Original Research Article

Quality Characterisation of biscuits from blends of Bambara groundnut (*Vigna subterranea*)**, Ground bean seed** (*Macrotyloma*) **and Moringa seed** (*Moringa oleifera*) **flour**

Abstract

The nutrient composition and the acceptability of biscuit from composite flours of wheat, Bambara groundnut (*Vigna subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) were evaluated. Bambara groundnut (*Vigna subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) was dried, processed into flour and used to substitute wheat flour as composite flour. The composite flour was at 0, 10, 20 and 30% level of the flour blends, the resulting mixtures were then used to produce biscuits. The pasting properties, proximate composition, minerals, physical (spread ratio, weight, thickness and colour) and sensory properties of the composite biscuit were evaluated. The pasting properties of the flours showed that pasting temperature were 68.50 ^{o}C - 70.0 ^{o}C and the peak viscousity range from 101.17 RVU – 207.17 RVU, while Break down (43.0 RVU) was highest in 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour) (WFF_1). The protein content increased from 12.50% in the control (100% wheat flour) to a range of 14.40% - 16.19% in the biscuits; crude fibre decreased from 2.83 to 2.40 - 1.84%.; ash content increased from 1.26% to a range of 1.53 - 2.01%, while carbohydrate and energy value reduced from 69.20 to 65.54 - 63.36% and 384.04 to 391.34 - 391.55% respectively. As the ratio of blends level increased, the thickness, diameter and weight increased but the spread ratio decreased. There was a significant difference in the overall acceptability of the control (100% wheat flour) and 10% blends substitution samples.

Keywords: Biscuit; Bambara groundnut; moringa; wheat; pasting.

1. INTRODUCTION

Protein-energy malnutrition (PEM) remains a major public health problem in Africa and some part of the world. A survey showed that high levels of malnutrition exist in children under 5 years of age with 46.9% stunted, 31% under-weighed and 11.6% [1], with a view to finding alternative and cheaper sources of protein to solve the problem of malnutrition due to inadequate protein in nutrition which is a prevalent problem in developing world, especially in Nigeria, legumes are recognized as a major source of dietary protein and energy. Dietary importance of legumes has been well established [2 - 5]. Due to their high protein content, legumes have been promoted as a source of protein especially for low-income families in countries with high rates of protein-energy malnutrition and the usage of animal protein is an economic constraint. They are also excellent sources of carbohydrate, fairly good sources of minerals and vitamins [6]. Legumes also contain numerous health protecting bioactive phytochemicals such as phenolic acids, flavonoids, isoflavones, saponins, phytosterols and sphingolipids [7]. *Macrotyloma geocarpa* Harm is a legume and an indigenous crop cultivated in parts of West Africa for food [8 - 9]. Ground bean can be consumed alone or supplemented with foods from other groups [10]. The proximate and antinutritional properties of fermented *Macrotyloma geocarpum* H. seed flour were reported [11 - 12] while its chemical, functional and amino acid composition were also reported [8-13]. *Vigna subterranea* (L). Verdc. commonly called Bambara groundnut is known as 'epa roro' in Yoruba, okpa in Igbo. In Côte d'Ivoire, it is commonly called 'Clô-Nglô' among the Akan Tribe [14]. Reports has it that Bambara groundnut flour has been used in making bread in Zambia [15] and milk [16 - 17]. Previous works have been reported on the nutritional and functional properties of protein concentrate and isolate from *Vigna subterranea* (L).Verdc.;

effect of domestic processing methods on chemical composition, anti-nutritional factors, *in-vitro* protein and starch digestibility on Bambara groundnut seed flour [18 - 19]. *Moringa oleifera* tree is a miracle tree due to its rich source of micro and macro nutrients [20]. Inclusion of *Moringa oleifera* seed as a food fortificant in producing snacks from bambara groundnut and ground bean is essential [21]. Biscuits are consumed all over the world as snack food by children and adults. It is a form of confectionery product dried to a low moisture content [22]. Biscuits had been suggested as a better form of composite food than bread because of its ready to eat nature. These characteristics make protein-rich biscuits attractive in countries where protein energy malnutrition is prevalent [23] and also in areas needing child feeding programmes. Biscuits with high sensory ratings had been produced from blends of wheat/cowpea flour Okaka and Isieh [24], wheat/soybean McWatters *et al*., [25], wheat and full fat soya [26 - 28] and composite flour from wheat and plantain [29]. Health conscious people are moving away from consumption of refined baked products to the consumption of functional, natural and fibre rich products. Therefore, this research on the incorporation of flour blends of Bambara groundnut (*Vigna subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) as a supplement in biscuit formulation was conducted with the focus to establish an alternative means of utilization of the blends through investigation of its quality characteristics.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Ground bean (Accession Tkg-8) and bambara groundnut (Accession TVSu-506) were procured from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State. Moringa seed was purchased from Afe Babalola University Ado Ekiti (ABUAD) farm Ado Ekiti, Ekiti State.

2.2 Preparation of Ground bean, Bambara groundnut and moringa seed flour.

Ground bean (*Macrotyloma*), Bambara groundnut (*Vigna subterranea*) and Moringa seed (*Moringa oleifera*) were sorted manually and washed under running water, oven dried at 60 ^{o}C for 20 h. All samples were milled using laboratory blender and sieved using a 200 µm mesh sieve (British Standard) to obtain fine flour of seeds powder. The flour were packed separately in plastic container, sealed and stored at room temperature (~27 ^{o}C) until required for use.

2.3 Formulation of flour blends

The four different blends of wheat, ground bean, bambara groundnut and moringa seed flour (Table 1) are used in composite flour. The composite flour were stored in airtight container until required.

Table 1: Blend formulation for biscuit

Formulations	Wheat flour (%)	Composite flour (%)
WFF_0	100	0
WFF_1	90	10
WFF_2	80	20
WFF_3	70	30

2.4 Production of wheat-bambara -ground bean-moringa biscuits

The biscuits were produced using the method described by Uchenna and Omolayo [30], with slight modifications. The flour were mixed together manually for 5 min. to get a creamy dough. The baking powder (2.5 g) and vanilla (5 g) were then added. The measured amount of water

(125 ml) was gradually added using continuous mixing until good textured, slightly firm dough was obtained. The dough was kneaded on a clean flat surface for four min. It was manually rolled into sheets and cut into shapes using the stamp cutting method. The cut dough pieces were transferred into fluid fat greased pans and baked in an oven at 105 ºC for 20 min., cooled and packaged for further analysis.

2.5 Pasting Properties of Bambara groundnut, ground bean seed and their blends.

The pasting properties of the flour blends were evaluated by using a Rapid Visco Analyser (RVA) (Perten Instruments RVA 4500). The moisture content of the samples were determined and used to calculate the weight of sample and water required to prepare the suspensions with the aid of the sample calculator on the software of the RVA. The sample and water was weighed into the canister and the paddle was fitted into it. The canister was placed on the tower of the RVA. It was a programmed heating and cooling cycle. Parameters recorded were pasting temperature (PT), peak viscosity (PV), minimum viscosity (MV), or trough viscosity (TV), final viscosity (FV), and peak time (PT). Breakdown viscosity (BV) was calculated as the difference between PV minus MV, while total setback viscosity (SV) was determined as the FV minus MV. All determinations were performed in triplicate and expressed in rapid viscosity units (RVU). (Newport Scientific Australia, 1998).

2.6 Physical analysis of biscuits

The diameter (width), thickness and spread factor were determined according to AACC [31].

2.7 Proximate Composition

The proximate composition (moisture, protein, fats, ash, fibre and carbohydrate) were determined as described by AOAC [32] method.

2.8 Colour Determination of wheat-bambara-ground bean-moringa biscuits

The colour of the samples was measured using the ColorTec – PCM^{TM} (USA US Patent 5,137, 64 Foreign Patent Pending Accuracy Microsensors Inc Pitsford, New York). The L, a, b type of scales was used. Values for L (0-100, black to white), a (positive-negative, red to green) and b (positive-negative, yellow to blue), were determined. An important factor characterizing the variation of colour in the test sample is the total colour difference or TCD. The total colour difference ΔE was defined by the Minolta equation [33].

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2} \quad (2.1)$$

2.9 Determination of minerals wheat-bambara-ground bean-moringa bread and biscuits:

Mineral Analysis. Potassium, sodium, calcium, magnesium, manganese, phosphorus, copper, zinc, and iron in the samples were determined by Xray spectrometric method (XRS). The mini pal 4 version PW4030X-ray Spectrometer (PerkinElmer, Inc., USA) was used to determine the concentration of the elements in the samples. The mini pal version PW4030 X-ray Spectrometer is an energy dispersive microprocessor controlled analytical instrument designed for the detection and measurement of elements in a sample (solids, powders, and liquids), from sodium to uranium [34].

2.10 Evaluation of Sensory Attributes of Bambara groundnut, moringa and Ground bean biscuits

All sensory analyses were conducted in a sensory laboratory with adequate lighting and no odor environment. Panelists were selected based on familiarity with control samples, recognition and perception of common odors. The biscuit samples were prepared and presented to 30 untrained panelists coded with random three digits. Water at room temperature was provided for mouth rinsing in between successive evaluation. Sample attributes (color, texture, taste, aroma, etc.) were rated on a scoring scale of 1 to 9, where 1 = dislike extremely and 9 = like extremely. Panelists made their responses on score sheets which were designed in line with the test procedures [35]. Mean scores for color, taste, texture, aroma and overall acceptability and degree of difference were analyzed by ANOVA. Post-hoc evaluation and separation of means was done using Duncan's test.

2.11 Statistical Analysis

The experimental results were expressed as mean ± standard deviation (SD) of three replicates. Data obtained were statistically analyzed using one way Analysis of Variance (ANOVA), a tool in Statistical Packages for Social Scientists (SPSS 18.0). The level of significance was set at $p < 0.05$. Means were separated with Duncan's New Multiple Range Test (DNMRT).

3.0 RESULT AND DISCUSSION

3.1 Pasting property of blends from wheat-bambara groundnut-moringa seed flour

Table 2 shows the pasting profile of blends produced from wheat-bambara groundnut-Ground bean seed-moringa seed flours. The pasting temperature is an indication of the minimum temperature required to cook or gelatinize the flour [36]. There were no significant differences in pasting temperatures between the composite flour as well as wheat flour, but in general the pasting temperature in composite flour were higher than that of wheat flour. This may be due to the addition of ground bean in composite flours. A higher pasting temperature is an indication of higher water binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour as a result of high degree of association between starch granules [37]. Peak viscosity which ranged between 114.17RVU (Relative visco-Analyzer unit) in WFF_1 (90% wheat: 10% composite flour) to 207.17 RVU in WFF_3 (70% wheat: 30% composite flour) is an index of the ability of starch-based fruits to swell freely before their physical break down [38]. The higher peak viscosity observed in the blends compared to 100% wheat could be attributed to the dilution of amylose contents in the composite blends. Zaidul *et al*. [39] and Blennow *et al*. [40] reported that high peak viscosity was associated with low amylose contents in flour. Peak viscosity is an indication of the thickening power of the starch, the higher the peak viscosity the higher the thickening power. The high peak viscosity values of the composite blends may be suitable for products requiring high gel strength and elasticity as reported [15]. The result for holding Strength revealed that sample WFF_3 ranked the highest (82.00) while sample WFF_1 had the least value (66.00 RVU). These values are relatively higher than the control sample value (64.33 RVU). It was observed that as the percentage of composite flour increased the holding strength increases. The Final Viscosity ranged between 111.86 RVU in WFF_1 and 123.44 RVU in WFF_3. Final viscosity is commonly used to define the quality of particular starch based flour, since it indicates the ability of the flour to form a viscous paste after cooking and cooling [41]. The break down value was high in sample WFF_1 (43.00) while the least value was recorded in sample WFF_3 (36.00). It was observed that as the concentration of the composite flour increased the break down values decreased. High values of breakdown are associated with high peak viscosities, which in turn, are related to the degree of swelling of the starch granules during heating [42]. Lower setback viscosity indicates higher potential for retro-gradation in food products and gives an idea about retro-gradation tendency of starch [43]. Higher setback value is associated with cohesiveness. This study showed a setback viscosity range of 45.70 to 42.01 RVU in WFF1 and WFF3 respectively. Arisa *et al*., [44] reported a setback value of plantain flour treated with sodium metabisulphide to be 35.83 RVU which is slightly lower than the values reported in this study.

Table 2: Pasting property of Bread produced from wheat-bambara groundnut-moringa seed flour

Properties	WFF_0	WFF_1	WFF_2	WFF_3
Pasting temp. (^oC)	68.50 ± 0.71^b	68.77 ± 0.51^b	69.50 ± 0.23^b	70.0 ± 0.17^a
Pasting time (min)	5.0 ± 0.11^b	5.07 ± 017^{ab}	5.07 ± 0.15^a	5.14 ± 0.21^a
Peak Viscosity (RVU)	101.17 ± 0.83^d	114.17 ± 0.51^c	119.17 ± 0.99^a	207.17 ± 1.27^b
Holding Strength (RVU)	64.33 ± 1.12^d	66.00 ± 0.83^c	77.0 ± 1.07^b	82.0 ± 0.92^a
Final Viscosity (RVU)	114.92 ± 2.55^d	111.86 ± 1.60^c	118.92 ± 3.42^b	123.44 ± 1.91^a
Break Down (RVU)	30.84 ± 0.91^d	43.0 ± 0.83^a	37.0 ± 0.86^b	36.0 ± 1.11^c
Set Back (RVU)	50.58 ± 1.61^a	45.70 ± 0.91^b	43.79 ± 0.82^c	42.01 ± 0.63^c

Results are mean of triplicates ± standard deviation. Values followed by different superscripts on the same row are significantly different ($p< 0.05$)

WFF_0: 100% wheat flour (control), WFF_1: 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour), WFF_2: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa flour), WFF_3: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

3.2 Physical composition of biscuit produced from wheat-bambara groundnut-moringa flour

The result of physical characteristics of biscuits prepared from the flour blends are presented in Table 3. There were significant differences in weight among the biscuit samples ($P < 0.05$). The highest weight was observed in the sample that contain wheat and 30% composite flour (WFF_3). However, the weight of biscuit sample increases with increasing level of the composite flour. This same trend was observed in composite flour made of soybean, maize, sweet potato and xanthan gum [45]. This could be of advantage to the biscuit industries as much weight gain in WFF_3 could lead to less packaging material thereby leading to much profit gained. The height ranged from 6.06 to 7.02cm. Sample WFF_0 (100% wheat) had the lowest value while sample WFF_3 (70%wheat, 30% composite flour) had the highest value. The height and diameter of the biscuit samples were also observed to increase gradually with increase in the level of composite flour, up to sample WFF_3. Therefore, biscuits prepared from Bambara ground nut seed, moringa seed and ground bean seed flour compared favorably in height and diameter with the control (100% wheat flour). These observation is similar to the report of Kiin-Kabari and Giami [29] for cookies made from a blend of plantain and bambara protein concentrates. thickness of the biscuits prepared from the composite flour containing Bambara groundnut, moringa seed and ground bean seed flour varied significantly ($P<0.05$) between the samples. The thickness of the biscuits was affected positively. Thickness of the biscuits showed gradual increase as the level of composite flour replacement from WFF_0 (100%) to WFF_3 (70%), except for sample WFF_1 which was lower than the control. Highest value (0.50 cm) was found in WFF_3 while the lowest value (0.40 cm) was found in WFF_1 (90% wheat flour: 10% composite flour). These findings were in agreement with what was observed by Bello *et al*., [46] who found that the thickness of the biscuits was affected positively as there was an increase in the thickness of the biscuits by increasing levels of Mushroom flour supplementation. Thickness increased with increasing amount of crude fiber and crude protein. Spread factor is the ratio that depends on the values of the thickness and diameter of the biscuits. The spread factor of formulated biscuit decreased from 86.26 - 80.00 with increase in composite flour content. The decrease in the spread factor of the flour blends biscuits with an increase in the level of composited seed flour could be due to the oil content of the moringa flour. A notable trend was observed, the biscuit spread factor decreased with increase in protein content of the biscuits. The Increase in the protein content observed competes for the available free water in the biscuits dough as a number of hydrophilic sites are available, this could result to decrease in the spread

factor [47 - 48]

Table 3: Physical Attributes of biscuits produced from wheat-bambara groundnut-moringa seed flour

Means (±SEM) with different superscripts in the same column are significantly different (p<0.05)

WFF_0: 100% wheat flour (control), WFF_1: 90% wheat: 10% (Bambara- groundnut-ground

Samples	Thickness (cm)	Diameter (cm)	Weight (g)	Height (cm)	Spread factor
WFF_0	0.43 ± 0.01^a	3.27 ± 0.14^b	6.43 ± 0.14^c	6.06 ± 0.14^c	76.04 ± 0.52^d
WFF_1	0.40 ± 0.07^a	3.45 ± 0.10^b	7.05 ± 0.30^c	6.34 ± 0.20^c	86.25 ± 0.91^a
WFF_2	0.46 ± 0.09^a	3.89 ± 0.16^a	7.23 ± 0.34^b	6.72 ± 0.31^b	84.56 ± 1.27^b
WFF_3	0.50 ± 0.03^a	4.00 ± 0.12^a	7.67 ± 0.24^a	7.02 ± 0.24^a	80.00 ± 1.50^c

bean- moringa flour), WFF_2: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa flour), WFF_3: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour)

3.3 Proximate and energy composition of biscuit produced from wheat-bambara groundnut-moringa seed flour

The proximate and energy compositions of wheat-bambara groundnut-Ground bean seed-moringa seed flour are shown in Table 4. The moisture content of the wheat-bambara groundnut-Ground bean seed-moringa seed biscuit increased from 7.85% in WFF_0 - 8.45% in WFF_3. These findings were lower than the results reported for sorghum-wheat composite flour biscuits [41]. The low moisture content of the biscuit will require a unique packaging material to prevent reabsorption of moisture. The protein content of the biscuit increased from 12.50% - 16.19% with increase in bambara groundnut, Ground bean seed and moringa seed flour. Sample WFF_0 had no addition of bambara groundnut, Ground bean seed and moringa seed flour hence, had lowest protein content. Bambara nut is a rich source of protein. In comparison, these results were within the same range 12.61 – 15.03% for cookies from wheat, acha and pigeon pea flour blends reported [49]. The fat content ranged from 6.36% - 8.15% with increase in the blends in bambara groundnut-Ground bean seed-moringa seed flour which is a rich source of mineral. Fat could play a role in determining the shelf-life of foods. The low amount of fat present in the sample could help to prolong the shelf life of the product as the rate of rancidity which could lead to the production of off flavours and odours will be reduced drastically. The ash content increased from 1.26-2.01% with increase in the sample ratio. Ash content indicates the presence of mineral matter in food. Ash is a non-organic compound containing the mineral content of food. It aids in the metabolism of other compound such as protein fat and carbohydrate [50]. The crude fibre decreased from 2.83-1.84% with increase in flour blends. The fiber contents of all the cookies were within the Recommended Daily Allowance which should not exceed 5 g dietary fiber per 100 g dry matter [51]. The carbohydrate content of cookies ranged from 63.36 to

69.20%. The carbohydrate content of the sample is favourably compared with the [52]. This also implies that the cookies could serve as a source of energy needed for body metabolism. The energy content of the samples ranged from 384.04 kcal/100 g (WFF_0) to 391.55 kcal/100 g in WFF_3. The energy value increased as the blends inclusion increase. This could be due to the low fiber content present in the blends. The energy values of the biscuits are higher than 332.88-342.01 kcal for wheat cowpea based snack as reported [53].

Table 4: Proximate and energy composition of biscuit produced from wheat-bambara groundnut-moringa seed flours

Parameters	WWF_0	WWF_1	WWF_2	WWF_3	FAO, 2007
Moisture Content (%)	7.85 ± 0.01^b	8.11 ± 0.00^b	8.26 ± 0.01^a	8.45 ± 0.09^a	<10
Crude Protein (%)	12.50 ± 0.02^c	14.40 ± 0.13^b	15.84 ± 0.04^b	16.19 ± 0.23^a	>15
Crude Fat (%)	6.36 ± 0.02^c	8.02 ± 0.07^b	8.03 ± 0.16^b	8.15 ± 0.00^a	10-25
Crude Ash (%)	1.26 ± 0.03^d	1.53 ± 0.01^c	1.62 ± 0.01^b	2.01 ± 0.00^a	<3
Crude Fibre (%)	2.83 ± 0.02^a	2.40 ± 0.02^b	2.20 ± 0.01^c	1.84 ± 0.13^d	<5
Carbohydrate (g/100g)	69.20 ± 0.05^a	65.54 ± 0.11^b	64.05 ± 0.30^c	63.36 ± 0.20^d	64
Energy (K/cal)	384.04	391.34	391.83	391.55	344

Results are mean of triplicates ± standard deviation. Values followed by different superscripts on the same row are significantly different (P< 0.05)

WFF_0: 100% wheat flour (control), WFF_1: 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour), WFF_2: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa flour), WFF_3: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

3.4 Colour attribute of biscuit produced from wheat-bambara groundnut-moringa seed flour

The colour attribute is presented in Table 5. The biscuit sample WFF_0 had the highest value for lightness 66.06 while WFF_3 had the least L* value 51.85. A notable trend was observed, as the blending ratio increased the lightness value decreased. Sample WFF_2 recorded higher a* (10.77) while sample WFF_3 (6.83) recorded the least degree of yellowness. The b^* value of the biscuit range from 26.05 in WFF_3 to 17.92 WFF_1. Baking process have influenced the colour of the samples. Results obtained from this study is in agreement with Abano *et al*., [54] who said that the effect of heat on the carbohydrate during extrusion as a result of high temperature in the extruder may have cause reaction between the amino acids and reducing sugars in the complementary foods which may have accounted for the variation in the colour of the formulated diets. Colour is an important quality parameter that influence market performance. Consumer perceptions about some products are based on colour and many foods are associated with a specific colour. Colour is by far one of the main quality criteria for consumers' acceptance of food flour [55].

Table 5: Colour of biscuit produced from wheat-bambara groundnut-moringa seed flour

Sample	L*	a*	b*
WFF_0	61.06 ± 4.95^{ab}	7.99 ± 2.80^{abc}	22.00 ± 6.70^{a}
WFF_1	59.07 ± 2.36^{ab}	6.83 ± 1.09^{bc}	17.92 ± 2.73^{a}

WFF_2	57.84±8.09[ab]	10.77±1.90[a]	22.03±2.60[a]
WFF_3	51.85±3.17[b]	9.64±0.95[ab]	26.05±0.52[a]

Results are mean of triplicates ± standard deviation. Values followed by different superscripts on the same column are significantly different (P< 0.05)

WFF_0: 100% wheat flour (control), WFF_1: 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour), WFF_2: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa flour), WFF_3: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

3.5 Mineral content of biscuit produced from wheat-bambara groundnut-moringa seed flour

The addition of Bambara- groundnut-ground bean- moringa flour is a good source of minerals as presented in Table 6. The Calcium, Sodium, magnesium, Potassium and Phosphorous are the predominant mineral elements present in the wheat-composite Biscuit. The mineral composition obtained in this study shows that there was an increase in the phosphorous content of the biscuit with increase in the level of flour blends. The Fe content of this study ranged from 3.61 in WFF_0 – 2.83 mg/100 g in WFF_3 and it is lower than the recommended daily allowance (RDA) - 10 mg of iron per day [56]. Iron is a major component of haemoglobin that carries oxygen to all parts of the body. Iron also has a critical role within cells assisting in oxygen utilization, enzymatic systems, especially for neural development, and overall cell function. Potassium was the most abundant mineral in the biscuit followed by phosphorus and then calcium. The potassium content of the samples ranged from 317.55 in WFF_0 - 395.25 mg/100 g in WFF_3 while phosphorus ranged from 251.49 in WFF_0 - 338.95 mg/100 g In WFF_3 and calcium ranged from 76.95 in WFF_0 - 98.20 mg/100 g in WFF_3. These are in line with the report that the most abundant mineral element in biscuit is potassium [57]. The increase in the phosphorous content of the biscuit with increase in the level of Bambara- groundnut-ground bean- moringa flour addition is an indication that Bambara- groundnut-ground bean- moringa is a good source of minerals. The Sodium and potassium ratio is less than 1. This is good because it is required to maintain osmotic balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose absorption, and enhance normal retention of protein during growth [57]. Calcium content ranged from 76.95 in WFF_0 to 98.20 mg/100g in WFF_3 and Mg ranged from 28.57 to 33.97 mg/100 g. The calcium content of the biscuits increased with increase in level of Bambara- groundnut-ground bean- moringa flour addition, which means that the Bambara- groundnut-ground bean- moringa has higher content of calcium than wheat. Without magnesium, calcium may not be fully utilized, and under-absorption problems may occur resulting in arthritis, osteoporosis, menstrual cramps, and some premenstrual symptoms. Manganese, copper and zinc are trace mineral elements that are essential for important biochemical functions and necessary for maintaining health throughout life. While, Zinc (Zn) ranges from 0.60 – 0.65 mg/100 g. These values were comparable to what was reported [58].

Table 6: Mineral content of biscuit produced from wheat-bambara groundnut-moringa seed flour

Parameters	WWF0	WWF1	WWF2	WWF_3
Sodium (mg/100g)	41.45±0.35^c	44.25±0.35^b	44.75±0.07^b	49.15±0.49^a
Calcium (mg/100g)	76.95±1.91^d	86.30±0.28^c	90.40±1.27^b	98.20±0.14^a
Potassium (mg/100g)	317.55±1.63^b	320.10±0.00^b	382.15±1.91^b	395.25±0.21^a

Iron (mg/100g)	3.61±0.00^{a}	2.64±0.00^{c}	2.75±0.00^{c}	2.83±0.0c^{b}
Magnesium (mg/100g)	28.57±0.01^{d}	32.66±0.18^{c}	41.00±0.18^{a}	33.97±0.21^{b}
Zinc (mg/100g)	0.60±0.00^{d}	0.62±0.01^{c}	0.63±0.01^{b}	0.65±0.00^{a}
Manganese (mg/100g)	0.35±0.01^{d}	0.35±0.00^{c}	0.37±0.00^{b}	0.48±0.00^{a}
Phosphorus (mg/100g)	251.49±0.99^{d}	262.45±1.02^{c}	294.87±0.38^{b}	338.95±1.75^{a}
Iodine (mg/100g)	0.38±0.06^{a}	0.30±0.01^{a}	0.35±0.07^{a}	0.36±0.12^{a}
Na/K	0.13	0.13	0.1	0.12

Results are mean of triplicates ± standard deviation. Values followed by different superscripts on the same row are significantly different ($P < 0.05$)

WFF_0: 100% wheat flour (control), WFF_1: 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour), WFF_2: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa flour), WFF_3: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

3.6 Sensory attribute of biscuit produced from wheat-bambara groundnut-moringa seed flour

The effect of added bambara groundnut-Ground bean seed-moringa seed flour on the quality of biscuit is summarized on Table 7. The addition of bambara groundnut-Ground bean seed and moringa seed flour decreased the mean score of the colour from 7.00 in WFF_0 - 5.20 in WFF_3 as the concentration (0-30%) of the blends increase. This could be due to the natural inherent pigment of the bambara groundnut-Ground bean seed and moringa seed flour added. It could also be due to enzymatic browning, which might have given an impression of the products been over baked to the panellist hence the less liking effect. These results are comparable to the result of Mouni *et al.,* [59] who also reported a decrease from 8.30 – 5.27 in the mean colour as the ratio of Jujubes increased. The addition of bambara groundnut-Ground bean seed-moringa seed flour decreased the mean score of the taste from 7.53 - 4.40 as the percentage (0-30%) of the blends increased. This could be due to increase in the sugar, fat and some other compounds in the bambara groundnut-Ground bean seed-moringa seed flour. The addition of bambara groundnut-Ground bean seed-moringa seed flour decreased the mean score of the texture from 6.60-5.47 as the percentage (0-30%) of the added bambara groundnut-Ground bean seed-moringa seed flour increased. This could be due to the increase in the sugar content and decrease in the carbohydrate content of the added bambara groundnut-Ground bean seed-moringa seed flour. The addition of the flour blends decreased the mean score of the aroma from 6.53-4.53 as the percentage (0-30%) of the blends increased. The addition of bambara groundnut-Ground bean seed-moringa seed flour decreased the mean score of the general acceptability from 7.20-4.87 as the concentration (0-30%) of the blends increased. Similar trend was observed by Akoja and Coker [60] for biscuits by increasing the concentration of okro powder in the formulation.

Table 7: Sensory attribute of biscuit produced from wheat-bambara groundnut-moringa seed flour

Parameters	**WFF$_0$**	**WFF$_1$**	**WFF$_2$**	**WFF$_3$**
Colour	7.00 ± 1.85^{a}	6.00 ± 1.07^{b}	5.60 ± 1.05^{b}	5.20 ± 1.32^{b}
Taste	7.53 ± 1.19^{a}	6.40 ± 0.83^{b}	6.00 ± 1.09^{c}	4.40 ± 1.35^{d}
Aroma	6.53 ± 1.19^{a}	6.13 ± 1.60^{a}	4.80 ± 1.21^{b}	4.53 ± 1.60^{c}
Texture	6.60 ± 1.24^{a}	6.13 ± 1.41^{b}	5.93 ± 1.22^{c}	5.47 ± 1.19^{c}
Overall acceptability	7.20 ± 0.86^{a}	6.80 ± 1.55^{b}	6.20 ± 1.01^{c}	4.87 ± 1.06^{d}

Results are mean of triplicates ± standard deviation. Values followed by different superscripts on the same row are significantly different (P< 0.05)

WFF_0: 100% wheat flour (control), WFF_1: 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour), WFF_2: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa flour), WFF_3: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

Conclusion

The inclusion of the blends of Bambara groundnut, Ground bean seed and Moringa seed flours to wheat flour in the production of biscuits enhanced the protein, energy and mineral contents of the biscuits. For the pasting properties a notable trend was observed that as the concentration of the flour blend increased the break down values decreased. Therefore, sample with 70% wheat: 30% blends (WFF_3) was the best formulation which guaranteed enough protein, energy value, Ash, fat, colour and minerals.

COMPETING INTERESTS

Authors have declared that no competing interest exist

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