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Research Article

Effects of Dehydrated Moringa (*Moringa oleifera*) Leaf Powder Supplementation on Physicochemical, Antioxidant, Mineral, and Sensory Properties of Whole Wheat Flour Leavened Bread

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Moringa (*Moringa oleifera*) has excellent nutritional significance as well as medicinal and therapeutic benefits, such as antidiabetic, anticancer, antimicrobial, and antioxidant activities. Whole wheat flour (WWF) is associated with a reduced risk of cancer (colon cancer), constipation, obesity, cardiovascular diseases, and type 2 diabetes. In this regard, the objective of the study is to determine the chemical composition, nutritional value, and antioxidant activity of moringa leaves and their MLP containing snack food (bread) to make a strong recommendation for their consumption in a balanced diet. The present study was aimed at assessing the effects of dehydrated moringa leaf powder (MLP) supplementation at 0–10% MLP levels on proximate, antioxidant, mineral, and sensory quality attributes of WWF leavened bread. Further, these quality attributes for MLP and WWF were also analyzed individually. As compared to WWF, MLP exhibited significantly higher ($p < 0.05$) antioxidant activities, such as DPPH activity ($10.38 \pm 0.25\,\mu$mol TE/g DW), FRAP activity ($21.43 \pm 0.08\,\mu$mol TE/g DW), and total phenolic content (2.33 ± 0.04 mg GAE/100 g DW). MLP-supplemented bread exhibited significantly improved proximate, antioxidant, and mineral profile. It was evident from the proximate and sensory analysis that there was significant improvement in the nutritional composition of MLP-supplemented leavened bread; however, the overall acceptability scores of WWF leavened bread showed gradually decreasing tendency with corresponding rises in the addition levels of MLP. Based on results, it was implied that maximum acceptability was exhibited by the sample T_2 supplemented at MLP addition level of 5%. Moreover, the nutritional, mineral profile, and antioxidant profile of the supplemented bread were significantly improved owing to MLP addition, and it may be implied that MLP could be exploited for improving the nutritional status of people in underdeveloped and developing countries.

1. Introduction

Wheat (*Triticum aestivum*) is a staple food and one of the most popular cereal crops around the world [1]. In terms of nutritional value, wheat is also a rich source of carbohydrates, proteins, and vitamins [2]. Wheat has vital economic and nutritional significance owing to the excessive consumption of cereals in formulating animal and human diets [3]. Wheat is a major cereal crop belongs to the genus *Triticum* and the grass family named *Poaceae*. It contributes to 30% of total cereal production in the world. Wheat is also employed as a staple food in Pakistan and other South Asian countries, such as India, Bangladesh, Sri Lanka, and Nepal. It is a major source of energy for most of the population fractions in various regions of the world [4].

Whole wheat flour (WWF) is associated with a reduced risk of cancer (colon cancer), constipation, obesity, cardiovascular diseases, and Type 2 diabetes [5]. Gluten is the major protein found in wheat, which makes it an ideal candidate as a flour ingredient for the production of baked goods, bread, pasta, noodles, and a range of other cereal products [6]. Wheat flour exhibits high antioxidant properties, which gives it the potential to alleviate oxidative stress and help in delaying the onset of chronic diseases. In Pakistan, intake of dietary fiber is not up to standards and, resultantly, children remain dependent on snack foods lacking essential nutrients in their nutritional profiles [7].

Wheat is a potential source of carbohydrates and energy in the human body, and wheat provides different macronutrients and micronutrients necessary for maintaining optimal health. Moreover, the different wheat processing techniques significantly reduce the essential nutrients and nutritive value of wheat and wheat products. Increasing food cost is one of the main causes of malnutrition in low-income countries such as Pakistan. Poor people are the most affected and are at significant risk of food insecurity and malnutrition especially in children [8]. The use of fiber in the diet is very important to maintain good health. Lack of fiber in the diet leads to constipation, weight gain, cancer, and cardiovascular diseases. Wheat bran is a rich source of protein (up to 14%), carbohydrates (up to 27%), fat (up to 6%), and minerals (up to 5%) [9].

Moringa (*Moringa oleifera*) is a plant usually cultivated in tropical and subtropical regions around the globe and belongs to the family *Moringaceae* having 13 species [10]. *Moringa oleifera* as the most important indigenous species is known as a potential source of vital nutrients and exhibits various health-beneficial properties [11]. It is rich source of antioxidants, such as flavonoids, carotenoids, β-carotene, and protein. As a source of vital nutrients, moringa leaves may enhance food security and reduce the risk of malnutrition [12, 13].

Moringa seed powder (MSP) fortification with wheat bread may cause a rise in bread protein content and improve the nutritional value [14]. This fortified bread may provide vital nutrients to people suffering from malnutrition in underdeveloped and developing countries as an alternative of expensive meat and meat products as protein foods of animals' origin [15, 16].

Bread is a main staple food usually ingested as food all over the world. Wheat flour fortification is necessary to enhance the nutritional and antioxidant profile of food products. Baked bread contains small amounts of nutrients including, antioxidants and phenolic compounds [17]. Kaur et al. [18] reported that *Moringa oleifera* has been widely utilized as a source of macronutrients, there has been a great demand for the development of value-added food products in recent years. Moringa is a potential source of bioactive compounds which protect against different diseases such as diabetes, cancer, and inflammation. Moringa has been widely utilized as a natural food additive in various food formulations [19]. Moringa plant parts have high polyphenolic contents; therefore, the demand of moringa has increased to prevent onset of many ailments all over the world [12].

Abdull Razis et al. [20] reported *M. oleifera*is' effectiveness against *E. coli, Staphylococcus aureus, Bacillus subtilus, Salmonella typhi, and Proteus vulgaris.* Anita et al. [21] studied that moringa leaves have antidiabetic potential to prevent Type-2 diabetes in humans. The *M. oliefera* leaves reduce the blood glucose level by regulating insulin release, so that it is an effective approach to manage the normal blood glucose level in the human body. Due to Covid-19, there is a dire need to develop nutraceuticals and value-added food products [17]. To overcome nutritional issues and enhance the nutritional value of bread, moringa is proving to be a first class resource with low production costs to prevent malnutrition, anemia, and multiple pathologies, such as child blindness associated with vitamin and element deficiencies in the diet [22, 23]. In this regard, the objective of the study was to determine the chemical composition, nutritional value, physicochemical, and sensory properties, as well as the antioxidant activity of moringa leaves and their MLP-containing snack food (bread), in order to make a strong recommendation for their consumption in a balanced diet.

2. Materials and Methods

This study was carried out at the Department of Food Science and Technology, Islamia University of Bahawalpur (IUB), Pakistan. The leaves of the moringa plant were collected from different areas of Bahawalpur City and from IUB Bahawalpur.

2.1. Preparation of Samples. After the collection of moringa leaves, the leaves were subjected to washing. After washing, the leaves were dried by sun drying and shade drying methods. Then, dried leaves were fully ground to powder form with the help of morter and pestle [24] Then, the ground sample was packed in plastic bags and stored at ambient temperature ($25 \pm 2^{\circ}$C).

2.2. Proximate Analysis of WWF and MLP. Proximate analysis and mineral profiling test of moringa powder and whole wheat flour, first separately and then in the form of a product, were determined. Moisture percentage of moringa powder and whole wheat flour separately and then in the form of product was determined by taking the measured amount of the sample (5 g) and then dried the measured sample in hot-air oven at temperature of 105°C after completing the time sample was removed from the hot-air oven and then weighed the samples after cooling according to standard method of AOAC [25] described by Sarkar and Chakraborty [26]:

$$\text{moisture content}\,(\%) = \frac{\text{weight of sample}\,(g) - \text{weight of dried sample}\,(\text{g})}{\text{weight of sample}\,(g)} \times 100. \quad (1)$$

The total ash content was determined as total inorganic matter. An oven-dried sample of moringa powder and whole wheat flour were charred and then ignited in a muffle furnace at a temperature of 550°C–600°C for 5-6 h until grayish ash was obtained according to the standard method of AOAC [25] described by Sarkar and Chakraborty [26]:

$$\text{ash content}\,(\%) = \frac{\text{final weight}\,(g) - \text{crucibe weight}\,(\text{g})}{\text{weight of sample}\,(g)} \times 100. \quad (2)$$

Protein proportion in the sample was anticipated using the Kjeldahl equipment following the approaches of AOAC [25] method no. 984-13.

Crude protein was intended by the subsequent rule:

$$N\,(\%) = \frac{\text{vol.of } 0.1N \text{ HCL used (titration)} \times 0.0014}{\text{weight of sample}\,(g) \times \text{volume}\,(mL)} \times 100. \quad (3)$$

Crude protein = N (%) × 6.25.

A moisture free sample was used for the determination of crude fat through the Soxhlet apparatus, and three gram of sample were weighed in an extraction thimble, and extraction was performed in the Soxhlet apparatus with ethanol according to the standard method of AOAC described by Sarkar and Chakraborty [26].

The fat content was determined according to the following formula:

$$\text{fat content}\,(\%) = \frac{\text{weight of empty flask and extracted flask}\,(W2) - \text{weight of empty flask}\,(\text{W1})}{\text{weight of sample}\,(g)} \times 100. \quad (4)$$

For the determination of crude fiber, fat free samples were taken, and the digestion was done first with 1.25% sulphuric acid and then with 1.25% sodium hydroxide. The rest of the filtrate was calculated and then brought to a muffle furnace at 550°C until white residues were obtained. Applying the method of AACC [27], the fiber percentage was determined by using this formulation:

$$\text{crude fiber}\,(\%) = \frac{\text{weight loss}\,(g)}{\text{weight of sample}\,(g)} \times 100. \quad (5)$$

The carbohydrate content was determined by difference, that is, addition of all the percentages of moisture, ash, crude lipid, crude protein, and crude fiber was subtracted from 100%. This gave the amount of nitrogen-free extract otherwise known as carbohydrate [28]:

$$\text{nitrogen free extract (NFE)} = 100 - [(\text{moisture\%} + \text{protein\%} + \text{ash\%} + \text{crude fibre\%} + \text{crude fat\%})] \quad (6)$$

The sample energy value was estimated (in kcal/g) by multiplying the percentages of crude protein, crude lipid, and carbohydrate with the recommended factors (2.44, 8.37, and 3.57, respectively) as proposed by Yusuf et al. [29].

2.3. Mineral Analysis. The concentration of minerals was determined using the wet digestion method reported previously [30]. Flame atomic absorption spectrophotometer (FAAS, Model 210-VGP, USA) was used for the examination of Ca, P, Fe, Zn, K, and Mg. Typical working solutions were equipped from stock standard solution (1000 ppm), and absorbance was noted from the standard solution of each element. The absorptions of all elements were determined by back titration against $MgCl_2{\cdot}6H_2O$ and $CaCl_2{\cdot}2H_2O$ [31].

2.4. Color Analysis. The color of bread crumb and crust was measured using a colorimeter (4Wave CR30-16) (Planeta, Tychy, Poland) under conditions (Light: D65; observer angle: 10°; space: LAB; dia: 16 mm). The color was determined in CIE- $(L^* - a^* - b^*)$ system, where L^* indicates degree of lightness. The degrees of redness +/greenness – and yellowness +/blueness – are denoted by a^* and b^* values, respectively. The overall color difference (ΔE) was also determined as follows given:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}. \quad (7)$$

Data from three slices per sample were averaged [32].

2.5. Total Phenolic Contents (TPC). TPC was determined according to the procedure of the Folin–Ciocalteu method described by Yilmaz et al. [33]. An extract of the sample was used and pipetted the sample extract into test tubes that contained deionized water, and Folin–Ciocalteu reagent was added into the mixture, vortexed, and kept at dark for 8 min. Sodium carbonate (Na_2CO_3) was mixed and then allowed to stand under darkness for 30 min, and absorbance of every sample was measured through a spectrophotometer at 750 nm against blank. A calibration curve was plotted against different gallic acid concentrations and expressed as mg GAE/kg on a dry weight (DW) basis. TPC was calculated using the following equation:

$$C = c \times \frac{V}{m}, \quad (8)$$

where C = total content of phenolic compounds (mg/g of GAE on DW basis), c = concentration of Gallic acid calculated from the calibration curve (mg/mL), V = volume of extract (mL), and M = weight of ethanolic extract (g).

2.6. DPPH Radical Scavenging Activity. Antioxidant activity of moringa powder and WWF depends upon the DPPH (2, 2 Diphenyl-1-picryllhydrazyl), and the sample was extracted from ethanol. From each treatment, about 2 g of the sample was taken, suspended in ethanol, and the amount was 10 mL. It was stirred for 40 min at 4°C, and centrifugation was done for 10 min at 4°C to reserve the supernatant [34].

Antioxidant content was calculated using the following equation:

$$\text{reduction of absorbance} = \left[\frac{\text{AB} - \text{AA}}{\text{AB}}\right] \times 100, \quad (9)$$

where AB = absorbance of blank, and A = absorbance of sample extract.

2.7. Ferric Reducing Antioxidant Power (FRAP). FRAP was measured by reducing antioxidants using the colorimetric method using the following equation [35]:

$$\text{FRAP}\,(\mu M) = \frac{\Delta\text{A593 test sample}}{\Delta\text{A593 test standa rd} \times \text{FRAP value of standa rd}\,(1000\ \mu M)}. \quad (10)$$

2.8. Preparation of MLP-Supplemented Leavened Bread. In the following method, supplemented leavened bread was made with the addition of moringa powder in different proportions as shown in Table 1. After drying, the leaves were grinded into powder for making of the bread. The overall procedure was being done in the Institute of Food Science & Technology IUB Bahawalpur, Pakistan. The baking ingredients were WWF, water, sugar, emulsifiers, leavening agent, yeast, salt, and preservatives. The above-mentioned ingredients were purchased from local market of BWP city.

2.9. Sensory Evaluation. The prepared breads were observed for sensory evaluation. Appearance, taste, color, texture, aroma, loaf volume, evenness of bake, and crust were the major sensory parameters which were observed on all bread samples. Semitrained panelists comprised of graduate students of the Department of Food Science and Technology, University of Bahawalpur were selected to evaluate the samples based on hedonic scales for sensory parameters. The overall acceptability was also assessed using the hedonic scale according to the method of Emmanuel Chukwuma et al. [36].

2.10. Statistical Analysis. The data obtained from all experiments was subjected to statistical analysis using one-way analysis of variance (ANOVA) at a level of significance of $p < 0.05$. Moreover, a mean comparison was also carried out according to the method described by Montgomery [37].

3. Results and Discussions

3.1. Physicochemical Properties of WWF and MLP. This study was conducted to determine the effects of MLP supplementation on WWF leavened bread. It had been observed that there was a significant increase in moisture, ash, fiber, protein, NFE, and calories. The proximate composition of WWF and MLP is presented in Table 2. The moisture, ash, fat, fiber, protein, and carbohydrates content of WWF were 12.38, 1.05, 1.42, 2.82, 8.93, and

Table 1: Treatment plan for moringa leaf powder (MLP)-supplemented whole wheat flour (WWF) leavened bread development.

Treatments	WWF (%)	MLP (%)
T_0	100	0
T_1	97.5	2.5
T_2	95	5
T_3	92.5	7.5
T_4	90	10

WWF = whole wheat flour; MLP = moringa leaf powder.

Table 2: Proximate composition, mineral composition, hunter color values, antioxidant properties of whole wheat flour (WWF), and moringa leaf powder (MLP) (g/100 g).

Parameters	WWF	MLP
Proximate composition (g/100 g)		
Moisture	12.38 ± 0.15^a	6.38 ± 0.15^b
Ash	1.05 ± 0.02^a	6.30 ± 0.01^b
Fat	1.42 ± 0.07^a	2.35 ± 0.07^b
Fiber	2.82 ± 0.08^a	18.03 ± 0.20^b
Protein	8.93 ± 0.04^a	25.97 ± 0.28^b
Carbohydrates	73.42 ± 0.02^a	40.98 ± 0.09^b
Calories	342.16 ± 0.34^a	288.93 ± 1.93^b
Mineral composition (g/100 g)		
Calcium	27.35 ± 0.08^b	440.40 ± 1.27^a
Magnesium	159.56 ± 1.26^b	3999.78 ± 1.56^a
Phosphorus	432.03 ± 2.16^a	1.40 ± 0.01^b
Zinc	6.02 ± 0.05^b	27.04 ± 0.36^a
Iron	3.20 ± 0.14^b	8.09 ± 0.16^a
Potassium	310.14 ± 2.32^b	1317.24 ± 1.05^a
Hunter color values		
L^* value	71.03 ± 1.06^b	8.05 ± 0.07^b
a^* value	1.44 ± 0.14^b	7.30 ± 0.01^a
b^* value	8.52 ± 0.05^a	7.47 ± 0.05^a
Antioxidant properties		
TPC (mg GAE/100 g DW)	0.44 ± 0.01^b	1911.23 ± 48.87^a
DPPH (μmol TE/g DW)	0.0105 ± 0.00^b	0.44 ± 0.00^a
FRAP (μmol TE/g DW)	0.0055 ± 0.01^b	20.16 ± 0.25^a

Values are expressed as mean ± SD and means with different letter superscript are significantly different ($p < 0.05$). WWF = whole wheat flour; MLP = moringa leaf powder.

73.42%, respectively. The moisture, ash, fat, fiber, protein, and carbohydrates content of MLP were 6.38, 6.30, 2.35, 18.03, 25.97, and 40.98%, respectively. Mineral contents of WWF and MLP were compared for nutritional composition assessment. Calcium, magnesium, phosphorus, zinc, iron, and potassium contents of WWF were 27.35, 159.56, 432.03, 6.02, 3.20, and 310.14 g/100 g, respectively. Calcium, magnesium, phosphorus, zinc, iron, and potassium contents of MLP were 440.40, 3999.78, 1.40, 27.04, 8.09, and 1317.24 g/100 g, respectively. L^*, a^*, and b^* values of the WWF and MLP were compared for the color profile assessment [38]. L^*,a^*, and b^* values of WWF were 71.03, 1.44, and 8.52 as compared to L^*,a^*, and b^* values of 8.05, 7.30, and 7.47, respectively (Table 2). The antioxidant profile of the WWF and MLP were compared for the antioxidant composition assessment [39]. Total phenolic content (TPC) of WWF and MLP were 0.44 and 1911.23 mg GAE/100 g DW, respectively. DPPH values of WWF and MLP were 0.0105 and 0.44 μmol TE/g DW, while FRAP values of WWF and MLP were 0.0055 and 20.16 μmol TE/g DW, respectively (Table 2).

3.2. Proximate Composition of MLP-Supplemented Leavened Bread. A proximate analysis of moringa-based supplemented leavened bread was performed. It has been observed that there is a significant increase in moisture, ash, fiber, protein, and calories [40]. The proximate composition of MLP-supplemented leavened whole wheat bread is presented in Table 3. The moisture content of the MLP-supplemented leavened bread was assessed for nutritional composition. The results for the moisture contents of the MLP-based leavened value-added bread are shown in Table 3. However, the highest moisture magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for the T_1, i.e., 8.0%, while the highest moisture contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4, i.e., 9.1%, in comparison with the control (T_0), i.e., 11.1%. Our results for moisture contents of MLP

Table 3: Proximate composition of moringa leaf powder (MLP)-supplemented whole wheat flour leavened bread (mg/100 g).

Treatments	Moisture	Ash	Fat	Fiber	Protein	NFE	Calories
T_0	11.02 ± 0.35^a	1.76 ± 0.16^a	1.53 ± 0.23^d	16.27 ± 0.86^b	12.06 ± 0.40^d	57.37 ± 1.51^e	291.45 ± 5.40^b
T_1	8.00 ± 0.71^d	1.95 ± 0.12^d	2.03 ± 0.05^c	17.31 ± 0.02^b	17.08 ± 0.43^c	53.40 ± 0.06^d	300.14 ± 3.48^c
T_2	8.83 ± 0.23^c	2.27 ± 0.04^c	2.04 ± 0.08^c	17.79 ± 0.02^b	19.06 ± 0.09^b	49.37 ± 0.02^c	292.01 ± 0.85^b
T_3	9.40 ± 0.37^a	3.91 ± 0.04^b	3.10 ± 0.07^b	18.26 ± 0.06^a	20.17 ± 0.40^a	44.78 ± 0.71^b	287.68 ± 2.73^a
T_4	9.11 ± 0.16^b	4.99 ± 0.10^a	3.63 ± 0.06^a	18.83 ± 0.23^a	21.67 ± 0.12^a	41.79 ± 0.18^a	286.43 ± 0.87^a

Values are means ± standard deviation of triplicate determinations ($n = 3$); $^{a-e}$means followed by different letters in a column are significantly different ($p < 0.05$). T_0 = 100% WWF-based value added bread, T_1 = control–2.5% MLP-based value added bread, T_2 = 5% MLP-based value added bread, T_3 = 7.5% MLP-based value added bread, and T_4 = control–10% MLP-based value added bread.

supplementation are in close agreement with the earlier studies, wherein moisture contents varied from 12.5 to 6.5%, respectively. The findings of moisture in present study portrayed significant ($p < 0.05$) for moisture of moringa leaf powder (MLP), which was 6.38%. The deductions of the present study for the ash content of whole wheat flour and moringa leaf powder have been in close corroboration with the earlier studies, wherein the contents of the fat for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 1.50% and 2.50%, respectively [41]. These results were in coherence with the findings reported by Zhao et al. [2], who reported reduced baking loss and an improvement in the proximate composition of pan bread fortified with tofu whey powder.

The results for the ash contents of the MLP-based leavened, value-added bread have been shown in Table 3. The substitution of MLP in the WWF at 2.5–10% supplementation level showed a significant ($p < 0.05$) improvement of ash contents of the leavened bread. However, the highest ash magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for the T_1, i.e., 1.95%, while the highest ash contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4, i.e., 4.99%, in comparison with the control (T_0), i.e., 1.76%. The findings of ash in the present study portrayed significant ($p < 0.05$) ash contents for whole wheat flour, i.e., 1.1%, which was a lower concentration when compared with the moringa leaf powder (MLP), which was 6.3%. The deductions of the present study for the ash content of whole wheat flour and moringa leaf powder have been in close corroboration with the earlier studies, wherein the contents of the ash for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 1.08% and 6.03%, respectively [42].

The results for fat contents of the MLP-based leavened value-added bread are shown in Table 3. The highest fat magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for T_1, i.e., 2.03%, while the highest fat contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4, i.e., 3.63%, in comparison with the control (T_0), i.e., 1.53%. However, the addition of MLP in the WWF resulted in a significant ($p < 0.05$) improvement of the fat concentrations from 2.03 to 3.63% for treatments T_1–T_4 on supplementing from 2.5 to 10% of MLP. Our results for fat contents of MLP supplementation are in close agreement with the earlier studies, wherein fat contents varied from 1.50 to 2.50%, respectively [42].

The results for the protein contents of the MLP-based leavened, value-added bread are shown in Table 3. The substitution of MLP in the WWF at 2.5–10% supplementation level resulted in a significant ($p < 0.05$) improvement of the protein contents of the leavened bread. However, the highest protein magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for T_1, i.e., 17.08%, while the highest protein contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4, i.e., 21.68%, in comparison with the control (T_0), i.e., 12.06%. Our results for protein contents of MLP supplementation are in close agreement with the earlier studies, wherein protein contents varied from 11.50 to 26.28%, respectively [42]. The results of the present study for protein content of whole wheat flour and moringa leaf powder have been in close affirmation with the earlier studies, wherein the contents of the protein for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 11.25% and 26.28%, respectively [40, 43].

The highest fiber magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for the T_1, i.e., 17.31%, while the highest fiber contents among the treatments, i.e., T_1–T_4 (2.5–10%) were recorded for T_4, i.e., 18.83%, in comparison with the control (T_0) (Table 3). However, the addition of MLP in the WWF showed a significant ($p < 0.05$) improvement of fiber concentrations from 17.31 to 18.83% for treatments T_1–T_4 on supplementing form 2.5–10% of MLP. Our results for fiber contents of MLP supplementation are in close agreement with the earlier studies, wherein fiber contents varied from 2.50 to 18.20%, respectively [40, 42]. The results of the present study for fiber content of whole wheat flour and moringa leaf powder have been in close affirmation with the earlier studies, wherein the contents of the fiber for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 11.25% and 26.28%, respectively [44].

The highest NFE magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for T_1, i.e., 53.40%, while the highest NFE contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_1, i.e., 53.40%, in comparison with the control (T_0), i.e., 57.37% (Table 3). However, the addition of MLP in the WWF showed a significant ($p < 0.05$) decrease in NFE concentrations from 53.40 to 41.79% for treatments T_1–T_4 on supplementing form 2.5–10% of MLP. Results for NFE contents of MLP supplementation are in close agreement with the earlier studies, wherein NFE contents varied from

70.92 to 40.16%, respectively [42] and Barminas et al. [43].The substitution of MLP in the WWF at 2.5–10% supplementation level showed a significant ($p < 0.05$) improvement of caloric contents of the leavened bread. However, the highest caloric magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for T_1 (300.14%). The findings of calories in the present study portrayed a significant ($p < 0.05$) ash contents for whole wheat flour (WWF), i.e., 342.16%, which was a higher concentration when compared with the moringa leaf powder (MLP), which was 288.93%. The results of the present study for calories content of whole wheat flour and moringa leaf powder have been in close affirmation with the earlier studies, wherein the contents of the calories for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 11.25% and 26.28%, [40, 43]. In a report by Jiang et al. [45], ginseng insoluble dietary fiber (GSI) was added to the wheat bread. and up to the addition levels of GSI, the fortified bread showed improvement in mineral, proteins, and fiber contents as compared to that of control.

3.3. Mineral Analysis of MLP-Supplemented Leavened Bread. Mineral profile of the moringa-based supplemented leavened bread was performed and observed significance increase in the mineral contents of leavened bread [46]. The results of mineral composition of MLP-supplemented leavened WWF bread are given in Table 4.

The highest calcium magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for T_1, i.e., 45.05%, while the highest calcium contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4, i.e., 55.22%, in comparison with the control (T_0), i.e., 12.66%. Our results for calcium contents of MLP supplementation are in close agreement with the earlier studies, wherein calcium contents varied from 3.84 to 489.00%, respectively [47]. The deductions of the present study for the calcium content of the whole wheat flour and moringa leaf powder have been in close corroboration with the earlier studies, wherein the contents of the calcium for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 3.84 mg/100 g and 489.01 mg/100 g, respectively [40, 43].

The substitution of MLP in the WWF at 2.5–10% supplementation level showed a significant ($p < 0.05$) improvement in the magnesium contents of the leavened bread (Table 4). However, the highest magnesium magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for T_1, i.e., 60.06%, in comparison with the control T_0. The deductions of the present study for the calcium content of whole wheat flour and moringa leaf powder have been in close corroboration with the earlier studies, wherein the contents of the magnesium for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 22 mg/100 g and 342 mg/100 g, respectively [42].

The substitution of MLP in the WWF at 2.5–10% supplementation level resulted in a significant ($p < 0.05$) improvement of the potassium contents of the leavened bread (Table 4). However, the highest potassium magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for T_1, i.e., 164.67%, while the highest potassium contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4, i.e., 291.18%, in comparison with the control (163.05%). Our results for potassium contents of MLP supplementation are in close agreement with the earlier studies, wherein potassium contents varied from 224 to 327%, respectively [46]. The conclusions of the present study for the potassium content of whole wheat flour and moringa leaf powder have been in close corroboration with the earlier studies, wherein the contents of the potassium for whole wheat flour and moringa leaf powder were seen in a similar range, i.e., 933.90 mg/100 g and 761 mg/100 g, respectively [48].

The substitution of MLP in the WWF at 2.5–10% supplementation level resulted in a significant ($p < 0.05$) improvement of the zinc contents of the leavened bread (Table 4). However, the highest zinc magnitudes among the treatments from T_1–T_4 (2.5–10% supplementation level) were noticed for T_1, i.e., 0.80%, while the highest zinc contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_4 (3.82%), in comparison with the control (T_0: 0.53%). Our results for zinc contents of MLP supplementation are in close agreement with the earlier studies, wherein zinc contents varied from 0.23 to 9.30%, respectively [42]. The deductions of the present study for zinc content of whole wheat flour and moringa leaf powder have been in close corroboration with the earlier studies, wherein the contents of the zinc for whole wheat flour and moringa leaf powder were seen in similar range, i.e., 0.23 mg/100 g and 9.30 mg/100 g, respectively [42]. In a report by Feng et al. [4]; the effects of papaya seed supplementation on the quality properties of wheat bread were evaluated. The authors reported that the papaya seed exhibited the higher amount of K, Ca, Zn, Mg, and Na, and concentration-dependent rises in the mineral content of wheat bread were observed with corresponding increases in the addition levels of papaya seed powder ranging from 1 to 7%. The mineral estimations showed rises of potassium (11.58%), calcium (21.05%), sodium (214.05%), magnesium (42.37%), zinc (42.37%), iron (96.38%), and copper (130.78%) in supplemented bread samples.

3.4. Color Analysis of MLP-Supplemented Leavened Bread. The results of Hunter color values of MLP-supplemented leavened WWF bread are given in Table 5. L^*,a^*, and b^* *values* of the MLP-supplemented leavened bread was assessed for nutritional composition. It has been observed that color profile of moringa-based product was significantly decreased [10, 49].

L^* *value* of the MLP-supplemented leavened bread was assessed for nutritional composition. The data of L^* *value* of the MLP-supplemented leavened bread anticipated a significant ($p < 0.05$) findings. The results for L^* *value* of the MLP-based leavened value-added bread are shown in Table 5. However, the highest L^* *value* magnitudes among the treatments from T_1–T_4 (2.5-10% level), were noticed for T_1, i.e., 47.22%, in comparison with the control (T_0), i.e., 61.78%. Our results for L^* *value* of MLP supplementation is in close

Table 4: Mineral composition of moringa leaf powder (MLP)-supplemented whole wheat flour leavened bread (mg/100 g).

Treatments	Ca	Mg	K	Zn	Fe	P
T_0	12.66 ± 0.16^{a}	57.16 ± 1.82^{a}	163.05 ± 3.40^{a}	0.53 ± 0.04^{a}	4.21 ± 0.33^{a}	8.48 ± 0.08^{a}
T_1	45.05 ± 1.40^{b}	60.06 ± 0.31^{b}	164.67 ± 140.59^{b}	0.80 ± 0.03^{b}	5.11 ± 0.18^{a}	8.70 ± 0.05^{b}
T_2	33.13 ± 1.22^{d}	62.22 ± 0.93^{b}	225.32 ± 2.34^{c}	1.81 ± 0.01^{c}	4.79 ± 0.15^{b}	8.45 ± 0.87^{a}
T_3	43.88 ± 1.85^{c}	356.73 ± 0.08^{c}	257.87 ± 2.04^{d}	2.07 ± 0.06^{c}	4.99 ± 0.51^{b}	8.47 ± 0.79^{a}
T_4	55.22 ± 1.27^{e}	455.26 ± 0.40^{d}	291.18 ± 1.49^{e}	3.82 ± 0.03^{d}	4.17 ± 0.28^{b}	8.39 ± 1.64^{b}

Values are means ± standard deviation of triplicate determinations ($n = 3$)]; [a–d]means followed by different letters in a column are significantly different ($p < 0.05$). T_0 = 100% WWF-based value added bread, T_1 = control—2.5% MLP-based value added bread, T_2 = 5% MLP-based value added bread, T_3 = 7.5% MLP-based value added bread, and T_4 = control—10% MLP-based value added bread.

Table 5: Hunter color values of moringa leaf powder (MLP)-supplemented whole wheat flour leavened bread.

Treatments	L^* value	a^* value	b^* value
T_0	61.78 ± 1.26^{a}	2.12 ± 0.18^{a}	22.17 ± 0.54^{a}
T_1	47.22 ± 0.62^{b}	3.34 ± 0.16^{b}	29.99 ± 0.16^{b}
T_2	39.97 ± 0.33^{c}	3.17 ± 0.10^{b}	29.40 ± 0.21^{b}
T_3	28.69 ± 0.66^{d}	4.04 ± 0.08^{c}	35.00 ± 0.15^{c}
T_4	27.06 ± 0.86^{d}	3.72 ± 0.23^{c}	36.43 ± 0.79^{c}

Values are means ± standard deviation of triplicate determinations ($n = 3$); [a–d]means followed by different letters in a column are significantly different ($p < 0.05$). T_0 = 100% WWF-based value added bread, T_1 = control—2.5% MLP-based value added bread, T_2 = 5% MLP-based value added bread, T_3 = 7.5% MLP-based value added bread, and T_4 = control—10% MLP-based value added bread.

agreement with the earlier studies, wherein L^* *value* varied from 63.3 to 47.66%, respectively [10, 49].

The highest a^* *value* magnitudes among the treatments from T_1–T_4 (2.5–10% level) were noticed for the T_1 (3.34%), while the highest a^* *value* among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_3 (4.04%), in comparison with the control (T_0: 2.12%). However, the addition of MLP in the WWF resulted in a significant ($p < 0.05$) increase in a^* *value* concentrations from 3.34 to 4.06% for treatments T_1–T_3 on supplementing form 2.5–10% of MLP. Our results for a^* *value* of MLP supplementation is in close agreement with the earlier studies, wherein a^* *value* varied from 2.36 to 3.36%, respectively [10, 49].

The highest b^* *value* magnitudes among the treatments from T_1–T_4 (2.5–10% level) were noticed for the T_1, i.e., 29.99%, while the highest b^* *value* among the treatments, i.e., T_1-T_4 (2.5–10%), were recorded for T_4 (36.43%), in comparison with the control (T_0: 22.17%). However, the addition of MLP in the WWF resulted in a significant ($p < 0.05$) increase in b^* *value* concentrations from 29.99 to 36.43% for treatments T_1–T_4 on supplementing from 2.5–10% of MLP. Our results for b^* *value* of MLP supplementation is in close agreement with the earlier studies, wherein b^* *value* varied from 18.84 to 26.54%, respectively [46]. In a report by Feng et al. [4], the effects of papaya seed supplementation on the quality properties of wheat bread were evaluated. The authors reported that the bread samples not supplemented with papaya seed (control) exhibited increased L^*-values indicative of degree of lightness in the samples. The L^*-values of the supplemented samples were found in decreasing manner from 47.05 to 36.29 with corresponding increases in the supplementation levels of the papaya seed from 1 to 7%. This was indicative of the effect that papaya seed addition led to slightly increasing dark color gradually in supplemented bread. Decreasing tendencies in L^*-values, degrees of yellowness and redness was implied to the attributable effect of Maillard reaction products synthesized during baking and these Maillard reaction products comprised of brown-colored melanoidins.

3.5. Antioxidant Profile of MLP-Supplemented Leavened Bread. Antioxidant profile of MLP-supplemented leavened WWF bread was assessed for TPC, DPPH, and FRAP activities and results are tabulated in Table 6. It has been observed that antioxidant compounds of MLP-supplemented bread exhibited significantly increased [39]. The results of TPC, DPPH, and FRAP activity of MLP-supplemented leavened WWF bread are given in Table 6. In case of TPC, T_0, T_1, T_2, T_3, and T_4 exhibited, TPC contents of 0.72, 2.04, 1.99, 2.18, and 2.33 mg GAE/100 g DW. In case of DPPH activity, T_0, T_1, T_2, T_3, and T_4 exhibited, DPPH activity of 25.26, 31.17, 18.60, 12.02, and 10.38 μmol TE/g DW. Regarding FRAP activity, T_0, T_1, T_2, T_3, and T_4 exhibited activity of 39.98, 32.83, 28.49, 3.27, and 21.43 μmol TE/g DW. This study results were in agreement with the findings of Mata-Ramírez et al. [50] who reported that Roselle (*Hibiscus sabdariffa*)-supplemented bread at 9% addition level exhibited 2.7 times higher antioxidant activity in comparison with that of control. These results are in agreement with the findings of Feng et al. [4]. The effects of papaya seed supplementation on the quality properties of wheat bread were evaluated by the authors. The authors reported that TPC and TFC values of the papaya seed-supplemented bread samples were found in ranges of 83.79–126.19 mg/100 g DW and 1.27–1.93 mg/100 g DW, respectively. Moreover, authors have reported that the papaya seed itself exhibited high values of radical-scavenging activities (DPPH, ABTS, and FRAP activities). Concentration-dependent rises in the antioxidant activities of supplemented bread samples were observed in gradually increasing tendencies. Such rises in the antioxidant could be ascribed to the rise in the antioxidant and phenolic

Table 6: Antioxidant profile of moringa leaf powder (MLP)-supplemented whole wheat flour leavened bread (mg/100 g).

Treatments	TPC (mg GAE/100 g DW)	DPPH (μmol TE/g DW)	FRAP (μmol TE/g DW)
T_0	0.72 ± 0.06^a	25.26 ± 0.40^a	39.98 ± 0.04^a
T_1	2.04 ± 0.08^b	31.17 ± 0.55^b	32.83 ± 0.08^b
T_2	1.99 ± 0.04^c	18.60 ± 0.25^c	28.49 ± 0.08^c
T_3	2.18 ± 0.11^d	12.02 ± 0.11^d	23.27 ± 0.10^d
T_4	2.33 ± 0.04^d	10.38 ± 0.25^d	21.43 ± 0.08^d

Values are means ± standard deviation of triplicate determinations ($n = 3$); $^{a–d}$means followed by different letters in a column are significantly different ($p < 0.05$). T_0 = 100% WWF-based value added bread, T_1 = control—2.5% MLP-based value added bread, T_2 = 5% MLP-based value added bread, T_3 = 7.5% MLP-based value added bread, and T_4 = control—10% MLP-based value added bread.

compounds. High antioxidant activities and high concentrations of polyphenolic compounds are found to be in correlation with each other, and this could be the probable reason of improved antioxidant activities [51, 52].

3.6. Textural Profile of MLP-Supplemented Leavened Bread. The textural attributes of hardness, springiness, and gumminess of MLP-supplemented leavened bread were assessed and results are tabulated in Table 7. It has been observed that hardness and springiness significantly decreased in gradual manner with corresponding rises in supplementation levels of MLP. However, gumminess exhibited a slightly increasing tendency in all supplemented samples of bread as compared to that of control. The hardness values of T_0, T_1, T_2, T_3, and T_4 were 5.16, 3.00, 2.74, 3.36, and 4.15 N, respectively. The gumminess values of all samples T_0, T_1, T_2, T_3, and T_4 were found to be in range of 0.26 to 0.59%, respectively. The springiness values of T_0, T_1, T_2, T_3, and T_4 were 1.03, 1.31, 1.62, 1.80, and 1.31 N, respectively. The results of present study were endorsed by the findings of Seleem and Omran [53], who carried out the study on the effects of supplementation of leavened bread by addition of bean or sorghum flour at addition levels of 5, 10, and 15%. Wheat bread supplemented with addition level of 10% sorghum flour exhibited improvement in textural attributes like hardness, springiness, and gumminess. In a report by Feng et al. [4], the effects of papaya seed supplementation on the quality properties of wheat bread were evaluated. The authors reported that papaya seed supplemented samples exhibited the hardness values in range of 3743.68–5064.01 g. The changes in textural attributes of the supplemented leavened wheat bread could be ascribed to the factor of gluten framework strengthening owing to dehydrated moringa leaf powder. Moreover, moringa leaf powder caused changes in the starch properties, and after the starch gelatinization after baking, the partially swollen granules underwent stretching and transformation because of inherent elongation. Starch granules elongation exhibited gas cells expansion. Therefore, it may be inferred based on findings in published literature that starch gelatinization plays a significant role as a determinant of bread texture. Leavened bread may have the reduced air bubbles in internal framework possibly because of supplementation effect as well as embedding of starch granules in lipids and sugar molecules [54, 55].

3.7. Sensory Properties of MLP Supplemented Leavened Bread. The substitution of MLP in the WWF at 2.5–10% supplementation level resulted in a significant ($p < 0.05$) improvement of the appearance contents of the leavened bread (Table 8). However, the highest appearance magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for the T_1, i.e., 7.18, while the highest appearance contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_3 (6.54) in comparison with the control (T_0: 7.86). However, the addition of MLP in the WWF showed a significant ($p < 0.05$) decrease in the appearance concentrations from 7.18 to 6.54 for treatments T_1–T_3 on supplementing form 2.5–10% of MLP. Our results for appearance contents of MLP supplementation are in close agreement with the earlier studies of Shiriki et al. [41] and Borune [56].

The substitution of MLP in the WWF at 2.5–10% supplementation level showed a significant ($p < 0.05$) improvement of aroma contents of the leavened bread (Table 8). However, the highest color magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for T_1 (7.12), while the highest color contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_3 (6.55) in comparison with the control (T_0), i.e., 7.85. Our results for taste contents of MLP supplementation are in close agreement with the earlier studies of Shiriki et al. [41] and Borune [56].

The highest taste magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for the T_1, i.e., 7.50, while the highest taste contents among the treatments, i.e., T_1–T_4 (2.5–10%), were recorded for T_3, i.e., 6.90 in comparison with the control (T_0), i.e., 7.73 (Table 8). However, the addition of MLP in the WWF resulted in a significant ($p < 0.05$) increase in the decreased concentrations from 7.50 to 6.74 for treatments T_1–T_3 on supplementing form 2.5–10% of MLP. Our results for taste contents of MLP supplementation are in close agreement with the earlier studies of Shiriki et al. [41] and Borune [56].

The substitution of MLP in the WWF at 2.5–10% supplementation level showed a significant ($p < 0.05$) improvement of the aroma contents of the leavened bread (Table 8). However, the highest aroma magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for T_1, i.e., 7.39. However, the addition of MLP in the WWF resulted in a significant ($p < 0.05$) resulted in decreased contents in the texture concentrations from

Table 7: Textural attributes moringa leaf powder (MLP)-supplemented whole wheat flour leavened bread.

Treatments	Hardness (N)	Springiness (%)	Gumminess (N)
T_0	5.16 ± 0.25^a	0.59 ± 0.02^a	1.03 ± 0.07^a
T_1	3.00 ± 0.15^b	0.57 ± 0.16^a	1.31 ± 0.03^a
T_2	2.74 ± 0.33^c	0.33 ± 0.06^b	1.62 ± 0.23^b
T_3	3.36 ± 0.33^b	0.38 ± 0.08^b	1.80 ± 0.18^b
T_4	4.15 ± 0.22^d	0.26 ± 0.08^c	1.31 ± 0.26^a

Values are means ± standard deviation of triplicate determinations ($n = 3$); $^{a-d}$means followed by different letters in a column are significantly different ($p < 0.05$). $T_0 = 100\%$ WWF-based value added bread, T_1 = control—2.5% MLP-based value added bread, $T_2 = 5\%$ MLP-based value added bread, $T_3 = 7.5\%$ MLP-based value added bread, and T_4 = control—10% MLP-based value added bread.

Table 8: Sensory attributes of moringa leaf powder (MLP)-supplemented whole wheat flour leavened bread.

Treatments	Appearance	Taste	Texture	Aroma	Color	Overall Acceptability
T_0	7.86 ± 0.02^a	7.73 ± 0.03^a	7.84 ± 0.02^a	7.81 ± 0.02^a	7.85 ± 0.06^a	7.89 ± 0.05^a
T_1	7.18 ± 0.05^a	7.50 ± 0.04^a	7.39 ± 0.05^a	7.35 ± 0.03^a	7.12 ± 0.04^a	7.55 ± 0.03^a
T_2	7.06 ± 0.05^a	6.90 ± 0.04^b	7.23 ± 0.03^a	7.06 ± 0.05^b	7.01 ± 0.03^a	7.20 ± 0.02^a
T_3	6.54 ± 0.03^b	6.74 ± 0.05^b	7.01 ± 0.05^b	6.76 ± 0.03^c	6.55 ± 0.02^c	6.70 ± 0.02^b
T_4	6.07 ± 0.02^c	6.71 ± 0.06^b	6.92 ± 0.04^b	6.57 ± 0.02^c	6.10 ± 0.01^c	6.10 ± 0.04^b

Values are means ± standard deviation of triplicate determinations ($n = 3$); $^{a-c}$means followed by different letters in a column are significantly different ($p < 0.05$). $T_0 = 100\%$ WWF-based value added bread, T_1 = control—2.5% MLP-based value added bread, $T_2 = 5\%$ MLP-based value added bread, $T_3 = 7.5\%$ MLP-based value added bread, and T_4 = control—10% MLP-based value added bread.

7.39 to 7.01 for treatments T_1–T_3 on supplementing form 2.5–10% of MLP. Our results for texture contents of MLP supplementation are in close agreement with the earlier studies of Shiriki et al. [41] and Borune [56].

The highest aroma magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for T_1, i.e., 7.81 (Table 8). Our results for aroma contents of MLP supplementation are in close agreement with the earlier studies of Shiriki et al. [41] and Borune [56]. The overall acceptability of the MLP-supplemented leavened bread was assessed for nutritional composition. The substitution of MLP in the WWF at 2.5–10% supplementation level showed a significant ($p < 0.05$) improvement of the aroma contents of the leavened bread. However, the highest aroma magnitudes among the treatments from T_1–T_4 (i.e., 2.5–10% supplementation level) were noticed for T_1, i.e., 7.55. Our results for overall acceptability contents of MLP supplementation are in close agreement with the earlier studies of Shiriki et al. [41] and Borune [56]. Consumer acceptability of foodstuffs usually depend on the sensory properties. In a report by Feng et al. [4], the effects of papaya seed supplementation on the quality properties of wheat bread were evaluated. The authors reported that supplementation up to addition levels of 3% caused increasing trend in sensory attributes of supplemented bread as compared to that of control. However, when the supplementation levels were raised above 3%, then the sensory scores of all attributes exhibited decreasing tendencies in panelist scores.

4. Conclusions

Recent study concluded that Moringa oleifera exhibited medicinal as well as nutritional quality (protein, mineral, and dietary fiber) in food. It is a rich source of several minerals, specifically P, K, Fe, Zinc, Ca, and Mg. On the contrary, antioxidants such as flavonoids, ascorbic acid, carotenoids, and phenolic are present in the moringa leaves that makes them an important plant source of antioxidants. It is a prospective and healthy food fortification choice. Furthermore, it was revealed in current study that the concentration of phenolic compounds and antioxidant activity in Moringa oleifera leaves is sufficient to be considered as a possible source of antioxidant supplements. In general, it may have the potential to contribute to a better Zn, Fe, and Ca content in the diet of children, mothers, and adolescents to combat the Fe deficiency problems and prevent many diseases including osteoporosis and cardiovascular disorders. The demand for snacks in the market is huge. Hence, Moringa fortification in snacks is convenient way to eradicate malnutrition. This abundant tree in Pakistan can become a great source of income for the nation if its potential for highly nutritious food is exploited by industries and researchers.

Data Availability

The data supporting the current study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Muhammad Asif Khan conceptualized and supervised the study and was involved in the project administration. Sadaf Shakoor was involved in the investigation, formal analysis, and methodology, conceptualized, wrote the original draft, –

and edited the manuscript. Kashif Ameer reviewed and edited the manuscript and was responsible for data interpreting, results, and discussion and finalized the draft. Muhammad Aslam Farooqi reviewed and edited the manuscript, and finalized the draft. Madiha Rohi finalized the draft. Muhammad Saeed finalized the draft and was responsible for methodology, results, and discussion. Muhammad Tuseef Asghar tabulated the data and was responsible for the results and discussion. Muhammad Bilal Irshad finalized the draft and was involved in the methodology, results, and discussion. Muhammad Waseem introduced the manuscript and was involved in the methodology. Saira Tanweer introduced the manuscript and was involved in the methodology. Umair Ali introduced the manuscript and was involved in the methodology. Isam A. Mohamed Ahmed reviewed, edited, and finalized the draft, and was also involved in funding acquisition. Yasra Ramzan introduced the manuscript and was involved in the methodology.

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