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Nutritional and Sensory Evaluation of Wheat Biscuits Fortified with Baobab (*Adansonia Digitata L.*) Fruit Pulp

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Abstract: As a potential source of calcium and or minerals, the nutritional, physical, and sensory characteristics of biscuits enriched with baobab pulp were studied. The six blends of composite flours used were prepared by incorporating baobab pulp flour (BPF) into wheat flour at 0, 5, 10, 15, 20, 25, and 30%. The BPF and biscuits produced were evaluated for nutritional, physical, and sensory quality and antioxidant activity. The results showed an increase in the proximate composition and antioxidant activity with increased incorporation of baobab flour. There was also an increase in protein (10.93 to 15.16%), lipid (45.66 to 51.83%), fiber (1.27 to 11.75%), and ash content (3.45 to 7.57%) but a decrease in carbohydrate (35.59 to 10.81%) and moisture content (3.10 to 2.88%) with increase incorporation. The mineral profile also showed an increase in calcium (88.88 - 751.90 mg/100 gDM), magnesium (79.06 to 105.65 mg/100 gDM), and Fe (2.29 to 6.03 mg/100 gDM) with the addition of baobab flour. Sensory evaluation showed that the most organoleptically accepted biscuits were those produced using 5% BPF though all the biscuit blends obtained were found to be suitable for use to combat calcium deficiency disorders. The 5% BPF had a high mineral profile with biscuits produced that were rich in calcium (350.19 mg/100 g), magnesium (80.81 mg/100 g), and iron (3.09 mg/100 g) as well as a high amount of antioxidants (47.62%). Thus, incorporating baobab pulp flour at various proportions improved the sensory, physical, and nutritional qualities of wheat biscuits as well as their antioxidant ability. Baobab-fortified biscuits could therefore be an alternative and accessible snack to both children and adults and could be exploited in the fight against calcium deficiency disorders.

Keywords: Biscuits, Baobab Pulp, Nutritional Quality, Sensory Quality, Calcium Deficiency

1. Introduction

According to Sustainable Nutrition Initiative (SNI), the Task Force report stated that about 3.5 billion people worldwide are at risk of inadequate calcium intake, with the vast majority of these individuals located in Africa and Asia [1]. Calcium deficiency is more prevalent in low-income and middle-income countries. Calcium is essential for bone health, but insufficient consumption has also been related to other health outcomes like rickets in children and osteopenia or osteoporosis in adults [2]. To ensure sufficient amounts of calcium in the body, its supply in the diet must be adequate. Enrichment of foods, mainly staple foods, are generally used to combat nutrient insufficiency where some nutrients are generally wanting or not contained in sufficient amounts in the diet of a population and it has been practiced to target specific health disorders like anemia [3].

Biscuits are widely consumed snacks and can thus be used as a substrate for food enrichment. Consumers demand a more natural product with, not only increased nutritional but also medicinal benefits for the prevention of diseases [4]. Cameroon does not grow wheat in commercial quantities. Therefore, the industry can only survive by utilizing local grains, fruits, or foods that can either partially or completely substitute wheat products without adversely affecting the quality of such products [5]. Biscuits may be considered as a form of confectionery dried to very low water content. It is commonly accepted and highly consumed by all ages. It can be eaten at all times as a result of its relatively long shelf-life, cholesterol-free, taste, ease of transportation, and low cost [6, 7]. It could be considered a good product for calcium enrichment and other nutritional improvements like fiber, protein and antioxidants [8-10].

With this backdrop, the baobab fruit pulp which is very nutritious, with high values of carbohydrates, energy, potassium, calcium (very high), thiamine, nicotinic acid and vitamin C [11] can serve as a source of calcium if used in the production of biscuits. It contains sugars but no starch and is rich in pectins. The fruit pulp has a very high vitamin C content, almost ten times that of oranges. The vitamin C content of the bulk fruit pulp reportedly varies from 1623 mg/kg to 4991 mg/kg [12, 13].

With these, there is a compelling need to find an adequate fortifier for wheat flour; a product that is readily available, affordable, and capable of adding more nutrients to wheat flour. Baobab pulp can therefore be used as a fortifier to wheat in varying ratios for biscuit making hence a composite flour from both baobab pulp flour and wheat flour can be used for biscuit production due to its nutritional composition, especially for its very high calcium content. The main objective of this study is to determine the ratio of incorporation of baobab fruit pulp flour with wheat flour for the production of a functional biscuit.

2. Materials and Methods

2.1. Production of Baobab Pulp Flour (BPF)

Baobab pulp from the northern region was transformed into baobab flour using the method described by Diop *et al.*, [14]. The baobab pulp was initially sun-dried for about 45 minutes and then carefully crushed. The obtained pulp was subsequently ground to reduce the particle size. With a 250µm sieve (ISO 3588) size, it was fractionated, packaged in plastic bags, labeled, and stored at room temperature (Figure 1).

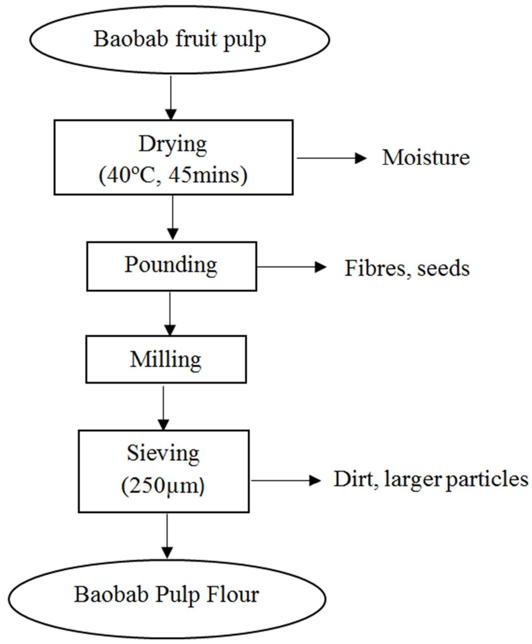

Figure 1. *Process Diagram for Baobab Pulp Flour (BPF).*

2.2. Production of Biscuits

2.2.1. Formulation

The Minitab software was used to obtain a mixture design. Six formulations, resulting from a simplex centroid mixture with two constraints (wheat flour and baobab pulp flour) were gotten, the highest incorporation ratio being 30% as presented in table 1.

Table 1. *Formulation of composite flour for biscuit production.*

	Different Formulations						
	B1	B2	B3	B4	B5	B6	B7
Wheat Flour (%)	100	95	90	85	80	75	70
Baobab Pulp Flour (%)	0	5	10	15	20	25	30

2.2.2. Preparation

This was done using the Miller [15] protocol. Sugar (125 g) and margarine (125 g) were mixed until fluffy after which one whole egg was added and mixed until a homogenous cloudy mixture was obtained. In another vessel, dry ingredients (250 g of composite flour (WF: BPF) and baking powder (10 g) were sieved and mixed properly. The dry ingredients were then poured into the liquid mixture and kneaded till a homogenous dough was obtained. The dough was then spread to a thickness of about 3 mm, and with a biscuit mold, it was cut into desired shapes. They were later baked at a temperature of 200°C for 10 minutes. The biscuits were allowed to cool completely at room temperature after which they were packaged in plastic bags.

2.3. Proximate and Mineral Composition

BPF and biscuits were analyzed for moisture [16], protein [17], lipid [18], ash [16], fiber [19], and carbohydrate [20]. Caloric value (Atwater factor), and sugar [21] content were also determined and iron and calcium quantified using the method of Rodier, [22] and AFNOR, [23] respectively.

2.4. Antioxidant Activity

The antioxidant activity of BPF and each biscuit blend was assayed as radical scavenging activity on 1, 1-diphenyl-2- picrylhydrazyl radical (DPPH) [24] and total reducing power [25].

2.5. Physical Characteristics of Biscuits

The weight (g) of biscuits was measured using a digital balance (Sartorius; BL6100) and the average value of six individual biscuits was taken. Biscuit thickness (cm) was determined by stacking six biscuits on top of each other and taking the average thickness. Diameter (cm) was the average value of six biscuits measured using a vernier caliper. Volume was determined by calculation [26]. Meanwhile, the spread ratio was calculated by dividing the average diameter by the average thickness of biscuits, and density as weight/volume. Hardness [27] and friability index [28] of the biscuits were also carried out.

2.6. Sensory Evaluation of Biscuits

Sensory evaluation of the biscuits was done using a consumer panel of 30 persons. A 9-point hedonic scale was used where 1 stands for dislike extremely and 9 for like extremely. Sensory attributes evaluated were color, taste, texture, flavor, and overall acceptability.

2.7. Statistical Analysis

Analyses were carried out in triplicates and the results obtained were expressed as mean ± standard deviation using Excel 2016. The data were submitted to a one-way Analysis of Variance (ANOVA). Differences between means were tested using the Duncan Multiple Range Test at $p < 0.05$) using OriginPro.

3. Results and Discussion

3.1. Physico-Chemical Composition of Baobab Pulp Flour

Before blending, the baobab pulp flour was analysed for its physico-chemical properties to determine its probable techno-functionality. The outcome of the analyses are presented in Table 2.

Table 2. *Physico-Chemical composition of baobab pulp flour.*

Component	Content
Moisture Content (g/100g DM)	12.0 ± 0.1
Total lipids (g/100g DM)	19.79 ± 0.22
Total Proteins (g/100g DM)	12.54 ± 0.43
Total Fiber (g/100g DM)	5.85 ± 0.09
Total Ash (g/100g DM)	6.74 ± 0.05
Carbohydrates (g/100g DM)	43.08 ± 0.17
Caloric Value (kcal/100g)	400.59 ± 0.00
Total sugars (%)	25.91± 0·00
Water Absorption Capacity (g/100g DM)	59.75±0.65
Iron (mg/100g DM)	2.92 ± 0.38
Calcium (mg/100g DM)	278.54 ± 0.05
Magnesium (mg/100g DM)	126.12 ±1.54
Vitamin C (mg/100g DM)	17.22±0.89
Antioxidant Activity (%)	71.43 ± 2.14

Low moisture content extends flour or product shelflife [29]. The average moisture content of the BPF presented a value of 12.0±0.1 g/100gDM. This value is within the range established by the European Union legislation [30] of 11.1% to 12% for baobab fruit pulp, and therefore the flour can be stored for a long period of time. This value is lower than those reported by Barakat [31] but similar to those of Murray *et al*., [32], and Soloviev *et al*. [33] where average moisture contents were 12% and Ibrahima *et al.* [34] for 5 different species of baobab with an average moisture of 12.5%. This variation may be a result of low altitude and precipitation, relatively high temperature, especially from the sun and wind exposure which contributed to the dehydration of the fruit pulp hence safe storage of the flour.

Lipids in flour can be oxidized and hence lead to flour deterioration. A 19.79 g/100gDM lipid content for the BPF was recorded and these results are in agreement with those reported by Glew *et al.* [35] but extremely lower than those reported by Nour *et al.* [36], and Lockett *et al*. [37].

Protein impacts flour functional properties such as water absorption, texture, cohesiveness, viscoelasticity, dough strength, and texture [38]. A protein content of 12.54g/100gDM for the BPF was recorded and this value was lower than those reported by Sena *et al.* [39], Obizoba and Amaechi [40], and Barakat [31]. This value was higher than those of Lockett *et al.* [37] and Osman [41] who obtained 5.3 g/100gDM and Ibrahima *et al.* [34] with a value range of 2.5 to 6.3 g/100gDM for the various baobab species.

A fibre rich diet could provide a better control of blood sugar and cholesterol levels, regulation of intestinal functions as well as protection against cardiovascular diseases. [42]. Also, fibres affect flour and dough properties like water absorption, mixing tolerance and extensibility of dough [43]. A Fibre content of 5.85 g/100gDM was recorded and this was in agreement with the values obtained by Muthai [44], [45], Lockett [37], Osman [41], and Nour [36].

Ash represents the inorganic matter (minerals) and an ash content of 6.74 g/100gDM was recorded. This value is similar to those reported by Ponka *et al.* [46] but higher than those of Monteiro *et al.* [47] with a range of 4.71 to 5.18 g/100gDM for the various samples. This value is within those reported by Ibrahima *et al.* [34], which were between 5.3 and 7.8 g/100gDM and Murray *et al*. [32], and Lockett *et al.* [37] between 5.1 and 5.7 g/100gDM. The differences may be due to the ripeness stage of harvest, the incidence of the soil, variation of the incineration time and temperature, and climatic conditions.

As compared to other values of different authors, there is variability in the carbohydrate contents as compared to the 43.08 g/100gDM obtained. Ibrahima *et al.* [34] obtained values that range from 26.1 to 71.7 g/100gDM and Murray *et al.* [32] had values that were higher than 35.6 g/100gDM. The sugar content of 25.91% was higher than those of Ibrahima *et al.* [34] (16.6%); Soloviev *et al.* [33] (7.2 to 11.2%) but similar to those of Nour *et al.* [36]. Therefore, the higher the carbohydrate content the lower the amount of sugar present, which is responsible for the sweet taste of the baobab pulp. The sugar variation is a result of the maturity of the fruits, the environment, soil, climatic conditions, etc. It is worth noting that these carbohydrate content were within the range of 37.00 and 88.60 g/100gDM of the European Union evaluation [30].

The calcium content in the flour was 278.54 ± 0.05 mg/100gDM and this value was lower than those of Monteiro *et al.* [47] (2938 – 3797 mg/100gDM). The calcium content is a natural source of calcium for supplementation of foods for children, pregnant and lactating women, and the elderly because it is an essential mineral for bone functioning and structure ([37, 48]. Such a high value makes baobab pulp flour a suitable source of calcium for fortification.

Vitamin C plays an important role in protection against oxidative stress on various tissues [49, 50]. Vitamin C values of 17.22 mg/100gDM were found to be lower than those obtained by Ibrahima *et al.* [34] (60 to 138 mg/100gDM), [51] (300 mg/100gDM) and Monteiro *et al.* (2022)[47] (163.8 – 288.9 mg/100gDM). This difference is attributed to climatic conditions, the type of soil, the intensity of the sunlight used in its drying stage, and its storage conditions as vitamin C is very sensitive to light and heat.

3.2. The Proximate Composition of Biscuit Blends

The different biscuit formulations were analysed for their moisture, lipid, protein, fiber, ash, total sugar contents and their caloric value. The outcome of the proximate composition is presented in table 3.

Table 3. *Proximate composition of biscuit blends (g/100g DM).*

Sample (WF: BPF)%	Moisture Content	Lipid Content	Protein Content	Fiber Content	Ash Content	Carbohydrate Content	Total Sugars	Caloric Value (Kcal/100g)
B1 (100: 0)	3.10±0.04^{abc}	45.66±0.36^{a}	10.93±0.07^{a}	1.27±0.05^{a}	3.45±0.13^{a}	35.59±1.05^{d}	17.36±0.00^{a}	597.02±0.72^{g}
B2 (95: 5)	5.31±0.58^{c}	46.41±1.04^{ab}	11.89±0.04^{b}	5.42±0.02^{b}	4.58±0.20^{b}	26.39±0.96^{cd}	27.53±0.00^{b}	570.81±0.59^{c}
B3 (90: 10)	4.46±0.61^{abc}	47.75±0.38^{bc}	12.36±0.04^{c}	5.94±0.11^{bc}	5.21±0.09^{c}	24.24±1.01^{c}	30.64±0.00^{c}	576.31±0.63^{e}
B4 (85: 15)	2.28±0.40^{a}	47.59±0.74^{bc}	13.51±0.04^{d}	6.70±0.01^{c}	6.35±0.06^{d}	23.57±0.99^{c}	33.87±0.00^{d}	576.63±0.18^{f}
B5 (80: 20)	3.93±0.84^{abc}	48.86±0.93^{cd}	14.70±0.41^{e}	7.92±0.15^{d}	6.69±0.14^{d}	17.90±1.00^{bc}	42.54±0.00^{e}	570.14±0.80^{a}
B6 (75: 25)	2.78±0.49^{ab}	49.94±0.84^{d}	15.53±0.08^{f}	8.59±0.05^{e}	7.20±0.10^{e}	15.96±1.00^{b}	44.97±0.00^{f}	575.42±1.42^{d}
B7 (70: 30)	2.88±2.33^{bc}	51.83±1.48^{e}	15.16±0.04^{f}	11.75±0.15^{f}	7.57±0.12^{e}	10.81±0.99^{a}	53.19±0.00^{g}	570.35±0.05^{b}

Means with different superscript letters in the same column are significantly different at $p<0.05$.

Moisture content decreased with increasing levels of BPF. The biscuits recorded values ranging from 2.88 to 5.31g/100gDM. This low moisture content of the biscuits was due to the efficiency of the drying process [52]. The Moisture of the biscuits was within the recommended range of 0-10% for storage of biscuits [53]. The results obtained were similar to the findings of Agu and Okoli [54] who found that the moisture content of biscuits decreased with the addition of beni seed and unripe plantain flour at different levels to wheat flour.

The Protein content ranged from 10.93 to 15.16g/100 gDM, lipids 45.66 to 51.83 g/100gDM, and 35.59 to 10.81 g/100gDM for carbohydrates. The high protein content is similar to those reported by Barakat, [31]. Growth and repair of worn-out tissues in the body are addressed by proteins hence the high protein content of the biscuits as a result of the BPF enrichment will go a long way to addressing protein deficiency in school children.

The total mineral content in food can be estimated as ash content which is an inorganic residue that remains after organic materials are burnt out hence the more the mineral content, the higher the ash content [55]. The higher ash content of a food item shows a high mineral content. Therefore the addition of BPF to each biscuit sample greatly influences the increase in ash content because baobab pulp has higher mineral content. As a result of the high mineral content of the BPF, it resulted in very high nutritive biscuit blends. The high mineral content of the BPF in the biscuit blends recorded made it suitable for potential exploitation in combating some mineral deficiencies.

There was a decrease in the carbohydrate content of the biscuits with the addition of BPF with B7 having 30% carbohydrates. BPF addition has the lowest carbohydrate. Available carbohydrate was significantly higher in the control than in the biscuit blends. The substitution of WF with BPF up to 30% significantly altered the moisture, crude protein, crude fat, and ash and fiber content.

The quantity of total sugars (17.36 - 53.19 g/100gDW) increased significantly with the addition of baobab contrary to caloric values which decreased with an increase in Baobab. The reason for the increase in sugars is in line with the findings of Airan and Desai [56], which showed that baobab contains saccharose, fructose, and glucose, responsible for pulp sweetness. The baobab fruit pulp is known to be dry, acidulous, mealy, and rich in mucilage, pectins, tartarate, and free tartaric acids but not in carbohydrates. Baobab is not as rich in carbohydrates as wheat which may be the cause of the decrease in energy levels with increased baobab.

3.3. Mineral Composition of Biscuit Blends

All biscuit samples of the different blends were analysed for their mineral content and the results are presented in table 4.

Table 4. *Mineral composition of biscuit blends (mg/100g DM).*

Sample (WF: BPF)%	Calcium Content	Magnesium Content	Iron Content
B1 (100: 0)	88.88 ± 2.65[a]	79.06±0.72[a]	2.29±2.34[a]
B2 (95: 5)	350.19 ± 3.52[b]	80.81±1.59[a]	3.09±6.96[ab]
B3 (90: 10)	398.17 ± 4.00[c]	89.91±3.53[b]	3.92±2.49[ab]
B4 (85: 15)	455.79 ± 39.65[d]	99.63±2.14[c]	4.21±5.11[b]
B5 (80: 20)	503.19 ± 11.58[e]	97.40±1.87[c]	4.54±0.25[b]
B6 (75: 25)	627.86 ± 8.26[f]	103.14±1.32[d]	5.19±4.27[c]
B7 (70: 30)	751.90 ± 4.89[g]	105.65±0.15[d]	6.03±0.01[d]

Means with different superscript letters in the same column are significantly different at $p<0.05$.

The mineral content increased with increasing quantities of BPF. Biscuits with 30% BPF had the highest calcium and iron content. The biscuit blends contained higher content of calcium (350.19 – 751.90 mg/100gDM), and magnesium (79.06 - 105.65 mg/100gDM) when compared with the WF biscuit. Also, the Fe content was higher (3.09 - 6.03 mg/100gDM) in the biscuit blends than in the pure wheat flour biscuits. This corroborates the findings of Sena *et al.* [39] and Osman, [41] where the baobab fruit pulp was found to contain iron and is relatively a poor source of manganese, but contains exceptionally high levels of calcium. The high calcium content of the fruit pulp makes baobab fruits a natural source of calcium for pregnant and lactating women, as well as for children and the elderly because it helps in the strength and rigidity of bones as well as tooth [41, 57]. Substituting WF with BPF at up to 30% level significantly increased the content of calcium, Magnesium, and iron, thus correlating with the findings of Barakat, [31].

The results obtained demonstrated that WF enriched with BPF within the range of 5–30% could modified the macro and microelement profile with significant increases in calcium, magnesium and iron contents to improve the nutritional profile and the desired health attributes [58].

3.4. Antioxidant Activities of Biscuits

The free radical scavenging potential (DPPH test) and the total reducing power (FRAP assay) of the biscuits were evaluated and the results are presented in table 5.

Table 5. *DPPH radical scavenging activity and total reducing power.*

Sample (WF: BP)%	DPPH radical scavenging activity (%)	TOTAL REDUCING POWER (mgAAE/gDM)
B1 (100: 0)	28.17 ± 8.17[a]	19.44 ± 3.72[a]
B2 (95: 5)	47.62 ± 3.38[b]	48.91 ± 1.57[b]
B3 (90: 10)	65.87 ± 2.38[cd]	73.43 ± 0.48[cd]
B4 (85: 15)	67.06 ± 1.65[cd]	79.98 ± 1.25[cd]
B5 (80: 20)	69.25 ± 1.60[cd]	87.53 ± 1.38[d]
B6 (75: 25)	73.41 ± 2.60[d]	91.15 ± 1.22[e]
B7 (70: 30)	79.96 ± 1.87[d]	91.33 ± 2.27[e]

Means with different superscript letters in the same column are significantly different at $p<0.05$.

The DPPH radical scavenging activity of the biscuits ranged from 28% to 79%. The addition of baobab increased the DPPH scavenging ability, which correlates with the findings of Tembo *et al.,* [59] who showed that baobab fruit possesses potential antioxidant properties that have been attributed to its bioactive compounds such as polyphenols and ascorbic acid [60, 61]. The antioxidant capacity of the biscuit blends was also demonstrated by their Ferric Reducing Antioxidant Power (FRAP). The biscuits reduced Fe^{3+} to Fe^{2+} with values ranging from 48.91 to 91.33 mgAAE/gDW. The reducing ability increased with an increase in WF substitution with BPF.

3.5. Physical Characteristics of Biscuits Blends

The results of the physical characteristics (Table 6) evaluated were the biscuit diameter, thickness, spread ratio, mass, hardness, friability, and water absorption capacity (WAC).

Table 6. *Physical characteristics of biscuit blends.*

Sample (WF: BP)%	Diameter (cm)	Thickness (cm)	Spread Ratio	Mass (g)	Hardness (N)	Friability Index (%)	WAC (%)
B1 (100: 0)	4.67 ± 0.15[a]	0.50 ± 0.02[a]	8.99	8.28±0.56[a]	28.08 ± 0.64[a]	4.89 ± 0.21[a]	54.72 ±1.60[a]
B2 (95: 5)	4.71 ± 0.20[ab]	0.53 ± 0.04[ab]	8.31	8.88±0.73[a]	29.11±6.32[ab]	6.58 ± 3.02[b]	59.60±0.04[b]
B3 (90: 10)	4.86 ± 0.13[b]	0.52 ± 0.05[a]	8.53	9.40±1.35[ab]	27.89 ± 3.73[a]	9.04 ± 2.46[c]	61.21±0.45[bc]
B4 (85: 15)	4.76 ± 0.13[ab]	0.52 ± 0.06[a]	8.85	8.90±1.88[a]	30.21 ±1.82[b]	11.86 ± 1.04[d]	62.70±0.40[bc]
B5 (80: 20)	4.72 ± 0.11[ab]	0.52 ± 0.03[a]	9.29	9.81±0.81[b]	31.34 ±1.19[b]	14.81 ± 6.80[e]	64.16±1.09[c]
B6 (75: 25)	4.72 ± 0.09[ab]	0.53 ± 0.04[ab]	9.03	9.53±0.72[ab]	34.07 ±1.99[b]	22.02 ± 3.53[f]	67.46±0.52[d]
B7 (70: 30)	4.76 ± 0.15[ab]	0.54 ± 0.07[ab]	9.17	9.40±1.86[ab]	37.23±0.96[c]	28.15 ± 2.75[f]	73.31±3.77[e]

Means with different superscript letters in the same column are significantly different at $p<0.05$.

The mass and diameter of the biscuit blends follow the same trend, where an increase in BPF increased the physical parameters. The weight ranged from 8.88 to 9.40g for B2 and B7 respectively. The high dietary fiber content of BPF may be attributed to the high mass observed in the BPF sample.

As the level of BPF increased there was an increase in water absorption capacity due to high water-absorbing fiber content compared to sugar content. An increase in fiber content retarded the spreading of biscuits thus reducing the diameter hence increase the thickness of biscuits [62].

There was a significant increase in the hardness of biscuits from 28.08N to 37.23N with increasing levels of BPF in biscuits. The hardness of biscuits is affected by both flour composition and the interactions among the ingredients [63]. A greater protein level may form a harder structure as a result of strong adherence between proteins and starch [64]. Hoseney and Rogers [65] reported that the hardness of biscuits is caused by the interaction of protein and starch thus the effect of hydrogen bonding.

The friability index helps to determine how much mechanical stress a product can withstand during handling by consumers. There was an increase with the addition of BPF. Adding 5 to 30% of BPF increased the WAC from 59.60 to 73.31%. This may be due to the high protein and mucilage contents reported in baobab pulp [66, 67]. A gradual increase in water absorption capacity, which was highest in 30% BPF, was possibly due to the rich content of pectin, minerals, and fiber (Calcium/Iron: 751.90±4.89/6.03±0.01 mg/100gDM) and fiber 11.75±0.15 g/100g DM)) in BPF [35, 41, 68].

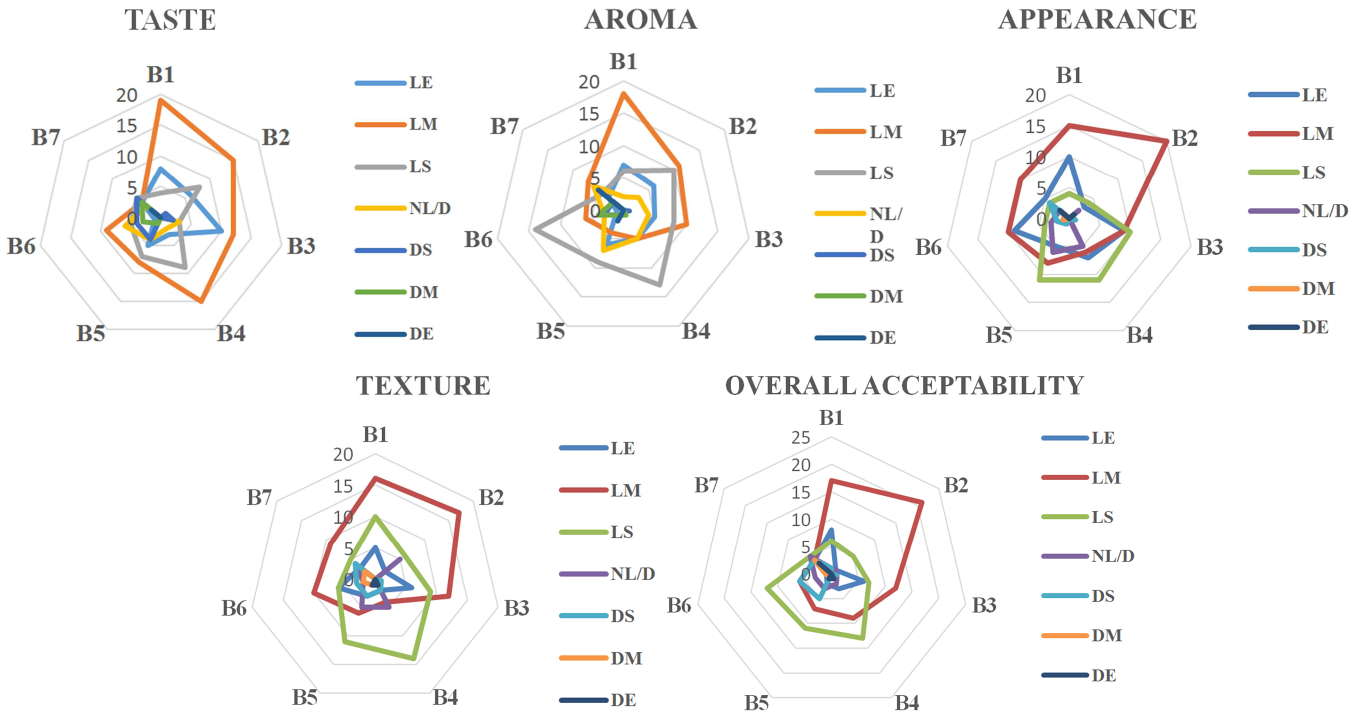

Figure 2. *The Appreciation of the taste, aroma, color, texture and overall appreciation of the biscuits.*

3.6. Sensory Properties of Biscuit Blends

Sensory evaluation indicated significant differences between WF biscuits and WF + BPF biscuits (biscuit blends) in all organoleptic characteristics when substituting with a high level of BPF with distinguished taste. However, improvement in taste using 5% to 15% BPF was recorded, even though adding BPF at even a low level can enhance some of the organoleptic properties [69]. Adding 5–10% of BPF did not drastically affect the organoleptic characteristics of these biscuits. Adding 15% (with more than 67% of panelists loving the biscuits ≤15% BPF addition) was still acceptable, but using high substituting levels (with less than 33% of panelists loving it) did not only affect the organoleptic characteristics slightly but also influenced the rheological properties [70, 71]. Contrary to that, Mounjouenpou *et al.*, [72] showed that the incorporation of BPF at 20% improved the sensory and nutritional qualities of rice cookies.

Fellows [73] reports that the taste of food is affected more by formulation than processing, and biscuit taste is mainly affected by composition than the baking parameter. With this, there was a significant difference in the taste of the various blends of biscuits, especially when compared to the WF biscuits. Panelists showed a preference for B1, B2, and B4 with 0, 5, and 15% substitution with BF respectively in terms of taste. For Aroma, the addition of BPF increased the aroma. Panelist preference showed no significant difference in the aroma of all the biscuit blends but for the WF biscuit and samples B4 and B6 with 20 and 25% substitution with Baobab.

Sample B2 which is the 5% substitution with baobab biscuit blend had the highest score for appearance while sample B7 (30% substitution) had the lowest. The appearance which was visualized revealed that the panelists showed a preference for the sample with a light color (sample B2). The browning appearance of the biscuit could have been a result of the Maillard reaction [74], which is a reaction between sugars, proteins, amino acids or caramelization, and severe heating during processing [75]. The acceptance level of the biscuit appearance decreased with increasing quantities of BPF.

There was a significant difference ($p<0.05$) between the texture of the zero baobab biscuit and the biscuit blends. In terms of texture, the panelist showed a preference for Samples with 0, 5, and 15% baobab (B2, B1, and B4). Product texture is an essential attribute in consumers' examination and buying judgment. The crunchiness of the biscuits was not significantly different in all the samples.

The overall acceptability of the biscuit blends was significantly different and varied between Samples B1 to B7 with the most accepted biscuit blends being B2 and the least accepted being B7. The baobab pulp is acidic due to the presence of organic acids including citric, tartaric, malic, succinic as well as ascorbic acid [56] which is most probably the reason why panelist preference was 5% BPF (sample B2). Nutritionally the 5% BPF addition had the lowest amount of nutrients while that of 30% was the richest. With that and in the fight against calcium deficiency in children and the population as a whole, the best biscuit is chosen in regards not only to the organoleptic properties but also the nutritional properties should be taken into consideration.

4. Conclusion

Incorporating BPF in WF for biscuits production increased the macro and micro-nutrient contents. To valorise the baobab fruit, it can effectively be used to enrich staple foods. BPF enhanced the calcium content of biscuits as a tool to combat micronutrient deficiencies.

This study also revealed that all the biscuit blends had improved nutritional quality and antioxidant ability, especially sample B7 (70%WF and 30%BPF) but the panelist preferred B2 (95%WF and 5%BPF) since there were no effects on the rheological and organoleptic characteristics. Rheological and Organoleptical in the sense that more than 67% of panelists loved the texture, flavour, taste, appearance, and overall acceptability as compared to the other biscuit blends. Though sensory evaluation showed that the panelists preferred sample B2 (95%WF and 5%BPF), all samples can still be used in the fight against calcium deficiency.

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