2010) on their reports for the increasing trend in the fat content of the cookies produced from wheat-defatted cashew nut and wheat-brewers spent grain (2.52–4.80%) flour blends respectively. The presence of high fat content in the cookies means high calorific value and also serves as a lubricating agent that improves the quality of the product, in terms of flavour and texture. In addition, fat is a rich source of energy and is essential as carriers of fat soluble vitamins; A, D, E and K. However, high levels of fat in food products should be $\leq 25\%$, since this could lead to rancidity in foods and development of unpleasant and odorous compounds (Ihekoronye & Ngoddy, 1985).

The crude fibre content of cookies produced from WF-MBB flour blends ranged from 1.32 to 6.38%; cookie sample (T_4) had the highest value (6.38%) while the reference sample (T_0) had the lowest value (1.32%). Malted barley bran has relatively higher crude fibre content than wheat and this justify the results obtained for the cookie samples. The increasing trend in the crude fibre content of the cookies upon substitution with malted barley bran flour could be a reflection of its composition that is reported to be 13.9% (Satinder et al., 2011). The finding conforms to the observation of Gernah et al. (2010) for the increasing trend in the crude fibre (1.32–10.82%) contents of cookies made from wheat-brewers spent grain flour blends. In contrast, the result was higher than the crude fibre (1.05–1.65%) of cookies produced from wheat-defatted cashew nut flour blends as reported by Omeire and Ohambele (2010). The presence of high fibre in food products is essential owing to its ability to facilitate bowel movement (peristalsis), bulk addition to food and prevention of many gastrointestinal diseases in man (Satinder et al., 2011).

Carbohydrate content of the cookies ranged between 40.05 and 52.79%. Cookie sample (T_4) had the lowest carbohydrate content (40.05%) while the reference sample (T_0) had the highest value (52.79%). The increase in proportion of malted barley bran flour brought about decrease in the carbohydrate content of the cookies. Similarly, a decreasing trend in the carbohydrate contents (73.46–46.20%) and (70.45–23.71%) of cookies made from wheat-brewers spent grain flour blends and whole wheat- full fat soya flour blends was reported by Gernah et al. (2010) and Joel, Fatima, and Stephen (2014) respectively. The low carbohydrate content and increased fibre content of the composite cookies have several health benefits, as it aids digestion in the colon and reduces constipation often associated with products from refined grain flours (Elleuch et al., 2011; Slavain, 2005).

The energy value of the cookie samples ranged between 509.98 and 525.05 kcal/100 g; cookie sample (T_3) had the lowest energy value, while the reference sample (T_0) had the highest value. The energy values of the composite cookies were significantly ($p < 0.05$) different from the reference samples. Similarly, a decreasing trend in the energy value (443.89–431.95 kcal) for cookies made from wheat and quality protein maize was reported by Giwa and Ikujenlola (2010). The protein, fat and carbohydrate constituents of the blend contributed to the energy value of the cookies. Cookies are energy-giving foods that are consumed mostly in-between meals by both young and old. The incorporation of malted barley bran could help to boost the level of protein and fibre contents of cookies.

3.2. Physical characteristics of cookies

The results of assessment of the physical characteristics of cookies are depicted in Table 4.

3.2.1. Cookies weight

The weight of the cookies ranged from 16.32 to 20.00 g; cookie sample (T_4) were heaviest and bulkiest among the samples, while the reference sample (T_0) had the least weight (16.32 g). Addition of MBB caused a significant ($p < 0.05$) increase in the weight of cookies. The findings were in contrary to the observation of some researchers who reported significant reduction in the weight of cookies produced from soya bean supplemented with wheat flour (Ayo et al., 2007), cowpea-wheat (Okaka & Isieh, 1997), millet-sesame flour (Alobo, 2001), bambara groundnut- maize flour (Akpapunam & Darbe, 1994) respectively.

3.2.2. Diameter

The diameter followed a similar trend as the weight of composite cookies, which significantly ($p < 0.05$) increased from 50.2 to 57.3 mm for the reference sample (T_0) and cookie sample (T_4) respectively. This could be attributed to the amount of fat added to the flour blends during production. Similarly, an increasing trend for the diameter (38.90–40.20 mm) of cookies made from wheat-brewers spent grain flour blends was reported by Gernah et al. (2010). However, the findings disagree with the observation of Abdul et al. (2015), who reported a decrease in diameter for cookies with increasing substitution level of oat bran.

3.2.3. Thickness

A similar increasing trend as the weight and diameter of the cookies was recorded for the thickness of the cookie samples. The thickness of the cookies ranged from 6.30 to 6.60 mm; cookie sample (T_4) had the highest thickness value (6.60 mm) while the reference sample (T_0) had the least (6.30 mm). The thickness of the cookies significantly ($p < 0.05$) increased with increasing level of substitution with MBB from 5, 10, 20 and 50% respectively. Increase in thickness could be due to the high adsorption of moisture of the dough with increase in malted barley bran level, owing to the presence of water binding components. Moreover, it could also be attributed to the inconsistent rolling thickness of the dough which was exhibited as a result of the addition of high fat content. A similar finding for thickness was reported by Abdul et al. (2015) for cookies produced from blends of wheat flour and oat bran.

3.2.4. Spread ratio

The spread ratio of the cookies ranged between 7.97 and 8.68; cookie sample (T_4) had the highest spread ratio value (8.68), while the reference sample (T_0) had the least (7.97). The addition of MBB caused a significant ($p < 0.05$) increase in the spread ratio of the cookies with increasing level of substitution from 0 to 50%. A similar finding was observed by Giwa and Abiodun (2010), who reported that the spread ratio of cookie samples increased with increasing substitution level with

Table 4. Physical characteristics of cookies produced from wheat flour- malted barley bran flour blend

Sample code	Physical characteristics of cookies				
	Weight (g)	Diameter "D" (mm)	Thickness "T" (mm)	Spread ratio (D/T)	Breaking strength (g)
T_0	16.32 ^e	50.2 ^e	6.30 ^e	7.97 ^e	290.26 ^a
T_1	16.84 ^d	54.0 ^d	6.40 ^d	8.44 ^d	261.54 ^b
T_2	17.28 ^c	55.0 ^c	6.50 ^c	8.46 ^c	211.86 ^c
T_3	18.10 ^b	56.0 ^b	6.55 ^b	8.55 ^b	180.13 ^d
T_4	20.00 ^a	57.3 ^a	6.60 ^a	8.68 ^a	169.33 ^e

Notes: Mean value with different subscripts on the same row are significantly different ($p \leq 0.05$); WF–Wheat flour; MBB–malted Barley Bran; T_0 –100% WF–0% MBB; T_1 –95% WF–5% MBB; T_2 –90% WF–10% MBB; T_3 –80% WF–20% MBB; T_4 –50% WF–50% MBB.

quality protein maize. Inconsistent with the study, Abdul et al. (2015) reported decreased spread ratios for cookies with increasing oat bran incorporation. However, the spread ratio values for cookies samples produced from blends of wheat flour and African oil bean seed flour did not follow a particular trend (Gbadamosi, Enujiugha, & Odepidan, 2011). Cookies with higher spread ratios are considered most desirable (Ayo et al., 2007). The control of cookies spread ratio is a serious problem encountered during production; cookies that spread so much cannot be filled into the package and those that spread slightly causes slack fill or excess height for package, thus creating havoc on the packaging line (Matz, 1992).

3.2.5. Breaking strength

The breaking strength of the cookies ranged between 290.26 and 169.33 g; reference sample (T₀) had the highest value (290.26 g), while cookie sample (T₄) had the least value (169.33 g). The breaking strength is referred to the force required to break the cookies. The breaking strength significantly ($p < 0.05$) decreased as the substitution level of malted barley bran increased from 5 to 50%. The reduction could be attributed to the carbohydrate/starch content of malted barley bran which may not be as hard/strong like that of wheat. The results clearly depict decreasing similar trend as reported by Adebowale et al. (2012) for cookies produced from sorghum-wheat blends as well as wheat-oat flour blends (Chavan & Kadam, 1993) respectively. Hardness of cookies is caused by the interaction of proteins and starch by hydrogen bonding. Comparatively, the finding agrees with the reports of Okaka and Isieh (1997) and Ayo et al. (2007) for the utilization of composite flours in cookies to reduce its break strength. Also, Adebowale et al. (2012) reported that increase in rigidity is due to increase in carbohydrate/starch granules, which is responsible for gel and structure formation in baked goods.

3.3. Sensory characteristics of cookies

The results of the sensory assessment of cookies produced from wheat- malted barley bran flour blends are presented in Table 5. The mean scores of colour, taste, flavour, crispiness and overall acceptability for the cookies were significantly different ($p < 0.05$) from one another. The reference sample had the highest scores for all the attributes observed, except for colour and crispiness.

The mean score for the cookies colour ranged between 7.1 and 8.4. Cookie sample (T₁) had the lowest value while sample (T₄) had the highest value. Generally, the scores for cookies colour increased as the substitution level of malted barley bran increased. This could be attributed to the dark brown coloration of the cookie samples with incorporation of 5–50% MBB as compared with that of the reference sample as well as the coarser texture of the former compared with the latter. The intense brown colour of the composite cookies could be due the presence of high amount of carbohydrate in the flour blends, thus resulting in caramelized product. In addition, this could be an indication that substitution of malted barley bran with wheat flour for cookie making actually provides more protein for Maillard reaction to take place, which is normally encountered and desirable in baked goods. Moreover, the change in colour with increasing substitution level of MBB might be due to

Table 5. Means scores for the sensory evaluation of cookies produced from wheat flour- malted barley bran blends

Sample code	Sensory attributes of cookies				
	Colour	Taste	Flavour	Crispiness	Overall acceptability
T ₀	7.3 ^d	7.6 ^a	8.3 ^a	7.7 ^b	8.8 ^a
T ₁	7.1 ^e	7.6 ^a	7.8 ^b	8.2 ^a	8.2 ^b
T ₂	7.5 ^c	7.1 ^b	6.5 ^c	5.3 ^d	7.3 ^c
T ₃	7.8 ^b	6.3 ^c	6.5 ^c	5.7 ^c	6.3 ^d
T ₄	8.4 ^a	4.1 ^d	4.3 ^d	5.2 ^d	5.4 ^e

Notes: Mean value with different subscripts on the same row are significantly different ($p \leq 0.05$); WF–Wheat flour; MBB–malted Barley Bran; T₀–100% WF–0% MBB; T₁–95% WF–5% MBB; T₂–90% WF–10% MBB; T₃–80% WF–20% MBB; T₄–50% WF–50% MBB.

nutrients interaction during processing and baking temperature and time combination. The results are in accordance with the findings of Tsuji, Kimoto, and Natori (2001) who observed that darker colour of cookies may be due to the non-enzymatic reaction (Maillard reaction) between reducing sugar molecules and lysine protein. Also, Sudha, Baskaran, and Leela-Vathi (2007) stated that darker colours are generally associated with enriched high fibre biscuits.

Based on taste, the scores for the cookies ranged from 4.1 to 7.6; cookie sample (T_4) had the lowest value while the reference sample (T_0) and sample (T_1) had the same high value (7.6). The astringent taste observed among the cookie samples could be attributed to the development of bitter substances, owing to the presence of tannin in malted barley bran. From the result, it could be deduced that up to 5% substitution level with malted barley bran could be acceptable by consumers with a mean score of 7.6.

The mean scores for flavour ranged between 4.3 and 8.3 for cookie sample (T_4) and the reference sample (T_0) respectively. However, there was a decrease in the flavour scores of the cookie samples with increase in the substitution level of MBB. No significant difference ($p > 0.05$) exist between cookie samples; T_2 and T_3 respectively.

The scores for the crispness of cookies ranged from 5.2 to 8.2; cookie sample (T_4) had the lowest value while sample (T_1) had the highest value. There was no significant difference ($p < 0.05$) between 10 and 50% substituted cookie samples.

The mean scores (5.4–8.8) for the overall acceptability of the cookies were above the average (4.5), indicating high acceptability of the cookie samples. The reference sample (T_0) had the highest value, while cookie sample (T_4) had the least value. The possible reason for low acceptability of the cookie samples produced with MBB substitution level above 5% could be due to the observed dark-brown coloration and bitter taste. It is therefore clear according to the result that substitution of malted barley bran up to 5% substitution level could produce good cookies that are even more acceptable than the reference sample with excellent attributes.

4. Conclusion

The results vividly showed that it could be possible to produce nutritious and acceptable cookies through the substitution of wheat flour with malted barley bran. The high protein, ash and fibre contents of cookies made from malted barley bran substitution as well as the acceptability of the composite cookies attested to this fact. The results also showed that substitution with malted barley bran did not alter the physical characteristics and consumer acceptability of the cookie samples especially at 5% substitution level. In conclusion, therefore, 5% MBB incorporation in cookies production could help to substantially reduce foreign exchange on wheat importation and reduce wastage of the by-product, while improving the nutritional status of consumers.

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Competing Interests

The authors declare no competing interest.

Author details

D.S. Ikuomola¹
E-mail: mercyoeye2001@yahoo.com
O.L. Otutu¹
E-mail: lootutu@yahoo.com
D.D. Oluniran¹
E-mail: darasimidayo@yahoo.com

¹ Department of Food Science and Technology, Joseph Ayo Babalola University, Ikeji- Arakeji, Ilesa, Osun State, Nigeria.

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