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Nutritional Composition and Sensory Evaluation of Cake Fortified with *Moringa oleifera* Leaf Powder and Ripe Banana Flour

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Abstract: Micronutrient deficiency is raising concern worldwide, especially among children and pregnant women in Africa, Southern Asia, and certain developing countries, posing a significant risk to the nutritional status. This study aimed to develop cake fortified with *Moringa* leaf powder (MOLP), ripe banana flour (RBF) and assessed the effect of MOLP and RBF on the nutritional composition as well as consumer acceptability. The nutritional, mineral, vitamin A and sensory attributes of MOLP and RBF fortified cakes were assessed. Proximate analysis results showed that the addition of MOLP and RBF significantly increased from 5.79% to 8.90% for protein, 1.25% to 1.66% for ash, 2.70% to 6.98% for fiber, and 53.0% to 60.88% for carbohydrate. However, the fat and moisture content decreased from 20.16% to 13.06% and 17.77% to 13.54%, respectively. The mineral contents (phosphorus, potassium, iron, and zinc) increased significantly in the fortified cake compared to the unfortified control. The vitamin A content (3.40–5.62 mg/100 g) of the fortified cakes was significantly (*p* < 0.05) higher than the vitamin A (1.62 mg/100 g) content of the unfortified cake. Although MOLP and RBF substitution raised most of the nutritional contents, the maximum consumer acceptability was recorded in the unfortified control, which was statistically similar to C2 (1.5% MOLP and 2% RBF) substitution in terms of shape, sweetness, flavor, mouth feel, and overall acceptability. The results indicated that cake supplemented with 1.5% MOLP and 2% RBF provided the enriched nutritional quality and potentially contributed to the improvement of food and nutritional security of the vulnerable populations. Furthermore, utilizing ripe bananas with peels in cake recipes will help to encourage the recovery of food waste for functional food preparation.

Keywords: food fortification; *Moringa* leaf powder; malnutrition; food security; sensory evaluation

1. Introduction

Snacking is a vital pattern of consumption that supports meeting the daily nutritional needs of children, which substantially contributes to healthy growth and development [1]. Processed snacks are primary nutrient sources, viz. energy, protein, iron, calcium, and vitamins. In low and medium-income countries in Asia, Latin America, and Africa, processed snacks are becoming increasingly popular [2]. The consumption of snacks in South Africa was reported to increase by 53.3% from 1992 to 2012, especially among children [3]. Among the snacks, cakes are one of the most popular bakery items consumed by nearly all classes of people due to their ready-to-eat nature and availability in various types at an affordable price [4]. Currently, baked cakes are an essential part of preschoolers’ diet to meet their nutritional demand alongside staple food. Traditional cakes are usually prepared from wheat flour, added sugar, eggs, and baking powder [5]. However, this type of cake is high
in sugar and rich in carbohydrates and fat but low in other nutrients, including protein, minerals, and vitamins [6]. Furthermore, the World Health Organization (WHO) reported snacks with high sugar and fat content as unhealthy [7]. In this context, the demand for functional food with higher nutrients and minerals has risen. Micronutrient deficiencies are most prevalent in Sub-Saharan Africa and Southern Asia, especially in women and young children [8]. Several studies reported that about 16 million children are malnourished worldwide, with 2.3 million children in South Africa having stunted growth and nutritional deficiencies [8]. The use of locally available, inexpensive, and nutrient-rich plant materials in cake formulations must be recognized and promoted to enhance health and nutritional safety in that particular region.

Moringa (*Moringa oleifera* Lam.) is an Indian subcontinent native plant that naturalized itself worldwide in tropical and subtropical regions [9]. Moringa is one of the most beneficial trees globally since nearly every portion of the tree can be used for food, medicines, and industrial purposes [10]. Although the leaves, flowers, and pods are used as vegetables, the tree has tremendous potential to enhance nutrition, increase nutritional safety and promote rural development [11]. Traditionally Moringa leaves have been used for human consumption in African countries for centuries [12]. These leaves are excellent as a source of vitamins A, B, and C and are known as one of the best plant mineral and iron sources [13]. *Moringa* leaf was also reported to contain a high amount of protein (28.25%), iron, calcium, phosphorous, magnesium, manganese, and zinc [14]. Moreover, *Moringa* leaf was reported to have a high content of essential amino acids, alpha-linoleic acid and a wide range of dietary antioxidants [15]. *Moringa* leaf is rich in phenolic compounds (e.g., phenolic acids, flavonoids, etc.). The anti-oxidative functionality of these compounds makes Moringa a promising natural additive that can be applied to foods for enhancing human nutrition [16]. Many studies have reported the potential use of Moringa leaves in making diverse food such as soups, weaning food, herbal biscuits, bread, and yogurt [15]. Thus, the idea was born of fortifying the *Moringa* leaf with other ingredients, such as banana flour; to prepare a food with a better nutritional composition can increase its consumption among different populations with improved nutritional safety [16].

In addition, Banana (*Musa* sp.) is one of the versatile tropical fruits that occupy a prominent position among tropical fruits for its nutritional and economic benefits. Bananas are rich in carbohydrates, vitamins (i.e., A, B6, C), and potassium, are an excellent source of dietary fiber, and are used as a first solid for infants in many parts of the world [17]. Soluble fibers present in bananas minimize the risk of colon cancer [18,19]. However, tonnes of banana peels, which render 30–40% of the banana’s total fruit weight, are generated as household and industrial waste due to the extensive use of banana pulp only [20]. It has been widely reported that banana peels also contain nutrients, dietary fiber, protein, polyunsaturated fatty acids, and essential amino acids [21]. Additionally, the banana peel contains higher phenolic compounds than other fruits representing antioxidant properties and making banana peel a higher potential for new food product developments [22,23]. Therefore, flour produced from whole bananas with peel can potentially offer both new food products with improved nutritional content and minimization of waste.

Banana flour can be ideal as a substitute with certain bakers because of the high content of pure sugars in mature banana flour [22]. Therefore, with the addition of non-starch polysaccharides and polyphenols, it is possible that flour obtained from mature bananas may show comparable functionality to sucrose in cake making while enhancing its nutritional properties [24]. Since banana flour contains highly useful compounds, including nutritional fiber fractions, it has a high potential for food and functional food preparation.

The prevailing literature provides us with insights regarding the chemical components and the economic, nutritional, and medicinal value of the plant; however, the inadequacy of studies regarding the tolerable limit of fortification demands further research. Moringa leaves and banana, both individually and fortified in a food item, have enormous potentials to meet the nutritional demand in developing and underdeveloped countries, where high-value animal protein and fruits are beyond the reach of impoverished people. However,
a fortificant inclusion of Moringa in various food items in a proportion that the taste remains intact and the nutritional value increases exponentially is still a challenging issue. Therefore, the current research was conducted to determine the proximate composition of the cake fortified with Moringa leaf powder and ripe banana, along with a sensory evaluation to justify consumer acceptability for improving food and nutritional security.

2. Materials and Methods

2.1. Preparation of Moringa oleifera Leaf Flour

Mature green and disease-free Moringa oleifera leaves were collected from a farmer’s field in Chittagong, Bangladesh. The harvested leaves were scrubbed and spread on a sheet with even thickness at room temperature for initial drying. Afterward, the leaves were dried at 50 °C for 10 h in a laboratory oven. The dried leaves were milled using a laboratory miller and sieved (1 mm sieve size). The leaf flour was then packed and stored at room temperature for further analysis. The chemical composition of Moringa leaf flour is presented in Table 1.

<table>
<thead>
<tr>
<th>Nutrition Value</th>
<th>Content (g/100 g Dry Matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g)</td>
<td>7.88</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>5.95</td>
</tr>
<tr>
<td>Acid insoluble Ash (g)</td>
<td>0.58</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>2.75</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>28.01</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>23.24</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>25.61</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>1231</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1875</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>55.41</td>
</tr>
<tr>
<td>Calories (cal)</td>
<td>358.43</td>
</tr>
</tbody>
</table>

2.2. Preparation of Whole Ripe Banana Flour

Mature green Banana Musa acuminate (called Sagarkola in Bangladesh) was harvested directly from farmers’ fields at Narayanganj District, Bangladesh. The banana was selected based on the degree of ripeness, color, and firmness and washed with clean water. The picked bananas with peels were cut into transverse slices of about 2 mm thickness, and slices were dipped into 0.5% (w/v) citric acid solution for 10 min. The slices were dried at 50 °C overnight on a laboratory dryer. The dried sliced were then ground, sieved, and flour was stored in sealed plastic bags for further analysis. The chemical composition of the banana flour is presented in Table 2.

<table>
<thead>
<tr>
<th>Nutrition Value</th>
<th>Content (g/100 g Dry Matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g)</td>
<td>7.95</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>6.81</td>
</tr>
<tr>
<td>Acid insoluble Ash (g)</td>
<td>0.31</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>3.75</td>
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<tr>
<td>Protein (g)</td>
<td>6.01</td>
</tr>
<tr>
<td>Fiber (g)</td>
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</tr>
<tr>
<td>Iron (mg)</td>
<td>2.61</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>875</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>19.20</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>75.48</td>
</tr>
<tr>
<td>Calories (cal)</td>
<td>359.71</td>
</tr>
</tbody>
</table>
2.3. Preparation of Sponge Cake

Wheat flour 250 g (gluten 8–9%) and other ingredients such as liquid glucose (14 g), salt (3 g), caster sugar (231 g), eggs (200 g), yeast and cake gel (10 g), water (4.45%), sodium acid pyrophosphate (SAPP) (3 g), sodium bicarbonate (1 g), and potassium sorbet (5 g) were used for cake preparation following the standard cake preparation procedure (Figure 1). At first, we measured all the components in a required amount and mixed them. Then, the liquid glucose, caster sugar, and eggs were mixed in a bowl of the mixer machine for 1 min. Then, we added the cold water and salt to a small bowl and placed it in the bowl of the mixer machine with wheat flour, cake gel, MOLP, ripe banana powder, sodium acid pyrophosphate (SAPP), sodium bicarbonate, potassium sorbet into the mixer machine and were mixed slowly at high speed for 4 min.

The specific gravity of the yeast was checked before placing it in the oven (72–75 °C). The heatproof paper in the mold was fastened and baked in the oven for 45–50 min at 145 °C. Subsequently, it was cooled it for 1 h at 18–22 °C and then sliced and packed.

Finally, the cake was termed as follows:
Cake (C0): 100% wheat flour (control)
Cake (C1): 97% wheat flour, 1% MOLP, 2% RBF
Cake (C2): 96.5% wheat flour, 1.5% MOLP, 2% RBF
Cake (C3): 96% wheat flour, 2% MOLP, 2% RBF

2.4. Determination of Moisture Content

Empty crucibles were dried for 3 h in an oven at 105 °C, cooled in a desiccator, and weighed soon after it attained room temperature. Afterward, a 5 g cake sample was taken in each dried crucible. The crucible with samples was dried in a 105 °C oven overnight, transferred to a desiccator, and weighed soon after attaining room temperature; afterward,
the moisture content of cake samples was determined following the formula described by [25].

\[
\% \text{ Moisture} = \frac{\text{Loss of the weight of the sample} (g)}{\text{Weight of the sample} (g)} \times 100 \quad (1)
\]

2.5. Determination of Ash Content

In the dry silica dish, a 5 g homogenized sample was taken and measured precisely. The sample was dried for one day in an oven at 130 °C on an electrical coil rack and then the dried sample was chipped until it was stopped smoking. The sample was then placed in a 550 °C muffle chamber and ignited until greyish or white ash was formed. The samples were cooled in desiccators and measured at room temperature immediately, and ash percentage was determined [25]. The following formula was used to calculate the percentage of ash in the sample:

\[
\% \text{ Ash} = \frac{\text{Weight of ash} (g)}{\text{Weight of sample} (g)} \times 100 \quad (2)
\]

2.6. Determination of Acid-Insoluble Ash

The acid-insoluble ash was determined based on the procedure described by [26]. A 5 g of ash sample was taken into a 50 mL ashing crucible, dried overnight at 100 °C and cooled in a desiccator. Then, ash was created through heating at 600 °C for 6 h and transferred to a 600 mL Berzelius beaker added with 100 mL of 2 N HCl. Subsequently, it was boiled for 5 min in a fiber rack, and hot hydrolysates were filtered through Whatman No. 541 paper. The filter paper was transferred back into the crucible and ash at 600 °C for 6 h. Afterward, the crucible was redried in an oven at 100 °C, cooled, and weighed. The following formula was used to determine the percentage of acid-insoluble ash in the sample:

\[
\% \text{ Acid} − \text{insoluble ash} = \frac{(\text{Weight of crucible} + \text{Ash} − \text{weight of crucible})}{\text{Sample dry weight}} \times 100 \quad (3)
\]

2.7. Determination of Crude Fiber

In a 500 mL flask, 1–3 g (W1) dried samples were taken, and 200 mL 0.255 N H₂SO₄ (reagent 1) were mixed and boiled for approximately 30 min. The hot contents were filtered through Whatman No. 541 paper into the original flask added with 200 mL of warm 0.313 N NaOH (reagent 2). Subsequently, the content was boiled for 30 min added with 2–3 drops of octyl alcohol to prevent foaming during boiling and again filtered through Whatman No. 541 paper and washed with 1% HCl (reagent 3). The content was evaporated to dryness over a boiling water bath and dried in an oven at 105 °C for 1 h. The residue and basin weight were recorded (W2). The residue was then ignited in a muffle furnace at 450 °C for 4 h, and the weight of ash and basin was recorded (W3). The following equation was used to calculate the crude fiber in the sample:

\[
\text{Crude fiber} (g) \text{ per 100 g sample} = \frac{W2 − W3}{W1} \times 100 \quad (4)
\]

where W1 = weight in g of food sample taken;
W2 = weight in g of the weight of basin + dried residue;
W2 = weight in g of the weight of basin + ash.

2.8. Determination of Fat

The fat content of the cake samples was determined according to the method described by [27] using a Soxhlet extractor and attach a weighed flask. Petroleum ether was used
as an extraction solvent for the determination of fat content. The crude fat content was calculated as follows:

\[
\% \text{ Fat in sample} = \frac{\text{Weight of residue (g)}}{\text{Weight of sample (g)}} \times 100
\] (5)

2.9. Determination of Crude Protein

The crude protein content of the cake samples was measured using the AOAC 990.033 process [27]. To measure the protein content of the cake samples, the LECO Truspec Nitrogen Analyser was used. Through an autoloader, the cake samples were mounted in a combustion chamber heated at 950 °C. The nitrogen derived from the samples was then processed into an amount of protein using a factor of 6.25 using the following formula:

\[
\% \text{ Crude protein} = \% N \times 6.25
\]

2.10. Total Carbohydrate

The carbohydrate content of the sample was determined as a total carbohydrate by subtracting the measured (protein, fat, moisture, ash) from 100. It was calculated using the following formula:

Total carbohydrate per 100 g sample: 100 − (weight in g (protein + fat + moisture + ash)).

2.11. Energy Content

The energy content of the cake was determined by calculating the amount of carbohydrate, fat, and protein, which was calculated using the following expression:

\[
\text{Energy} = (\text{Carbohydrate} \times 4) + (\text{Fat} \times 9) + (\text{Protein} \times 4)
\]

2.12. Determination of Mineral Content in Cake Samples

The mineral content of the cake (iron, potassium, phosphorus, and zinc) were measured by Atomic Absorption Spectrophotometer (Model AA-7000 Shimadzu, Kyoto, Japan) [28]. For the digestion of samples, 65% nitric acid (HNO₃) was used as a digestion sample.

2.13. Determination of Vitamin A Content

Vitamin A content of the cakes was estimated using the method described by [29]. The cake sample (5 g) was mixed with 10 mL acetone and few anhydrous sodium sulfate crystals for settling; then, the supernatant was decanted into a beaker and poured into a separator funnel. Afterward, 10 mL petroleum ether was added, well mixed, and the layers were allowed to separate. The top layer was collected in a 100 mL volumetric flask, which was then filled with petroleum ether to reach the desired volume. Using petroleum ether as a blank, the optical density (OD) of the solution was measured at 452 nm. To determine the vitamin A content, the following formula was used:

\[
\beta - \text{carotene} = \frac{\text{OD} \times 13 \times 9 \times 10,000 \times 100}{\text{Weight of sample (g)} \times 560 \times 1000} \] (6)

where OD = optical density of the solution at 452 nm

\[
\text{Vitamin A} = \frac{\beta - \text{carotene (µg/100)}}{0.6}
\]

2.14. Sensory Evaluation

Sensory evaluation of the developed cakes was performed by 30 untrained tasters who were regular cake consumers. Standard sensory evaluation technique was followed to minimize the bias, ensuring that tasters did not influence each other, as described by [30]. On the basis of appearance, color, taste, flavor, texture, mouthfeel, and overall acceptability,
the tasters rated the acceptability of samples on a 9-point hedonic scale [31]. The scale of values ranged from 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely. The 9-point hedonic scale is straightforward to use and was widely studied for sensory evaluation.

2.15. Statistical Analysis

Data generated from the chemical analysis and sensory evaluations were conducted in triplicates. The means and standard deviations (SD) were tested and subjected to analysis of variance (ANOVA). The statistical analyses were performed using the statistical software package SPSS (version 20). Mean comparisons were performed by Duncan’s Multiple Range Test (DMRT) at a level of significance \( p \leq 0.05 \) to ascertain the significance of the mean.

3. Results

3.1. Proximate Composition of the MOLP and RBF Fortified Cake

The proximate composition of the developed cake fortified with MOLP and RBF is presented in Table 3. The moisture content of the fortified cake differed significantly among the treatments and ranged from 13.54 to 17.77 g/100 g and decreased with the increased substitution level of MOLP. However, ash content and acid insoluble ash content significantly increased as the substitution level of MOLP increased. The maximum ash and acid content were recorded from sample C3, whereas the minimum was recorded from the C0 (control). A similar trend was observed from the carbohydrate and fiber content as the increasing level of MOLP, fiber, and carbohydrate content significantly increased compared to C0 (control). Conversely, an opposite phenomenon was observed regarding fat content, which showed a significant decrease as the substitution level of MOLP increased. Similarly, total calorie content also decreased significantly with the progressive increase of the level of MOLP in flour blends. The cake sample fortified with 1.5% MOLP (C2) showed maximum protein content, whereas the minimum was recorded from the unfortified control (C0).

Table 3. Proximate composition of the MOLP and RBF fortified cake.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture (g/100 g)</th>
<th>Ash (g/100 g)</th>
<th>Acid Insoluble Ash (g/100 g)</th>
<th>Fat (g/100 g)</th>
<th>Protein (g/100 g)</th>
<th>Carbohydrate (g/100 g)</th>
<th>Fiber (g/100 g)</th>
<th>Total Calories (g/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0</td>
<td>17.77 ± 0.01 a</td>
<td>1.25 ± 0.01 b</td>
<td>0.054 ± 0.002 b</td>
<td>20.16 ± 0.02 a</td>
<td>5.79 ± 0.02 a</td>
<td>53.03 ± 0.04 a</td>
<td>2.70 ± 0.01 a</td>
<td>434.73 ± 0.13 a</td>
</tr>
<tr>
<td>C1</td>
<td>16.34 ± 0.01 b</td>
<td>1.29 ± 0.01 b</td>
<td>0.054 ± 0.001 b</td>
<td>18.68 ± 0.01 b</td>
<td>6.57 ± 0.01 b</td>
<td>57.12 ± 0.01 a</td>
<td>5.48 ± 0.01 c</td>
<td>422.87 ± 0.07 b</td>
</tr>
<tr>
<td>C2</td>
<td>14.96 ± 0.01 c</td>
<td>1.61 ± 0.05 a</td>
<td>0.074 ± 0.002 a</td>
<td>16.50 ± 0.03 c</td>
<td>8.90 ± 0.02 b</td>
<td>58.38 ± 0.02 b</td>
<td>6.78 ± 0.01 a</td>
<td>417.66 ± 0.30 c</td>
</tr>
<tr>
<td>C3</td>
<td>13.54 ± 0.01 d</td>
<td>1.66 ± 0.06 a</td>
<td>0.077 ± 0.001 a</td>
<td>13.06 ± 0.01 d</td>
<td>8.81 ± 0.02 b</td>
<td>60.88 ± 0.03 a</td>
<td>6.98 ± 0.17 a</td>
<td>393.51 ± 0.06 d</td>
</tr>
</tbody>
</table>

Note: Values are means ± standard error. Treatment values in a column not sharing a letter are significantly different at \( p \leq 0.05 \).

3.2. Mineral Composition and Vitamin A Content of MOLP and RBF Fortified Cake

The mineral content of the MOLP and RBF fortified cake is presented in Table 4. The mineral content of the cake samples increased significantly with the increment of MOLP substitution in the flour blend. The maximum iron content was recorded from the cake sample C3, which was statistically similar to C2, whereas the minimum was recorded from the unfortified control (C0). In the case of potassium and phosphorus, the maximum value was recorded from the cake sample C2, whereas the minimum was recorded from the unfortified control (C1). However, maximum zinc content was recorded from the cake sample C3, which was statistically similar to that of C2, whereas the minimum was recorded from the unfortified control (C0). Vitamin A contents (3.4–5.62 mg/100 g) of the fortified cakes were significantly \( p < 0.05 \) higher in comparison to the vitamin A content of the unfortified cake (1.62 mg/100 g) (Figure 2). The graph clearly depicts that
the vitamin A content of the cake samples increased significantly with the increment of MOLP substitution in the flour blend.

Table 4. Mineral content of cake fortified with MOLP and RBF.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Iron (g/100 g)</th>
<th>Potassium (g/100 g)</th>
<th>Phosphorus (g/100 g)</th>
<th>Zinc (g/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₀</td>
<td>1.56 ± 0.02 c</td>
<td>27.04 ± 0.03 c</td>
<td>0.11 ± 0.007 c</td>
<td>0.018 ± 0.0009 c</td>
</tr>
<tr>
<td>C₁</td>
<td>10.57 ± 0.02 b</td>
<td>3027.04 ± 0.48 b</td>
<td>0.14 ± 0.007 b</td>
<td>0.024 ± 0.0005 b</td>
</tr>
<tr>
<td>C₂</td>
<td>14.00 ± 0.28 a</td>
<td>3474.10 ± 49.89 a</td>
<td>0.35 ± 0.011 a</td>
<td>0.029 ± 0.0011 a</td>
</tr>
<tr>
<td>C₃</td>
<td>14.47 ± 0.31 a</td>
<td>3534.11 ± 63.33 a</td>
<td>0.32 ± 0.009 a</td>
<td>0.030 ± 0.003 a</td>
</tr>
</tbody>
</table>

LSD 1.34  374.84  0.06  0.05

Table 5. The sensory qualities varied significantly among the cakes in terms of color, texture, sweetness, flavor, mouthfeel, and overall acceptability. However, the shape did not differ significantly among the cakes. The cake’s color changed from a light brown (control) to a dark-greenish color with the concentration of MOLP increased in the formulation. Among the cakes, maximum sweetness and flavor value was recorded from the C₂, which was significantly higher over the non-fortified control (C₀). The maximum consumer acceptability was recorded in C₂, which was statistically similar to the non-fortified control (C₀).
Table 5. Sensory attributes of cake fortified with MOLP and RBF.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Color</th>
<th>Shape</th>
<th>Texture</th>
<th>Sweetness</th>
<th>Flavor</th>
<th>Mouth Feel</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₀</td>
<td>7.40 ± 0.34 a</td>
<td>5.65 ± 0.28 a</td>
<td>6.40 ± 0.26 a</td>
<td>5.20 ± 0.32 b</td>
<td>4.20 ± 0.30 c</td>
<td>6.45 ± 0.17 a</td>
<td>7.20 ± 0.20 a</td>
</tr>
<tr>
<td>C₁</td>
<td>6.45 ± 0.26 b</td>
<td>5.50 ± 0.29 a</td>
<td>6.25 ± 0.38 a</td>
<td>5.30 ± 0.31 ab</td>
<td>5.10 ± 0.36 b</td>
<td>5.00 ± 0.32 b</td>
<td>5.85 ± 0.25 b</td>
</tr>
<tr>
<td>C₂</td>
<td>5.50 ± 0.24 bc</td>
<td>5.95 ± 0.20 a</td>
<td>5.60 ± 0.19 b</td>
<td>5.70 ± 0.22 a</td>
<td>7.60 ± 0.18 a</td>
<td>6.10 ± 0.18 a</td>
<td>6.95 ± 0.17 a</td>
</tr>
<tr>
<td>C₃</td>
<td>5.10 ± 0.29 c</td>
<td>5.40 ± 0.30 a</td>
<td>5.15 ± 0.26 c</td>
<td>4.05 ± 0.31 c</td>
<td>5.10 ± 0.32 b</td>
<td>3.95 ± 0.38 c</td>
<td>5.50 ± 0.30 b</td>
</tr>
<tr>
<td>LSD</td>
<td>0.16</td>
<td>0.16</td>
<td>0.15</td>
<td>0.18</td>
<td>0.20</td>
<td>0.19</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Note: Values are means ± standard error. Treatment values in a column not sharing a letter are significantly different at p ≤ 0.05.

4. Discussion

Fortification of food is widely practiced in several foods to increase the content of essential micronutrients, to enhance the nutritional quality of the food, and to ensure higher health benefits with minimal risk to health [32]. However, it is imperative to ensure that thefortified food and fortificant must be compatible, and the fortificant must be readily available and accessible without producing a substantial change in the fortified meal’s sensory characteristics or consumer acceptability. Under the current experiment, locally available MOLP and RBF were used as fortificant to develop fortified cake, and their nutritional, sensory evaluation, and consumer acceptability were assessed. The cakes became darker in color than the unfortified cake with the increase of MOLP concentration in the formulations (Figure 3). The darker color was expected with the addition of MOLP in the formulations, as Moringa leaves contain higher concentrations of chlorophyll [33] and are naturally dark green in color, which causes the undesirable green tint in the fortified cakes. A similar color change trend was also reported in several studies in cookies and snacks due to the chlorophyll concentration of the leaves used for fortification [34,35]. This dark color can adversely affect the acceptability of the MOLP-fortified cake by consumers, as it is more attractive in terms of appearance. However, nutritional and other sensory attributes of MOLP fortified cake may outweigh that limitation as people are more concerned today about health benefits rather than appearance.

![Figure 3](image-url)

**Figure 3.** Cake (C₀): 100% wheat flour (control); Cake (C₁): 97% wheat flour, 1% MOLP, 2% RBF; Cake (C₂): 96.5% wheat flour, 1.5% MOLP, 2% RBF; Cake (C₃): 96% wheat flour, 2% MOLP, 2% RBF.

The proximate composition of MOLP-fortified cake represented in Table 1 shows that fortification with MOLP has significantly increased the cakes’ protein, fiber, and ash content. The increment in the protein content of the fortified cake may be the reason that Moringa leaves are exceptionally rich in protein content [36]. In agreement with our study, [15] reported that bread samples fortified with MOLP showed a 17–88% increment...
in protein content. Fiber content ranging from 5–9% is considered nutritious [37]. The fiber content of our fortified cake increased dramatically from 5.48% to 6.98% as compared to the unfortified one. This can undoubtedly be attributed to the high fiber content of 6.00–9.60% for MOLP and RBF [18,33,37]. High fiber content further provides numerous health benefits such as maintenance of bowel integrity, lowering blood cholesterol, and controlling blood sugar levels [38,39]. As a result, consuming MOLP-enriched cake may offer an adequate quantity of fiber to the body for normal digestive and excretory system function. The Moringa leaves contain higher ash content [36], which reasonably resulted in the increment in ash content of the fortified cakes. Consistent with our studies, [40] reported higher ash content of 1.7–2.6% for cookies fortified with dried MOLP. The absorbance efficiency and digestibility of food were measured using acid-insoluble ash [41]. In the fortified cakes, the acid-insoluble ash level was considerably higher than the unfortified control, which can potentially improve consumer digestibility.

The fat content of our MOLP and RBF fortified cake decreased from 20.16% to 13.06%, with the increased level of MOLP in the formulations. The inclusion of MOLP and RBF in the formulations may have resulted in an overall reduction in the fat content of the cakes. Moringa leaves and ripe bananas contain a lower level of fat, which may facilitate shelf stability of a food product, minimizing rancidity development [42]. The considerable rise in carbohydrate content (57.12% to 60.88%) with increased MOLP replacement in the cake blend indicates that the cake’s carb index is preserved. This may be due to the reason that RBF and MOLP contain a substantial amount of carbohydrates [43,44]. However, contradictory results were also reported where fortification with Moringa, wheat, and soy flour mixture decreased the carbohydrate content with the increased level of Moringa in the flour blend [45]. Such fluctuations in the quantity of carbohydrates in the cakes may occur, owing to the variations in the chemical composition of the fortificants and level of fortification. The relatively low moisture contents (16.34–13.54%) of the fortified cakes compared to the control (17.77%) indicate that the cakes fortified with the greater MOLP will not be as soft as the unfortified cakes. However, the fortified cakes will have a longer shelf life and can be stored for a more extended period than unfortified cakes, as their moisture content is comparatively low. Conversely, this also implies that the MOLP and RBF fortified cakes will not be as fluffy as the unfortified cake.

The significantly higher amount of minerals in the fortified cakes in comparison to the unfortified cake may be due to the high contents of essential minerals in Moringa leaves and ripe bananas. A plethora of research reported that Moringa leaves and ripe bananas are rich in essential minerals for human growth and development [43,46–48]. The iron concentration significantly increased with the increasing level of MOLP in the flour blend. This was expected, as Moringa leaves and ripe banana contain a high iron amount [49,50]. The iron content recorded in the fortified cakes aligns with the results obtained from several types of research, which also reported a substantial increase of iron to contend with the addition of MOLP [13,51,52]. Potassium and phosphorus, which is vital for controlling heartbeat and blood pressure, were found significantly higher in the fortified cakes than nonfortified cake. This may be due to the addition of MOLP and RBF, which contains a higher concentration of phosphorus and potassium [17,48]. Good nutritional intake of zinc is important for normal sperm cell development and is required for DNA and RNA synthesis [53]. Our current study found higher zinc concentration in the fortified cakes compared to the nonfortified cake, which is consistent with the earlier study that reported that Moringa leaves contain 25.5–31.03 mg of zinc/kg, which is the daily dietary zinc requirement [54]. Moreover, the increased vitamin A concentration in fortified cakes may also be attributed to the greater vitamin A content of MOLP and RBF compared to unfortified cakes. It has been reported that dried leaves of Moringa contain 10 times higher vitamin A than carrots [46], whereas RBF is reported to have 1680 to 10,630 µg/100 g FW pro-vitamin A carotenoids in ripe fruit [55,56].

Overall, the sensory assessments indicated that the control cake sample had the highest consumer acceptance compared with their respective cake samples containing MOLP and
RBF. The lower consumer acceptance value may be due to the darker color of the fortified cakes. These findings are consistent with earlier research, which indicated a small reduction in overall acceptability as MOLP increased [51,57]. However, the cake fortified with 1.5% MOLP rated similar in almost all the sensory attributes evaluated, which is also statistically similar to that of the unfortified control. This study’s findings are comparable to [58], who found that cookies containing 1% Tulshi and MOLP were marginally more acceptable than the control. Food products supplemented with MOLP were generally acceptable, according to [59] and [60], but reported acceptance dropped dramatically as MOLP concentrations were increased to 8% or more for cakes. However, for customers who prefer light brown cakes, the darkening effect of MOLP can be mitigated by adding a lightening agent to the dough along with the MOLP and RBF.

5. Conclusions

Fortification of cake with MOLP and RBF collectively resulted in enhanced nutritional, mineral, and vitamin A contents of the fortified cake. Sensory evaluation of the study revealed that the acceptability of the snacks decreased as MOLP concentration was increased, but the cakes containing 1.5% MOLP + 2% RBF were almost as acceptable as the control. The study also found that fortifying cake with MOLP resulted in a significant increase in protein content, which may benefit developing nations where many people cannot afford high animal protein diets due to their high cost. Furthermore, the MOLP- and RBF-enriched cake’s high vitamin A content may help developing countries combat vitamin A deficiency. Overall, the research demonstrates that fortifying cakes with 1.5% MOLP and 2% RBF can enhance nutrient content and contribute to better food and nutritional security. Moreover, using ripe banana with peel in cake preparation will aid in promoting the recovery of food waste for synthesizing value-added food commodities.


Funding: This research received financial support from Universiti Malaysia Sabah Niches Grant Project code: DN20082.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets generated during and/or analysed during the current study is available from the corresponding author on reasonable request.

Acknowledgments: All the authors would like to express their sincere thanks to the Department of Food Science and Engineering, German University Bangladesh, SGS Bangladesh Limited, Modern Food Testing Laboratory, Chittagong City Corporation and Universiti Malaysia for providing research facilities and funding.

Conflicts of Interest: The authors declare no conflict of interest.

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