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Effect of Malted Mung Bean and Watermelon Rind Flour on Wheat Bread Quality

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to evaluate the nutrient composition, microbiological, physical and sensory properties of bread produced from wheat, malted mung bean and watermelon rind composite flours. The wheat, mung bean and watermelon rind flours were blended in the ratios of 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25, respectively, for the production of bread, while the bread made from 100% wheat flour was used as control. The proximate, mineral, vitamin, microbiological, physical and sensory properties of the bread samples were determined using standard methods. The proximate composition of the bread loaves showed that the samples had a range of 8.11 to 8.61% moisture, 2.18 to 2.69% ash, 3.37 to 4.19% crude fibre, 3.60 to 4.43% fat, 9.18 to 18.42% protein, 61.67 to 73.57% carbohydrate and 350.21 to 363.98 kJ /100g energy. The moisture, ash, crude fibre, fat and protein contents of the samples increased significantly ($p < 0.05$) with increase in the addition of malted mung bean and watermelon rind flours, while the carbohydrate and energy contents decreased. The mineral composition of the bread loaves were

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77.01 to 97.77mg/100g calcium, 48.89 to 114.74mg/100g magnesium, 41.11 to 97.76mg/100g phosphorus, 62.67 to 94.21mg/100g potassium, 2.18 to 2.78mg/100g iron and 1.62 to 2.25mg/100g sodium. The result showed that the mineral contents of the bread loaves produced from composite flours increased with increased substitution of malted mung bean and watermelon rind flours. The thiamine, niacin, riboflavin, vitamin A, ascorbic acid and folic acid contents of the bread samples ranged from 3.36 to 4.57mg/100g, 2.45 to 3.36mg/100g, 3.51 to 4.60mg/100g, 2.23 to 4.27mg/ 100g, 1.55 to 3.22mg/100g and 1.02 to 1.81mg/100g, respectively. These vitamins increased with increased substitution of malted mung bean and watermelon rind flours. The total viable count of the samples ranged between 0.62 to 1.80cfu/g, while the coliform and fungi counts were nil. The physical properties of the bread samples showed that the loaf volume, specific loaf volume, height, and oven spring decreased, while the weight increased ($p<0.05$) significantly with increased substitution of malted mung bean and watermelon rind flours. The sensory properties also revealed that the bread loaves produced from 100% wheat flour were most acceptable to the panellists and also differed significantly ($p<0.05$) in colour, taste, texture and aroma from the composite flour bread samples. However, the composite bread loaves were also acceptable by the judges because they were relatively rated high in all the sensory attributes evaluated. The study, therefore, showed that the addition of malted mung bean and watermelon rind flours to wheat flour at different stated levels in the production of bread samples relatively enhanced the nutritional quality of composite bread loaves compared to the control.

Keywords: Bread; supplementation; mung bean flour; nutrient composition; sensory properties; watermelon rind flour; wheat flour.

1. INTRODUCTION

Breads are baked products made from the dough or meal that is moistened, kneaded, fermented and baked in an oven. Bread is a food foam because the Carbon dioxide (Co_2) is released by yeast, and when compressed, the Carbon dioxide (Co_2) aerates the dough that has been made in various forms using different ingredients. It was a homemade item for most people in the past years. It represents the largest category of snack item among baked food products throughout the world [1]. Breads are mostly prepared from wheat flour, water, shortening agent, yeast or baking powder and sugar, and are consumed by all demographic groups. The water, flour and yeast are the main ingredients in bread recipe and they affect the texture and the crust of most bread loaves. Although ingredient like salt has become a common component in baked products, it performs a number of sensory and technological functions. The sensory function is related to flavour, while the technological functions are related to changes in the dough properties during bread making and fermentation by the yeast. The addition of salt contributes to flavour, helps to control fermentation by yeast, toughens the gluten and gives less sticky dough. Bread flavour is affected not only by salt but also by the baking process through the formation of coloured crust that occur during Maillard reaction [2].

Wheat (*Triticum aestivum L.*) is one of the major grains used for the production of baked products due to its gluten content. The gluten content in wheat grain has the ability to entrap Carbon dioxide (Co_2) released by yeast during fermentation which leads to elasticity and increase in the size of the dough. Wheat grain is a staple food used to make flour that is primarily used for preparation of breads, biscuits, cookies, cakes, noodles and pastries. It can also be used for the brewing of beer and other alcoholic beverages. The grains can be milled to leave just the endosperm for white flour. The by-products obtained after wheat grains are milled into flour are the bran and germ. The whole grain is a concentrated source of vitamins, minerals and protein, while the refined grain is mostly starch. Nutritionally, wheat flour is rich in carbohydrate but it is relatively low in protein content [3]. Wheat flour is deficient in lysine, methionine and tryptophan. Therefore, the addition of legume flour such as mung bean flour would improve the levels of these essential amino acids.

Mung bean (*Vigna radiata (L.)* is one of the lesser known and underutilized legumes that is rich in protein. Mung bean is also rich in essential minerals but contain small quantity of fat. It is usually consumed either alone or in combination with starchy staples such as cereals, roots and tubers after prolonged cooking to destroy the anti-nutrients and toxic substances that are inherent in mung bean and other legumes and to soften its hard seed coat [4]. Mung bean is an important source of nutrients for humans as well as livestock. It is also a better source of good quality protein for infants and small children because it contributes to their growth, liver weight, liver nitrogen and plasma protein [5]. Mung bean is rich in essential amino acids such as phenylalanine, leucine, isoleucine, valine, lysine and arginine. It also contains antioxidants such as phenolic acids, flavonoids, caffeic acid and cinnamic acid. These antioxidants help to neutralize potentially harmful molecules known as free radicals, which have the ability to cause degenerative diseases such as heart diseases, cancer, stroke and diabetes mellitus in human body. Mung bean has been recommended as a suitable ingredient that can be used to enhance the nutrient density of pasta products without affecting their sensory properties. The modification of mung bean flour by malting has been reported to reduce its anti-nutrient contents and improve both the nutrient content and functionality of the flour [6].

Watermelon (*Citrullus lanatus*) rind is the tough, outer layer of watermelon, which is typically green on the exterior, fading to a pale white inside, before changing to red to pink flesh of the fruit itself. The rind is edible and contains high percentage of nutrients, which are usually found in the juicy fruits. The tough rind contains low levels of calories, but is high in vitamin C, vitamin A, vitamin B_6, potassium, zinc, lycopene, amino acids, flavonoids and phenolic compounds [7]. The use of watermelon rind flour in combination with wheat and malted mung bean flours in the production of bread has not been practised. Furthermore, the incorporation of malted mung bean and watermelon rind flours to wheat flour in bread making would enhance both the protein and micronutrients contents of the product and also modify the functionality of the flour and the final product [8]. This would also reduce the overdependence on importation of wheat flour, address the problems of protein – energy malnutrition and micronutrients deficiencies and create varieties for health-conscious individuals in Nigeria and other developing countries of the world [8,9].

It has been reported that the application of composite flour in various food products would be economically advantageous because it would minimize the problems associated with wheat gluten and meet the demand for baked and confectionery products especially in most sub – Saharan African countries where they are consumed mostly as snack foods [10,11]. Although nutritionists are more interested in nutritional value, consumers rely heavily on good sensory attributes of finished products as the most important guiding principle for making choice of food products. The fortification of baked products such as bread among others with legume flours for the purpose of improving their nutritional value without adversely affecting their sensory properties has been advocated due to their positive health benefits to humans [1,12]. This can be achieved through supplementation or fortification of wheat flour with modified flours from indigenous food crops in the production of baked and snack foods. This would also lead to increase in the utilization of these locally available raw materials in bread making and improvement in the nutrient density of the final product [13]. Therefore, this present study was designed to evaluate the effect of malted mung bean and watermelon rind flours addition on the nutrient composition, microbiological, physical and sensory properties of wheat flour bread samples.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Materials

Mature mung bean seeds and watermelon fruits (*Citrullus Lanatus*) used for this study were bought from New Market, Enugu, Enugu State, Nigeria. The wheat flour and other ingredients such as bakery fat, sugar, yeast, salt and vanilla flavour used for the production of bread were purchased from the same market. The chemicals used for the analyses were of analytical grade.

2.2 Preparation of Mung Bean Seed Flour

The malted mung bean flour was prepared according to the method described by Okoye et al. [1]. One kilogramme (1kg) of mung bean seeds was cleaned to remove dirt and other extraneous materials. The cleaned seeds were soaked in 4 litres of potable water in a plastic bowl at room temperature (30± 2°C) for 20 h with a change of water at every 5 h to prevent fermentation. After soaking, the seeds were drained, rinsed and immersed in 2% Sodium hypochlorite solution for 10 min to disinfect the seeds. The seeds were rinsed for five consecutive times with excess water and cast on a moistened jute bag, covered with polyethylene bag and left for 48 h to fasten sprouting. The seeds were then spread carefully on the jute bag and allowed to germinate in the germinating chamber at room temperature (30±2°C) and relative humidity of 95% for 72 h. During this period, the seeds were sprinkled with water at intervals of 12 h to facilitate germination. Non – germinated seeds were discarded and the germinated seeds were collected, spread on the trays and dried in a tray dryer (Model EU850D, UK) at 60°C for 18 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. After drying, the radicles and plumules of the malted mung bean seeds were removed by rubbing them in-between palms along with the hulls. The dehulled malted mung bean seeds were milled into flour in the attrition mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an air tight plastic container, labelled and stored in a refrigerator until needed for further use.

2.3 Preparation of Watermelon Rind Flour

The watermelon rind flour was prepared according to the method described by Oseni and Okoye[14]. The water melon rinds were manually separated from washed watermelon fresh fruits with a sterile kitchen knife. The cleaned watermelon rinds were sliced into smaller slices of 5mm in diameter with a stainless steel knife. The slices were dried in a tray dryer (Model EU850D, UK) at 50°C for 18 h to obtain the dried chips. The chips were milled in the attrition mill and sieved through a 500 micron mesh sieve to obtain the fine flour. The flour produced was packaged in an air tight plastic container, labelled and stored in the refrigerator until needed for further use.

2.4 Formulation of Flour Blends

The wheat, mung bean and watermelon rind flours were blended in the ratios of 100:0:0, 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25 in a Kenwood mixer (Model Philips, type HR, 1500/ A, Holland) to obtain homogenous samples of composite flour. Thereafter, the flour blends were individually packaged in air tight plastic containers, labelled and kept in a refrigerator until needed for the preparation of bread loaves. The flour blends used for the production of bread loaves are given in Table 1.

2.5 Preparation of Bread Samples

The bread loaves were prepared according to the method described by Akoja and Coker [15]. The recipe used for the preparation of breads were 100% flour, 60% sugar, 20% fat, 2% yeast, 2.5mL vanilla flavour, 5% milk and 0.25% salt. All the raw materials were thoroughly mixed together manually to obtain homogeneous mixture and kneaded properly on a dusty table to incorporate air into the dough. The mixed and kneaded dough was milled thoroughly using a manually operated milling machine (Model X – 60A, China) until the gluten content of the dough was stretched to the extent that it could entrap the Carbon dioxide (Co_2) released by the yeast during fermentation in order to increase its elasticity and the size of the dough. The milled dough obtained was manually divided into smaller sizes and moulded into desired shapes. Thereafter, the moulded doughs were separately placed into greased baking pans, covered with cellophane and kept at room temperature ($30+2^0$C) to ferment further and increase in size. The fermented doughs were separately baked in a convention oven (Model Mac Adams Rotary Oven, South Africa) at 170°C for 20 min. After baking, the baked bread loaves were removed from the oven and allowed to cool at ambient temperature (30±2°C). The cooled breads were depanned, packaged, labelled and kept in a refrigerator until needed for analysis. The bread sample made from 100% wheat flour was similarly prepared and used as control. Samples for analyses were milled into flour.

2.6 Proximate Analysis

The moisture content was determined by hot air oven drying of the samples at a temperature of 105°C to constant weight according to the method described by Onimawo and Akubor [16]. The ash, protein (Nx6.25), crude fibre and fat (Solvent extraction) were determined by the

Table 1. Flour blends used for bread production

Samples	Wheat flour	Mung bean flour	Watermelon rind flour
A	100	0	0
B	90	5	5
C	80	10	10
D	70	15	15
E	60	20	20
F	50	25	25

methods of AOAC [17]. Carbohydrate was calculated by difference as 100% - % (Moisture + Fat + Protein + Ash + Crude fibre). The energy value of the samples was calculated by multiplying the percentage values of protein, fat and carbohydrate contents by Atwater factors of 4,9 and 4, respectively [17]. All determinations were carried out in triplicate samples on dry weight basis.

2.7 Micronutrients Analyses

The mineral elements were extracted by dry ashing of the samples in a muffle furnace at 550°C to constant weight followed by the dissolution of the ash obtained from each sample in a volumetric flask by the addition of 50mL of de-ionised water and a few drops of Hydrochloric acid. The calcium, magnesium, phosphorus and sodium contents of the samples were determined by the use of atomic absorption spectrophotometer on dry weight basis. The potassium and iron contents were also determined using the Techcomp AA600 atomic absorption spectrophotometer and further confirmed by the use of a digital flame photometer according to the methods of AOAC [17]. The ascorbic acid, thiamine and niacin contents of the samples were determined on dry weight basis using the atomic absorption spectrophotometer (Perkin-Elmer, Model 300, Norwalk, CT, USA) after extraction. The riboflavin and folic acid contents were determined by the use of a digital flourimeter. The vitamin A content was determined using the ultraviolet absorption spectrophotometer after extraction with chloroform. All determinations followed the AOAC [17] procedures and were carried out in triplicate samples.

2.8 Microbiological Evaluation

The total viable, coliform and fungal counts of the bread samples were determined in triplicates using the pour plate culture technique described by James [18]. Two grams (2g) of each sample was weighed and mixed with 9 mL of sterile water and properly shaken for 2 min to form a suspension. The microbial counts of the samples were determined by performing a ten – fold serial dilution of each sample in a sterile test tube containing sterile distilled water up to 10^{-5} dilution factor. After that, one mililitre (1mL) of each dilution was pipetted and transferred into the sterile petri dish and 15mL of sterile nutrient agar was poured into the same petri dish. The mixture was thoroughly mixed by rocking until it was solidified. When it was solidified, it was turned upside down and cultured by incubating at the temperature of 37°C for 24 h. At the end of incubation period, the colonies were counted using the digital electronic colony counter (Gallenkamp colony counter, Model CNW330-010X, China) and the mean values of the colonies were recorded accordingly. The above procedure was repeated for coliform and fungal counts except that the MacConkey agar was used for coliform count and the sample was incubated at 37°C for 96 h, whereas potato dextrose agar was used for fungal count and incubation was done at 37°C for 120 h. After incubation, the colonies were counted separately using the same digital electronic colony counter (Gallenkamp colony counter, Model CNW330-010X, China). Thereafter, the mean values of the colonies formed were individually recorded after counting.

2.9 Physical Properties

The loaf volume and the specific loaf volume of the samples were determined according to the methods described by Okoye et al. [10]. The loaf height was determined according to the method described by Oke et al. [19]. The loaf weight was determined by the use of a digital electric weighing balance as described by Pico et al. [20]. The oven spring was determined according to the method described by Bridgewater and Beatrice [21]. All determinations were carried out in triplicate samples.

2.10 Sensory Evaluation

Semi – trained consumer taste panellists consisting of twenty (20) staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria were used to evaluate the sensory attributes of the bread. The criteria for selection were that the panellists were 18 years and above, regular consumers of bread loaves and not allergic to any food. The panellists filled a consent form approved by the University Institutional Review Board and received instructions on how to carry out the sensory test. After baking, the freshly baked breads were sliced, coded and served after 2 h they were removed from the oven (in order to avoid staling) to the panellists in white plastic plates of uniform sizes at room temperature (30 $\pm$ 2°C) with cold water and unsalted crackers for oral rinsing of their mouth after tasting each sample to avoid residual effect. The attributes of colour, texture, taste, aroma and overall acceptability were assessed by the judges. The panellists were seated in such a way that they could not see the rating of each other. The panellists evaluated and rated each sample based of their preference and acceptability of each of the products using a nine-point Hedonic scale with 1 representing dislike extremely and 9 representing like extremely, respectively [22]. Expectoration cups with lids were also provided to the judges who would not like to swallow the samples after tasting each of them.

2.11 Statistical Analysis

The data were subjected to one–way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS Version 20) software in a completely randomized design. Means were separated using Tukey's test at p<0.05.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Bread Samples

The proximate composition of the bread samples are presented in Table 2.

The moisture content of the samples ranged from 8.11 to 8.61%. The sample substituted with 25% malted mung bean and 25% watermelon rind flours had the highest value (8.61%), while the control sample (100% wheat flour bread) had the least (8.11%) moisture content. There were significant (p<0.05) differences in the moisture content of the samples. Moisture content is an indicator of shelf stability hence, the increase in moisture content promotes microbial activities and chemical reactions that could lead to spoilage or reduction in food quality and stability [23]. The moisture content of the bread samples increased with increase in the addition of malted mung bean and watermelon rind flours. A similar increase in moisture content was reported by Dabels et al. [9] for wheat, acha and mung bean composite breads. The moisture content of all the samples were below 10% moisture content level recommended as the normal moisture content for the shelf stability of breads with proper packaging and storage [1, 12].

The ash content of the samples ranged from 2.18 to 2.69%. The sample supplemented with 25% malted mung bean and 25% watermelon rind flours had the highest value (2.69%), while the control sample (100% wheat flour bread) had the least ash content (2.18%). There were significant (p<0.05) differences in the ash content of the samples. The differences could be due to variation in the proportions of the raw materials used for the preparation of breads. The result showed that the sample supplemented with higher levels of malted mung bean and watermelon rind flours had higher ash contents compared to the control sample and this is an indication that mung bean seeds and watermelon rind are rich in minerals [8]. The values (2.18 – 2.69%) obtained in this study were higher than the ash content (2.10 – 2.62%) reported by Dabels et al. [9] for bread produced from wheat, acha and mung bean composite flours.

The crude fibre content of the bread samples ranged from 3.37 to 4.19%. The sample substituted with 25% malted mung bean and 25% watermelon rind flours had the highest value (4.19%), while the control sample (100% wheat flour bread) had the least value (3.37%). There were significant (p<0.05) differences in the crude fibre content of the samples. The differences could be due to variation in the proportions of raw materials used for the preparation of bread samples. The result showed that the crude fibre content of the samples increased significantly (0<0.05) with increase in the addition of malted mung bean and watermelon rind flours to the products. This is a clear indication that mung bean seeds and watermelon rind are rich sources of crude fibre [24]. A similar increase in crude fibre content of the bread samples was reported by Imoisi et al. [8] for breads produced from wheat and watermelon rind composite flours. Dietary fibres help to maintain the moist and soft condition of faecal mass which facilitates easy passage of it through the large intestine.

The fat content of the samples ranged from 3.60 to 4.43%. The sample substituted with 25% malted and 25% watermelon rind flours had the highest value (4.43%), while the sample made with 100% wheat flour (control sample) had the least value (3.60%). There were significant (p<0.05) differences in the fat content of the samples. The differences could be attributed to variation in the proportions of raw materials used for the preparation of the products. The values (3.60 – 4.43%) obtained in this study were lower than the fat content (4.24 – 5.32%) reported by Dabels et al.[9] for bread produced from wheat, acha and mung bean composite flours. Fat improves the flavour and increases the mouth feel of foods because it improves their textural characteristics. It is also a significant factor in the formulation of food products especially the baked food products because it enhances the texture and flavour of such products [9, 25].

Table 2. Proximate composition (%) of bread samples

Samples	WF:MMBF :WRF	Moisture	Ash	Crude fibre	Fat	Protein	Carbohydrate	Energy (KJ/100g)
A	100:0:0	8.11^{f}±0.11	2.18^{f}±0.02	3.37^{e}±0.04	3.60^{e}±0.06	9.18^{f}±0.09	73.57^{a}±0.13	363.98^{a}±0.47
B	90:5:5	8.17^{e}±0.10	2.25^{e}±0.04	3.53^{d}±0.02	3.74^{d}±0.08	10.28^{e}±0.10	72.06^{b}±0.14	362.94^{b}±0.05
C	80:10:10	8.25^{d}±0.09	2.37^{d}±0.06	3.65^{-c}±0.03	3.85^{-c}±0.05	12.48^{d}±0.11	69.42^{c}±0.10	360.19^{c}±0.04
D	70:15:15	8.36^{c}±0.08	2.29^{c}±0.07	3.88^{b}±0.05	4.03^{c}±0.03	14.35^{c}±0.13	66.92^{d}±0.12	356.27^{d}±0.07
E	60:20:20	8.48^{b}±0.07	2.56^{b}±0.05	4.02^{b}±0.03	4.19^{b}±0.02	16.15^{b}±0.14	64.64^{e}±0.11	352.75^{e}±0.06
F	50:25:25	8.61^{a}±0.06	2.69^{a}±0.08	4.19^{a}±0.08	4.43^{a}±0.07	18.42^{a}±0.16	61.67^{f}±0.13	350.21^{f}±0.09

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other. A: Bread made from 100% wheat flour, B: Bread made from 90% wheat flour, 5% malted mung bean flour and 5% watermelon rind flour, C: Bread made from 80% wheat flour, 10% malted mung bean flour and 10% watermelon rind flour, D: Bread made from 70% wheat flour, 15% malted mung bean flour and 15% watermelon rind flour, E: Bread made from 60% wheat flour, 20% malted mung bean flour and 20% watermelon rind flour, F: Bread made from 50% wheat flour: 25% malted mung bean flour and 25% watermelon rind flour. WF: MMBF: WRF = % Substitution; Where: WF — Wheat flour, MPPF — Malted mung bean flour, WRF — Watermelon rind flour.

The protein content of the bread samples ranged from 9.18 to 18.42%. The sample substituted with 25% malted mung bean and 25% watermelon rind flours had the highest value (18.42%), while the 100% wheat flour bread sample had the least value (9.18%). There were significant ($p<0.05$) differences in the protein content of the samples. The variations could be due to high protein content of mung bean flour used in composite with wheat and watermelon rind flours for the bread production. It has also been reported by Olaoye and Ade–Onowaye [23] that the increase in the addition of mung bean to the wheat flour increased the protein content of the composite flour breads. A similar increase in protein content of the bread samples was reported by Akter and Abdulalim [26] for bread prepared from wheat, potato and peanut composite flours. Dietary proteins are useful in the synthesis of new cells, enzymes and hormones required for the development of the body [25].

The carbohydrate content of the bread samples ranged from 61.67 to 73.57%. The sample produced from 100% wheat flour had the highest value (73.57%), while the sample substituted with 25% malted mung bean and 25% watermelon rind flours had the least value (6.67%). The decrease could be due to the low proportion of wheat flour used in the preparation of the composite flour bread samples compared to the control (100% wheat flour bread). A similar decrease in carbohydrate content was reported by Giami et al. [12] for bread samples made from wheat and roasted and boiled African breadfruit composite flours.

The energy content of bread samples ranged from 350.21 to 365.98KJ/100g. The control sample (100% wheat flour sample) had the highest value (365.98KJ/100g), while the sample substituted with 25% malted mung bean and 25% watermelon rind flours had the least value (350.21KJ/100g). There were significant ($p<0.05$) differences in the energy value of the samples. The differences could be attributed to variation in the proportions of raw materials used for bread production. The energy content (350.21-365.98KJ/100g) obtained in this study was lower than the values (362.12-379.87KJ/100g) reported by Dabels et al. [9] for bread loaves produced from wheat, acha and mung bean composite flours.

Generally, the addition of mung bean and watermelon rind flours to wheat flour in the preparation of bread loaves relatively increased the ash, fat, crude fibre and protein contents with remarkable decrease in carbohydrate and energy contents of the products.

3.2 Mineral Composition of Bread Samples

The mineral composition of bread samples are presented in Table 3.

The calcium content of the samples ranged from 77.01 to 97.77 mg/100g. The sample substituted with 25% malted mung bean and 25% watermelon rind flours had the highest value (97.77mg/100g), while the control (100% wheat flour bread) had the least value (77.01mg/100g). The observed increase in calcium contents of all the composite bread samples could be attributed to increase in the addition of malted mung bean and watermelon rind flours to the samples which is an indication that mung bean seeds and watermelon rind are good sources of calcium [5,8]. Calcium plays a vital role in the development of strong teeth and bone especially in foetus, infants, children and elderly people. It also helps in the regulation of contraction and relaxation of the muscles as well as in the absorption of cyanocobalamin (vitamin B_{12}) in the body [25].

The magnesium content of the bread samples ranged from 48.89 to 114.74mg/100g. The sample fortified with 25% malted mung bean and 25% watermelon rind flours had the highest value (114.74mg/100g), while the control (100% wheat flour bread) had the least value (48.89mg/100g). The increase could be attributed to substitution effect which is an indication that mung bean seeds and watermelon rind are good sources of magnesium [3, 27]. There were significant ($p<0.05$) differences in the magnesium content of the samples. The differences could be due to variation in the proportions of raw materials used for the production of bread loaves. Magnesium is important for bone formation, control of constipation and management of diabetes mellitus. Magnesium is also needed for the synthesis of proteins and contraction of the muscles. It is equally important in nerve transmission and maintenance of electrical potential of the nerves [28].

The phosphorus content of the samples ranged from 41.11 to 97.76mg/100g.There were significant ($p<0.05$) differences in the phosphorus content of the samples. The variation could be attributed to differences in the proportions of raw materials used for the production of bread samples. The increase in the incorporation of malted mung bean and watermelon rind flours in the preparation of bread samples resulted in increase in their phosphorus contents. Phosphorus helps in the formation of healthy bones, improvement of digestion, regulation of excretion and formation of protein in human body. It also enhances the quick release of energy in the body [25].

The potassium content of the samples ranged from 62.67 to 94.21mg/100g. There were significant ($p<0.05$) differences in the potassium content of the samples.The sample substituted with 25% mung bean and 25% watermelon rind flours had the highest value (94.21mg/100g) compared to the control sample (100% wheat flour bread) which had the least potassium content(62.67mg/100g). The values (62.67 - 94.21mg/100g) obtained in this study were similar to the potassium content (62.69-94.23mg/100g) reported by Onwurafor et al. [2] for cookies made from wheat, malted mung bean and unripe plantain composite flours. Potassium helps in the maintenance of fluid balance, regulation of nerve and impulse conduction. It is also essential in blood clotting and muscle contraction. Potassium is equally important in the maintenance of cell integrity and regulation of heart beat in the body [28].

The iron content of the bread samples ranged from 2.18 to 2.78mg/100g. There were significant ($p<0.05$) differences in the iron content of the samples. The samples substituted with malted mung bean and watermelon rind flours at different stated levels showed remarkable increase in iron contents with increased substitution of the flours. The result showed that the sample substituted with 25% mung bean and 25% watermelon rind flours had the highest iron content(2.78mg/100g), while the control sample had the least value (2.18mg/100g) which is an indication that mung bean seeds and watermelon rind are relatively rich in iron [29]. Iron is an important component of heamoglobin which is an essential pigment that is responsible for the transfer of oxygen from the blood to the muscles in the human body [25].

The sodium content of the bread samples ranged from 1.62 to 1.97mg/100g. There were significant ($p<0.05$) differences in the sodium content of the samples. The differences could be due to variation in the proportions of raw materials used for the production of the bread samples. The samples with higher proportions of mung bean and watermelon rind flours had relatively higher sodium contents compared to the control sample. The increase could be due to substitution effect which clearly showed that mung bean seeds and watermelon rind are good sources of sodium [6,14]. Sodium is an essential element required for human growth and prevention of high blood pressure. It also regulates the plasma and acid – base balance in the body. It is equally involved in the maintenance of cell permeability and osmotic pressure of the body fluids [30]. The low sodium and high potassium contents of the bread loaves produced in this study make them suitable for use by hypertensive individuals [10,19].

Generally, the addition of mung bean and watermelon rind flours to wheat flour in the production of breads greatly increased the mineral contents of the products.

3.3 Vitamin Composition of Bread Samples

The vitamin composition of the bread samples are presented in Table 4.

The thiamine content of the samples ranged from 3.36 to 4.57 mg/100g. The sample substituted with 25% malted mung bean and 25% watermelon rind flours had the highest value (4.57mg/100g), while the control (100% wheat flour bread) had the least value (3.361mg/100g). The observed increase in thiamine contents of all the composite bread samples could be attributed to increase in the addition of malted mung bean and watermelon rind flours to the samples. There were significant ($p<0.05$) differences in the thiamine content of the samples. The values (3.36 – 4.57mg/100g) obtained in this study were lower than the thiamine content (4.86 – 6.67mg/100g) reported by Ndirika et al. [31] for bread produced from composite flours of wheat and beans. Thiamine plays a vital role in muscle contraction and conduction of nerve signal. It also functions as a coenzyme in energy metabolism. Thiamine equally helps in the proper functioning of peripheral nerves and in the treatment of beriberi [29].

Table 3. Mineral composition (mg/ 100g) of bread samples

Samples	WF: MMBF: WRF	Calcium	Magnesium	Phosphorus	Potassium	Iron	Sodium
A	100:0:0	77.01^{f}±0.75	48.89^{f}±0.47	41.11^{f}±0.69	62.67^{f}±0.20	2.18^{f}±0.07	1.62^{f}±0.03
B	90:5:5	82.04^{e}±0.70	53.92^{e}±0.69	58.69^{e}±0.71	68.05^{e}±0.70	2.29^{e}±0.10	1.66^{e}±0.02
C	80:10:10	86.91^{d}±0.71	67.95^{d}±0.72	66.34^{d}±0.69	73.45^{d}±0.18	2.35^{d}±0.03	1.75^{d}±0.04
D	70:15:15	87.22^{c}±0.62	81.33^{c}±0.69	73.33^{c}±0.71	79.33^{c}±0.55	2.48^{c}±0.11	1.83^{c}±0.06
E	60:20:20	91.77^{b}±0.73	95.37^{b}±1.44	89.37^{b}±0.57	86.74^{b}±0.69	2.65^{b}±0.10	1.97^{b}±0.07
F	50:25:25	97.77^{a}±0.72	114.74^{a}±0.73	97.76^{a}±1.27	94.21^{a}±1.32	2.78^{a}±0.09	2.25^{a}±0.08

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other. A: Bread made from 100% wheat flour, B: Bread made from 90% wheat flour, 5% malted mung bean flour and 5% watermelon rind flour, C: Bread made from 80% wheat flour, 10% malted mung bean flour and 10% watermelon rind flour, D: Bread made from 70% wheat flour, 15% malted mung bean flour and 15% watermelon rind flour, E: Bread made from 60% wheat flour, 20% malted mung bean flour and 20% watermelon rind flour, F: Bread made from 50% wheat flour, 25% malted mung bean flour and 25% watermelon rind flour. WF:MMBF:WRF = % Substitution; Where: WF — Wheat flour, MPPF — Malted mung bean flour, WRF — Watermelon rind flour.

Table 4. Vitamin composition (mg/ 100g) of bread samples

Samples	WF:MMBF:WRF	Thiamin	Niacin	Riboflavin	Vitamin A	Ascorbic acid	Folic Acid
A	100:0:0	3.36^{c}±0.03	2.45^{d}±0.07	3.51^{f}±0.16	2.23^{f}±0.08	1.55^{f}±0.06	1.02^{f}±0.04
B	90:5:5	3.54^{d}±0.04	2.60^{c}±0.05	3.59^{e}±0.11	2.54^{e}±0.04	1.88^{e}±0.08	1.13^{e}±0.02
C	80:10:10	3.79^{c}±0.06	2.65^{c}±0.03	3.65^{d}±0.12	2.85^{d}±0.03	2.15^{d}±0.06	1.24^{d}±0.03
D	70:15:15	3.97^{b}±0.09	2.67^{c}±0.06	3.82^{c}±0.10	3.43^{c}±0.07	2.79^{c}±0.04	1.36^{c}±0.05
E	60:20:20	3.97^{b}±0.10	3.17^{b}±0.04	3.96^{b}±0.14	3.87^{b}±0.02	3.01^{b}±0.09	1.67^{b}±0.07
F	50:25:25	4.27^{a}±0.12	3.36^{a}±0.02	4.60^{a}±0.13	4.27^{a}±0.06	3.22^{a}±0.10	1.81^{a}±0.06

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other. A: Bread made from 100% wheat flour, B: Bread made from 90% wheat flour, 5% malted mung bean flour and 5% watermelon rind flour, C: Bread made from 80% wheat flour, 10% malted mung Bean flour and 10% watermelon rind flour, D: Bread made from 70% wheat flour, 15% malted mung bean flour and 15% watermelon rind flour, E: Bread made from 60% wheat flour, 20% malted mung bean flour and 20% watermelon rind flour, F: Bread made from 50% wheat flour, 25% malted mung bean flour and 25% watermelon rind flour.WF:MMBF:WRF = % Substitution; Where: WF — Wheat flour, MPPF — Malted mung bean flour, WRF — Watermelon rind flour.

The niacin content of the bread samples ranged from 2.45 to 3.36mg/100g. The sample fortified with 25% malted mung bean and 25% watermelon rind flours had the highest value (3.36mg/100g), while the control (100% wheat flour bread) had the least value (2.45mg/100g). The increase in the niacin content of the sample could be attributed to substitution effect which is an indication that mung bean seeds and watermelon rind are good sources of niacin [9, 14]. The niacin content (2.45 – 3.36mg/100g) obtained in this study was higher than the values (2.14 – 3.10 mg/100g) reported by Onoja et al. [32] for bread supplemented with legume, root, tuber and plantain flours. Niacin plays an important role in the reduction of the level of blood cholesterol in the body [25].

The riboflavin content of the samples ranged from 3.51to 4.60mg/100g.There were significant ($p<0.05$) differences in the riboflavin content of the samples. The variation could be due to differences in the proportions of the raw materials used for bread production. The increase in the incorporation of malted mung bean and watermelon rind flours in the bread samples resulted to a remarkable increase in riboflavin contents of the samples. Riboflavin (vitamin B_2) helps the body to convert carbohydrate in food into fuel (glucose), which is used to produce energy. It also helps the body to metabolize fats and proteins. Riboflavin equally plays a critical role in the improvement of growth, reproduction and development processes in human body [25, 28].

The vitamin A content of the samples ranged from 2.23 to 4.27mg/100g. There were significant ($p<0.05$) differences in the vitamin A content of the samples. The differences could be due to the variation in the proportions of the raw materials used for the bread production. The sample substituted with 25% mung bean and 25% watermelon rind flours had the highest vitamin A content (4.27mg/100g) compared to control sample (100% wheat flour bread) which had the least value (2.23mg/100g). The values (2.23 to 4.27mg/100g) obtained in this study were higher than the vitamin content (2.16 to 4.10mg/100g) reported by Onwurafor et al. [5] for cookies made from wheat, malted mung bean and unripe plantain composite flours. Vitamin A helps in the maintenance of good sight. It is also an anti-oxidant which plays a vital role in the prevention of certain diseases like glaucoma and diabetes mellitus in the human body [29].

The ascorbic content of the bread samples ranged from 1.55 to 3.22mg/100g. There were significant ($p<0.05$) differences in the vitamin C content of the samples. The sample substituted with 25% mung bean and 25% watermelon rind flours had the highest value (3.22mg/100g), while the control sample had the least value (1.55mg/100g). The result showed that the ascorbic acid content of the samples significantly ($p < 0.05$) increased with increase in the addition of mung bean and watermelon rind flours. The observation is an indication that mung bean seeds and watermelon rind are good sources of ascorbic acid [5, 28]. The values (1.55 – 3.22mg/100g) obtained in this study were lower than the ascorbic acid content (12.15 – 12.74mg/100g) reported by Okoye et al.[10] for bread produced from wheat, ground bean and sweet potato flour blends. Ascorbic acid plays an important role in the prevention of scurvy. It also serves as an important antioxidant which helps to scavenge free radicals from the cells in human body [28].

The folic acid content of the bread samples ranged from 1.02 to 1.81mg/100g. The result showed that there were significant ($p<0.05$) differences in the folic acid content of the samples. The samples substituted with higher proportions of mung bean and watermelon rind flours had higher folic acid contents than the control sample. This could be as a result of substitution effect which showed that mung bean seeds and watermelon rind are relatively high in folic acid contents [5, 28]. The folic acid content (1.02 – 1.81mg/100g) obtained in this study was lower than the values (2.22 – 4.22 mg/100g) reported by Ndife et al. [33] for bread produced from whole wheat and soybean flour blends. Folic acid is essential in the maintenance of mental and emotional health in human body [34].

The addition of mung bean and watermelon rind flours to wheat flour in the production of breads generally increased their vitamin contents.

3.4 Microbial Qualities of the Bread Samples

The microbial qualities of the bread samples are presented in Table 5.

The total viable count of the samples ranged from $0.62\times12.\ 10^4$ to $1.80 \times 20.\ 10^4$cfu/g. The sample substituted with 25% malted mung bean and 25% watermelon rind flours had the highest

Table 5. Microbial qualities (cfu/g) of the bread samples

Samples	WF:MMBF:WRF	Total viable count	Coliform	Fungal count
A	100:0:0	0.62 x12.10^4	Nil	Nil
B	90:5:5	0.67x11.10^4	Nil	Nil
C	80:10:10	1.10x13.10^4	Nil	Nil
D	70:15:15	1.40x15.10^4	Nil	Nil
E	60:20:20	1.60x17.10^4	Nil	Nil
F	50:25:25	1.80x20.10^4	Nil	Nil

value (1.80 × 20. 10^{4}cfu/g), while the control sample (100% wheat flour bread) had the least value (0.62× 12. 10^{4}cfu/g). The result showed that the control sample had the lowest total viable count than the composite bread samples. The differences could be due to the variation in the processing treatments given to the raw materials used for the bread production. The increase in the total viable count of all the composite bread samples could be attributed to increase in the addition of malted mung bean and watermelon rind flours to the samples which were suspected to contain some thermophilic microorganisms that were able to survive the relatively high temperature used for the baking of the bread loaves. The total viable count (0.6 x 12.10^4 – 1.80 x 20.10^{4}cfu/g) obtained in this study was lower than the values (0.65 x 12.10^4 – 1.90 x 20.10^{4}cfu/g) reported by Ndife et al.[33] for bread produced from whole wheat and soybean flour blends.

In addition, the absence of coliform bacteria and fungi from the samples coupled with their relatively low total viable count showed that the products were safe and wholesome for human consumption and would also have longer keeping quality with proper packaging and storage. This observation is in agreement with the findings of Okoye et al. [10] for bread produced from wheat, ground bean and sweet potato flour blends.

Microbial quality is critical for predicting the shelf life, safety and wholesomeness of food products. However, the low total viable count in addition to the absence of coliform bacteria and fungi observed in this study is desirable and appreciable for the retardation of the spoilage of the bread loaves during storage by the activities of microorganisms or enzymes secreted by microorganisms due to their high nutrient density.

3.5 Physical Properties of the Bread Samples

The physical properties of the bread samples are presented in Table 6.

The loaf volume of the bread samples ranged from 3.10 to 15.5 cm^3.The control sample (100% wheat flour bread) had the highest value (15.5cm^3), while the sample substituted with 25% mung bean:25% watermelon rind flours had the least value (3.10 cm^3). The decrease could be due to the addition of high amounts of mung bean and watermelon rind flours to the sample. The result is in agreement with the findings of Dabels et al. [9] who reported a reduction in loaf volume of bread as the level of addition of non-wheat flour increased. The values (3.10 – 15.5 cm^3) obtained in this study were higher than the loaf volume (3.08 – 12.20cm^3) reported by Akubor and Badifu [35] for bread produced from African bread fruit kernel and wheat flour blends.

The specific loaf volume of the bread samples ranged from 1.30 to 5.40cm^3. There were significant ($p<0.05$) differences in the specific loaf volume of the samples.The specific loaf volume of the bread samples decreased with increase in the addition of mung bean and watermelon rind flours. The decrease could be attributed to the addition of mung bean and watermelon rind flours which weakened the gluten content of the wheat flour with resultant collapse of the dough after leavening during proofing and baking. [36]. The specific loaf volume (1.30 – 5.40 cm^3) obtained in this study was higher than the values (1.56 – 3.24 cm^3) reported by Adubofuor et al. [37] for bread made from ripe banana and wheat composite flours.

The weight of the bread samples ranged from 294.00 to 306.00 g. There were significant ($p<0.05$) difference in the weight of the samples. The weight of the bread samples increased as the levels of substitution of mung bean and watermelon rind flours increased. The increase could be due to the fact that mung bean and watermelon rind flours contain high amounts of fibre which has the ability to absorb and retain high amount of water which in turn contributes to the weight of the composite flour breads. The weight and volume of bread and other baked products have been reported to be dependent on bulk densities of the flours used for their production [5]. The values (295.00 – 306.00g) obtained in this study were higher than the weight (225 – 275g) reported by Pico et al*.* [20] for gluten – free bread samples.

The height of the bread samples ranged from 2.98 to 10.20m^2. There were significant ($p<0.05$) differences in the height of the samples. The height of the bread samples decreased as the levels of substitution of mung bean and watermelon rind flours increased in the products. The result showed that the samples substituted with higher proportions of mung bean and watermelon rind flours had the lowest values for height compared to the control sample. Zhang and Datta [36] reported that the height of the bread loaf is primarily affected by the volumetric expansion of the dough due to gas evolution during proofing coupled with the onset of gelatinization which causes the plasticization of the starch – protein network formed on the gas cell wall to take place as fast as possible. The height (2.98 – 10.20m^2) obtained in this study was lower than the values (3.34 – 12.12m^2) reported by Oke et al*.* [19] for bread produced from wheat and tiger nut composite flours.

The oven spring of bread samples ranged from 1.10 to 2.70m^2. There were significant ($p<0.05$) differences in the oven spring of the samples. The sample substituted with 25% mung bean and 25% watermelon rind flours had the least value (1.10 m^2), while the control sample (100% wheat flour bread) had the highest value (2.70m^2). The reduction might be as a result of substitution effect. The decrease is quite undesirable at the retail end as consumers prefer bread with good height and volume. The values (1.10 – 2.70m^2) obtained in this study were lower than the oven spring (2.26 – 3.58m^2) reported by Bridgewater and Beatrice [21] for bread produced from cassava and wheat composite flours. Oven spring is the difference between the height of the dough after proofing and the height of loaf after baking.

Generally, the addition of malted mung bean and watermelon rind flours to wheat flour in the production of bread loaves greatly decreased the loaf volume, specific loaf volume, height and oven spring with a remarkable increase in the weight of the products.

3.6 Sensory Properties of the Bread Samples

The sensory properties of the bread samples are presented in Table 7.

The score for the colour of the bread samples ranged from 5.25 to 8.25. The control sample (100% wheat flour bread) had the highest value (8.25), while the sample substituted with 25% malted mung bean and 25% watermelon rind flours had the least value (5.25). The colour of the bread sample produced from 100% wheat flour (control) was most preferable and also differed significantly ($p<0.05$) from the composite bread samples. The change in the colour of breads during baking could be attributed to increased substitution together with caramelization and Maillard reactions which tend to enhance the colour and aroma of the baked bread loaves [23].

The score for the taste of the bread samples ranged from 5.50 to 7.95. The result showed that the control sample (100% wheat flour bread) had the highest value (7.95), while the sample substituted with 25% malted mung bean and 25% watermelon rind flours had the least value (5.50). The taste of the bread samples decreased significantly ($p<0.05$) with increased substitution of malted mung bean and watermelon rind flours. The taste of the bread sample produced from 100% wheat flour (control) was rated higher by the judges compared to the other test samples. The difference could be due to the unique quality of wheat flour in the preparation of bread and other baked products [26, 11].

The score for the texture of the bread samples ranged from 5.05 to 8.80. The bread sample produced from 100% wheat flour was rated higher by the panellists in terms of texture compared to the composite flour breads. The texture of the bread samples decreased significantly ($p<0.05$) with increase in the addition of mung bean and watermelon rind flours. This observation is in close agreement with the report of Shittu et al*.* [37] for bread produced from cassava and wheat composite flours.

Table 6. Physical properties of bread samples

Samples	WF:MMBF:WRF	Loaf volume (cm^3)	Specific loaf volume (cm^3)	Weight (g)	Height (m^2)	Oven spring (m^2)
A	100:0:0	$15.5^a\pm0.71$	$5.40^a\pm0.09$	$295.00^f\pm0.18$	$10.20^a\pm0.11$	$2.70^a\pm0.06$
B	90:5:5	$14.05^b\pm0.37$	$4.70^b\pm0.11$	$296.50^e\pm0.74$	$8.19^b\pm0.12$	$2.40^b\pm0.05$
C	80:10:10	$12.0^c\pm0.24$	$3.31^c\pm0.12$	$298.01^d\pm0.63$	$6.95^c\pm0.10$	$2.00^c\pm0.04$
D	70:15:15	$10.00^d\pm0.26$	$3.31^c\pm0.10$	$300.00^c\pm0.68$	$5.50^d\pm0.13$	$1.50^d\pm0.03$
E	60:20:20	$6.10^e\pm0.27$	$2.30^d\pm0.13$	$302.50^b\pm0.72$	$4.00^e\pm0.08$	$1.30^e\pm0.07$
F	50:25:25	$3.10^f\pm0.33$	$1.30^e\pm0.15$	$306.00^a\pm0.76$	$2.98^f\pm0.07$	$1.10^f\pm0.09$

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly ($p<0.05$) from each other. A: Bread made from 100% wheat flour, B: Bread made from 90% wheat flour , 5% malted mung bean flour and 5% watermelon rind flour, C: Bread made from 80% wheat flour, 10% malted mung bean flour and 10% watermelon rind flour, D: Bread made from 70% wheat flour, 15% malted mung bean flour and 15% watermelon rind flour, E: Bread made from 60% wheat flour, 20% malted mung bean flour and 20% watermelon rind four, F: Bread made from 50% wheat flour, 25% malted mung bean flour and 25% watermelon rind flour. WF:MMBF:WRF = % Substitution; Where: WF — Wheat flour, MPPF — Malted mung bean flour, WRF — Watermelon rind flour.

Table 7. Sensory properties of bread samples

Samples	WF: MMBF:WRF	Colour	Taste	Texture	Aroma	Overall acceptability
A	100:0:0	$8.25^a\pm1.77$	$7.95^a\pm1.23$	$8.80^a\pm1.11$	$7.65^a\pm1.34$	$8.25^a\pm1.07$
B	90:5:5	$7.60^b\pm0.94$	$7.60^b\pm0.94$	$7.25^b\pm0.10$	$6.75^b\pm2.15$	$7.75^b\pm0.85$
C	80:10:10	$7.15^c\pm0.88$	$7.20^c\pm0.89$	$6.65^c\pm0.88$	$5.80^c\pm1.61$	$7.10^c\pm0.64$
D	70:15:15	$6.25^d\pm1.71$	$6.10^d\pm1.74$	$5.15^d\pm1.46$	$5.35^d\pm0.93$	$5.85^d\pm1.84$
E	60:20:20	$5.50^e\pm0.95$	$5.85^e\pm1.15$	$5.45^e\pm1.15$	$5.25^e\pm1.55$	$5.35^e\pm0.92$
F	50:25:25	$5.25^f\pm1.33$	$5.50^f\pm1.14$	$5.05^f\pm0.76$	$5.20^e\pm1.52$	$5.25^f\pm0.49$

Data are mean ± standard deviation of twenty (20) semi–trained judges. Means in the same column bearing different superscripts differed significantly ($p<0.05$) from each other. A: Bread made from 100% wheat flour, B: Bread made from 90% wheat flour, 5% malted mung bean flour and 5% watermelon rind flour, C: Bread made from 80% wheat flour, 10% malted mung bean flour and 10% watermelon rind flour, D: Bread made from 70% wheat flour, 15% malted mung bean flour and 15% watermelon rind flour, E: Bread made from 60% wheat flour, 20% malted mung bean flour and 20% watermelon rind flour, F: Bread made from 50% wheat flour, 25% malted mung bean flour and 25% watermelon rind flour. WF:MMBF:WRF = % Substitution; Where: WF — Wheat flour, MPPF — Malted mung bean flour, WRF — Watermelon rind flour.

The score for the aroma of the bread sample ranged from 5.20 to 7.65. The bread sample produced from 100% wheat flour (control) was rated higher in terms of aroma compared to the other test samples. The improvement in the aroma of the samples could be attributed to caramelization and Maillard reactions which enhance the taste and aroma of the bread loaves and other baked products [23]. The observation is in agreement with the findings of Awolu et al. [38] who reported a significant difference in aroma of wheat flour bread compared to the samples substituted with young corn powder.

The score for the overall acceptability of the bread samples ranged from 5.25 to 8.25. The control sample (100% wheat flour bread) had the highest value (8.25), while the sample substituted with 25% malted mung bean flour and 25% watermelon rind flours had the least value (5.25).The bread sample produced from 100% wheat flour (control) was most acceptable to the panellists compared to the composite bread samples. The increase in the acceptability of wheat bread was due to the unique quality of wheat flour in bread production [11]. Therefore, the control sample was rated higher in colour, taste, texture and aroma compared to the composite flour bread samples. The observation is in consonance with the findings of Awolu et al. [38] who reported a significant difference in acceptability of bread produced from 100% wheat flour and the samples substituted with young corn powder.

Generally, the result showed that the bread produced from 100% wheat flour was most acceptable organoleptically than the composite bread samples substituted with mung bean and watermelon rind flours at different stated levels during production.

4. CONCLUSION

The study showed that the substitution of wheat flour with mung bean and watermelon rind flours in the production of bread improved the nutrient contents of the products. It was observed from the study that the protein, fat, crude fibre, and ash contents of the composite flour breads increased sequentially with increased substitution of mung bean and watermelon rind flours compared to the control sample (100% wheat flour bread) with a slight decrease in carbohydrate and energy contents. The mineral and vitamin contents of the samples also showed that the calcium, magnesium, phosphorus, potassium, iron, sodium, niacin, thiamine, folic acid, riboflavin, vitamin A and ascorbic acid contents of the bread samples increased gradually with increase in the addition of mung bean and watermelon rind flours. The increase in protein, fat, mineral and vitamin contents of the samples observed in this study revealed that the addition of mung bean and water melon rind flours to wheat flour in bread making would have the potential to address the problems of protein-energy malnutrition and micronutrients deficiencies especially in the regions where these nutritional disorders are prevalent. The microbial counts of the samples showed that the total viable count was relatively low with the absence of coliform bacteria and fungi which is an indication that the bread loaves were safe and wholesome and would also have good keeping qualities with proper packaging and storage.

The physical properties of the bread samples showed that the loaf volume, specific loaf volume, height and oven spring of the samples decreased drastically with increase in the addition of mung bean and watermelon rind flours with a remarkable increase in the weight of the products.

The sensory properties of the bread samples also revealed that the control sample (100% wheat flour bread) was most acceptable by the judges and also differed significantly ($p<0.05$) in colour, taste, texture and aroma from the composite flour bread samples. In addition, the composite bread loaves were equally acceptable by the judges because they were also rated relatively high in all the sensory parameters evaluated in this study.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) here by declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of the manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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