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Nutritional, textural, and sensory quality of bars enriched with banana flour and pumpkin seed flour

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Abstract:
Introduction. Nowadays, health-conscious consumers attend to nutritional, health, and easy-to-use products. Demand for healthy snacks is significantly increasing. Our study aimed to develop high protein nutrition bars by incorporating pumpkin seed flour and banana flour and assess their quality.
Study objects and methods. We analyzed three bar samples for nutritional, textural, and sensory quality. The bars contained banana flour, pumpkin seed flour, and the mixed flour. Proximate analysis was performed following the AOAC method. The mineral content and antioxidant properties of the bars were determined by using emission spectrophotometry and the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging modified method, respectively.
Results and discussion. The mixed flour nutrition bar had significantly higher total phenolic content and antioxidant activity than the bar with banana flour and the bar with pumpkin seed flour. Textural analysis demonstrated that the mixed flour sample had significantly ($P < 0.05$) higher hardness and color parameters compared to the other bar samples. Nutritional analysis indicated that mixed flour bar contained significantly higher amounts of protein, fat, and calcium; while pumpkin seed flour bar had higher ash, iron, and magnesium contents. The mixed flour sample also had better sensory parameters.
Conclusion. The mixed flour demonstrated good quality. Hence, both banana and pumpkin seed flour have a potential to be used in bar formulations.

Keywords: Nutrition bar, banana, pumpkin seed, flour, nutritional value, textural properties, sensory analysis

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INTRODUCTION

Lifestyle changes and dietary habits of human all over the world may affect nutrient intake. Therefore, a healthy and balanced diet is important to meet the basic needs of human body. Accordingly, nutrition bars/cereal bars are the most sophisticated ready-to-eat products due to the natural ingredients and health concerns [1].

Nowadays, a special attention has been given to by-products to utilize raw materials as much as practical and avoid economic losses and environmental pollution. Nutrition or energy bars are getting popular among health aware consumers, school goers, and weight watchers [2] due to its nutritive value and easy-to-use. The increasing demand of consumers for nutritious snacks, results the fastest outgrowth in cereal bars market more than 20% per year [3] that provide nutrition and convenience [4].

Health-conscious consumers prefer nutritious foods to conventional sweets. This tendency driven to the development of several ready-to-eat, nutritious, and energy bars containing different fruits and nuts [5–6]. Incorporation of fruit and vegetable by-products in nutrition bars not only adds the value to products but also contributes to newly formulated food products and minimize losses of raw materials by utilizing peels, seeds, etc. [7].

Modern consumers prefer snacks not only to satisfy their hunger but also to provide themselves with essential nutrients. In this regard, food scientists today are aiming to develop formulations of cereal bars with various highly nutritious ingredients. Thus, Russian scientists have developed a cereal bar with rolled oat flakes, bee honey, walnut, dried cranberry, sunflower seeds, peanut butter, dates, and prunes [8].

Snacks satisfy hunger, replace a meal, and provide the body with essential nutrition, including protein, carbohydrates, fats, and vitamins [9–10]. One of the popular fruits in Bangladesh is banana [11], which is a rich source of energy (90 kcal/100 g) [12]. In addition, banana contains health benefiting antioxidants, crude fiber, and minerals [13]. Health beneficiary effect of banana pulp is due to bioactive compounds [14] such as phenolic acid compounds, flavonoids, carotenoids, sterols, and antimicrobial compounds. The compounds make banana a perfect functional food [15].

Russian researchers revealed that main sources of vegetable protein are seeds of legumes and oilseeds [16]. Pumpkin (*Cucurbita pepo* L.) seed has also received considerable attention due to its nutritional value (200 calories) and high content of amino acids, such as palmitic, oleic, linoleic, and stearic, as well as dietary fiber [17]. Pumpkin seed also shows pharmacological activities including anti-fungal [18], anti-cancer [19], anti-bacterial, anti-inflammation, and anti-oxidant effects [20]. The robust flavor of pumpkin seed allows using it as a valuable ingredient in cooking [21]. Pumpkin seed oil obstructs changes in plasma lipids and blood pressure together with inadequate estrogen availability [22].

Recent research on pumpkin seed flour indicated that it increased reducing sugars, vitamin C, and carotenoid content in bread [23]. 10% of pumpkin seed flower in a cake formulation had strong effects on physicochemical and organoleptic properties of the cake [24]. Replacement of refined wheat flower with pumpkin seed flower improved the textural and sensory qualities of cookies [25]. Addition of 15% of pumpkin seed flower into biscuit dough had a significant effect on the rheological and sensory characteristics of the final product [26].

Searching safe methods to extend the shelf life of food products is a relevant task for the food industry. Banana and pumpkin seed demonstrate significant anti-oxidant properties. Natural antioxidants can be an alternative to existing preservatives due to its ability to inhibit oxidation of the main nutrients [27]. An increasing growth of metabolic diseases and obesity worldwide is a global problem that makes food scientists and researchers develop not only tasty but also health beneficial snacks.

In Bangladesh, mango or peanut bars with glucose syrup are popular among the population, however, their nutritional value is low and energy value is high. We did not find research on the quality of bars enriched with pumpkin seed flour. The findings of this work will be beneficial for the local food industry and will reduce malnutrition problems.

Our work aimed to formulate bars with banana flour and pumpkin seed flour and evaluate their nutritional, textural, and sensory quality.

STUDY OBJECTS AND METHODS

Our research featured nutritional bars with banana flour, pumpkin seed flour, and the mix of banana and pumpkin seed flours.

Materials. Raw materials, such as brown sugar, sunflower oil, oats, corn flakes, chickpea, nuts, and raisins, were purchased from the local supermarket. All the ingredients were purchased evaluated for safety standards. The following technical and food safety information was evaluated: name of the products with batch number, physicochemical composition, information about recognized food allergens, sensory properties (appearance, flavor, and aroma), microbial information, and shelf life. To store the ingredients, we used high-density polyethylene and low-density polyethylene as a packaging material.

Pumpkin seed flour preparation. Pumpkin seed was collected from the local market as a by-product of pumpkin processing. Seeds were cleaned with potable water and sun dried to remove extra water from the surface of the seeds. After that, the pumpkin seed with shell was dried in a cabinet dryer (M-1816, Modern Laboratory Equipment, USA) at 55°C for 4 h, ground using a grinder (Panasonic Mixer Grinder MX-AC555, India), and finally sieved through 20 mesh (0.841 mm) to get fine pumpkin seed flour. Then the pumpkin seed flour was weighed and vacuum packed for further use.

Banana flour preparation. Ripe banana (Sagor variety) was collected from the Horticulture center of Bangladesh Agricultural University, Bangladesh. Banana was sorted to remove defected banana and washed with running water. Banana was sliced into 0.5 cm thick pieces with peel. To reduce enzymatic browning, the slices were then dipped in 10% citric acid solution for 10 min. The peel was removed and sliced banana was air dried to remove extra water. Banana then was dried in a cabinet dryer (M-1816, Modern Laboratory Equipment, USA) at 60°C for 5 h, ground using a grinder (Panasonic Mixer Grinder MX-AC555, India), and sieved through 30 mesh (0.595 mm) to get fine flour. The banana flour was vacuum packed for further use.

Bar preparation. Three nutrition bars were formulated: with banana flour, with pumpkin seed flour, and with the mixed flours (Table 1). Amounts of banana flour, pumpkin seed flour, salt, and lecithin were chosen based on trial and error methods to find the optimum color and texture of the bars. Similarly, the other ingredients were chosen based on consumer interest by survey (data not shown).

Figure 1 demonstrates the production process of nutrition bars. At first, all the dry ingredients, such as oats, corn flakes, pumpkin seed flour and/or banana flour, nuts, raisins, chickpea, and skim milk powder, were weighed and mixed gently. The heated sugar syrup, sunflower oil, and lecithin were added into the dry mixture and mixed. The mixture was heated in a water bath at 70°C. The mixture then was compressed, dried in an oven at 110°C for 15 min, and cut into uniform pieces (12×2.5×2.0 cm) and cooled at room temperature (25°C) for 30 min. The bars were packed in low and high density package and then kept in a sealed container at ambient temperature for further analysis.

Table 1 Formulation of nutrition bars with banana flour, pumpkin seed flour, and mixed flour, g/100 g

Ingredient	Bars with:		
	Banana flour	Pumpkin seed flour	Mixed flour
Oats	10	10	10
Corn flakes	10	10	10
Pumpkin seed flour	0	15	10
Banana flour	15	0	5
Sunflower oil	10	10	10
Nuts	7	7	7
Raisins	6	6	6
Water	6	6	6
Salt	0.2	0.2	0.2
Lecithin	0.8	0.8	0.8
Glucose syrup	10	10	10
Brown sugar	10	10	10
Chickpea	5	5	5
Skim milk powder	10	10	10

The proximate analysis of pumpkin seed flour, banana flour and newly formulated bars were determined by Tasnim *et al.* [28] using the guidelines and methods of AOAC (Association of Official Analytical Chemists): moisture content – method 950.46; crude protein, 981.10; crude fat, 922.06; crude fiber, 978.10; and ash, 920153.00. Total carbohydrate contents in the both flours and nutrition bar were estimated according to the methods of Food and Agriculture Organization (FAO) [29]. Mineral contents were determined following the procedures described in [30]. Inductively coupled plasma emission spectrophotometer was used to analyze calcium, iron, magnesium, phosphorus, and potassium in the samples.

The antioxidant activities of flours and nutrition bars were determined by using the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging modified method, as described by Brand-Williams *et al.* [31]. In methanol, DPPH in oxidized form gives a deep violet color. However, antioxidant compounds usually denote an electron to DPPH, thus causing reduction. In reduction form, DPPH turns to yellow. A 0.002% DPPH solution was prepared in methanol and measured at 517 nm. Sample extracts (50 μL) were mixed with 3 mL of the DPPH solution and kept for 15 min in the dark. Then the absorbance was measured again at 517 nm.

The total phenolic content in the banana flour, pumpkin seed flour, and nutrition bar was determined using the modified method of Odabasoglu *et al.* [32]. The total phenolic content of the samples was calculated as gallic acid equivalents (mg GAE/g) and every experiment was performed in triplicate. Peroxide value, free fatty acids, and thiobarbuturic acid (MA/kg sample), which are generally used to evaluate lipid oxidation in food products, were measured in accordance with Rukunudin *et al.*, Sallam *et al.* and Schmedes and Holmer, respectively [33–35].

The color characteristics of the nutrition bar were determined using a Minolta colorimeter (Cr-400/410, Japan). The CIELB scale with *L**, *a** and *b** was used to analyze the results, where *L** showed the lightness (*L** = 0, black and *L** = 100, white) of the product, *a** showed red-green color (+60 to –60), and *b** showed yellow-blue color (+60 to –60) [36].

The textural parameters of the nutrition bar under the study (12×2.5×2.0 cm) were determined using a texture analyzer (Stable Micro Systems, UK) and the modified method described by Momin *et al.* [37]. The cutting probe and compression platen of the texture

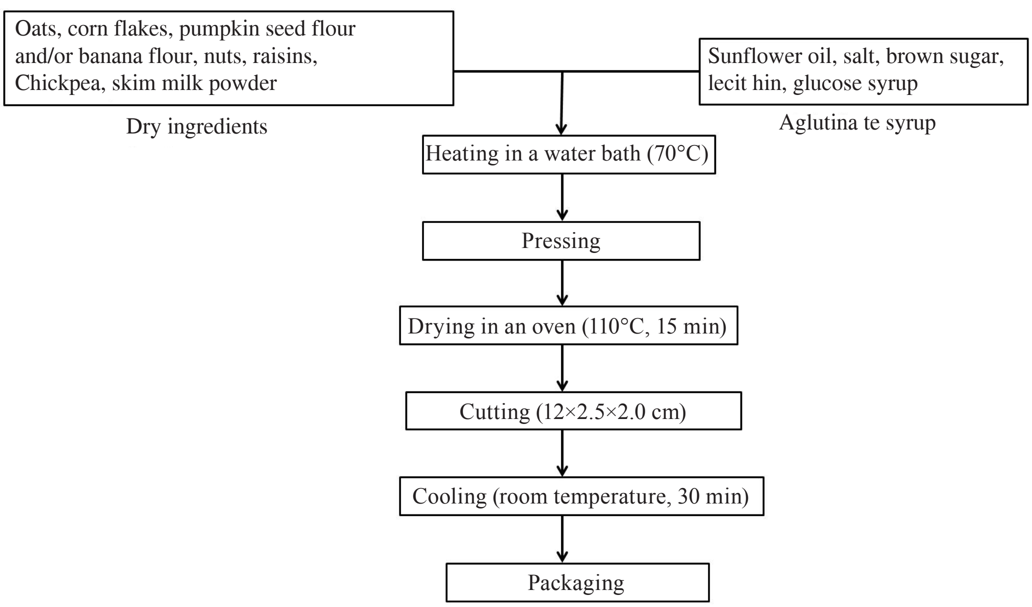

Figure 1 Flowchart of nutrition bar production process

Table 2 Nutrient content of pumpkin seed flour and banana flour (per 100 g)

Ingredients	Pumpkin seed flour	Banana flour
Moisture, %	$1.20^b \pm 0.05$	$3.00^a \pm 0.75$
Carbohydrate, %	$14.47^b \pm 1.00$	$78.30^a \pm 1.50$
Protein, %	$29.54^a \pm 1.50$	$3.9^b \pm 0.50$
Fat, %	$47.6^a \pm 2.35$	$1.8^b \pm 0.45$
Crude fiber, %	$2.13^b \pm 0.25$	$9.9^a \pm 1.15$
Calcium, mg	$30.07^a \pm 2.00$	$22.96^b \pm 2.50$
Magnesium, mg	$1103.19^a \pm 10.50$	$108.05^a \pm 5.25$
Phosphorus, mg	$3205.13^a \pm 11.20$	$74.54^a \pm 3.50$
Iron, mg	$0.31^a \pm 0.01$	$1.22^a \pm 0.04$
Potassium, mg	$809.03^a \pm 3.25$	$1491.88^a \pm 8.50$
Energy, kcal	604.44	385.00

Values are expressed as mean ± SD. Means in the same row with different superscripts were significantly different ($P \leq 0.05$)

a b c

Figure 2 Appearance of nutrition bars with banana flour (a), pumpkin seed flour (b), and the mix of banana and pumpkin flour (c)

analyzer were calibrated at a 20 cm distance using data acquisition software. The following parameters were used for the analysis: pre-test speed 1.0 mm/s, trigger 5 g, and post-test speed 10 mm/s. Each sample was texted in three replications.

Three different types of the nutrition bars were evaluated by 10 semi-trained panelists for color, flavor, texture, and overall acceptability. For statistical analysis, the 9-point hedonic rating test [38] was used to access the sensory quality of the newly nutrition bar. The analysis was performed three times. The significant difference of mean values was assessed by the analysis of variance (ANOVA) using a software STATISTIC version 8.1. For the significant difference, DMRT was applied.

RESULTS AND DISCUSSION

Table 2 shows the nutrient composition of pumpkin seed flour and banana flour. It is remarkable that the pumpkin seed flour contained significantly ($P < 0.5$) higher amount of protein and fat but lower amount of water, crude fiber, and carbohydrate, compared to the banana flour. Among the minerals, calcium, magnesium, and phosphorus concentrations were higher in the pumpkin seed flour and iron and potassium was higher in the banana flour (Table 2). The energy value of the pumpkin seed flour (604.44 kcal/100 g) was also higher than that of the banana flour (385 kcal/100 g).

The nutrition bars developed (Fig. 2) were analyzed to determine their nutritional value (Table 3). Dietary protein is one of the vital nutrients for human due to its functional properties, including the improving of health growing of muscles [28, 39]. All the nutrition bars under study may easily supply recommended daily allowance for protein. The mixed nutrition bar contained significantly higher amount of protein compared to the others.

The fat content of the mixed bar sample was significantly higher than of the sample with banana flour and the bar with the pumpkin seed flour. The ash content was higher in the pumpkin seed flour bar, which did not significantly differ from the mixed flour sample.

The total carbohydrate content solely depends on the other nutrient components of the nutrition bars. The mixed flour nutrition bar had the lowest carbohydrate (66.11%) content compared to the pumpkin seed flour (73.19%) and banana flour (80.20%) nutrition bar. The banana flour and mixed flour nutrition bars had the lowest and highest energy values, respectively (398.60 and 424.94 kcal/100 g).

Table 3 Nutritional composition of nutrition bars with banana flour, pumpkin seed flor, and mixed flour

Composition	Banana flour	Pumpkin seed flour	Mixed flour
Moisture content, %	$6.94^a \pm 1.0$	$6.61^a \pm 1.25$	$6.82^a \pm 1.55$
Ash content, %	$1.16^b \pm 0.05$	$1.46^a \pm 0.35$	$1.32^a \pm 0.50$
Protein content, %	$5.50^c \pm 0.75$	$9.74^b \pm 1.15$	$14.25^a \pm 1.55$
Fat content, %	$6.20^c \pm 0.50$	$9.05^b \pm 0.45$	$11.50^a \pm 0.75$
Carbohydrate content, %	$80.20^a \pm 2.50$	$73.19^b \pm 3.05$	$66.11^b \pm 3.00$
Energy content, kcal	$398.60^b \pm 3.00$	$412.72^a \pm 2.75$	$424.94^a \pm 1.80$
Calcium (Ca), mg	$3.75^b \pm 0.05$	$3.10^c \pm 0.25$	$4.90^a \pm 0.75$
Iron (Fe), mg	$0.04^b \pm 0.02$	$0.2^a \pm 0.05$	$0.05^b \pm 0.03$
Magnesium (Mg), mg	$15.20^c \pm 0.05$	$153.45^a \pm 5.00$	$118.25^b \pm 4.25$
Phosphorus (P), mg	$10.20^c \pm 1.10$	$450.75^a \pm 2.55$	$345.20^b \pm 2.35$
Potassium (K), mg	$115.20^c \pm 5.20$	$220.45^a \pm 5.55$	$150.79^b \pm 4.75$

Values are expressed as mean ± SD. Means in the same row with different superscripts were significantly different ($P \leq 0.05$)

Table 4 Total phenolic content, antioxidant activity, and textural properties of nutrition bar with different types of flour

Nutrition bar	Total phenolic content, mg GAE	DPPH inhibition, %	Texture analysis	
			Hardness, gf	Fracturability, s
Banana flour	7.10[b] ± 0.03	40.50[b] ± 0.35	41254.00[b] ± 210.80	17.85[b] ± 2.10
Pumpkin seed flour	6.45[c] ± 0.07	38.25[c] ± 0.45	39806.00[c] ± 205.07	17.50[b] ± 1.35
Mixed flour	8.55[a] ± 0.05	45.35[a] ± 0.10	47453.00[a] ± 195.70	18.95[a] ± 2.45

Values are expressed as mean ± SD. Means in the same column with different superscripts were significantly different ($P \leq 0.05$)

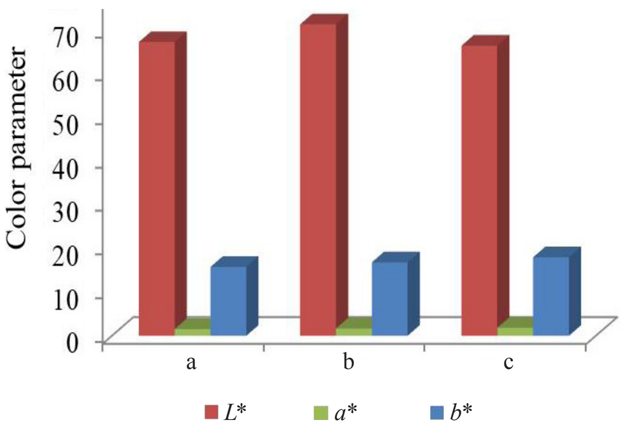

Figure 3 Color parameter of nutrition bar with banana flour (a), pumpkin seed flour (b), and the mix of the flour (c)

Iron is an essential element whose deficiency causes anemia [40]. According to Institute of Medicine, Food and Nutrition Board, iron and calcium contents in 100 g of the nutrition bars would contribute less than 4 and 10%, respectively, of recommended daily allowance for men aged 19–50 years reported in 2001 [41]. Our results also indicated that 100 g of the nutrition bars with pumpkin seed flour, banana flour, and mixed flours would provide more than 45, 32, and 10% of phosphorus, respectively [42].

The total phenolic content was found to be highest in the mix flour bar (8.55 ± 0.05 mg GAE/g), compared to that in the banana flour and pumpkin seed flour samples (7.10 ± 0.03 and 6.45 ± 0.07 mg GAE/g, respectively (Table 4). Phenolics combat with free radicals, which are harmful to human, and stop their further activity [43]. DPPH inhibition level indicates free radical scavenging property and is a measure of antioxidant potential. The DPPH radical scavenging activity of the nutrition bars depended on an amount of phenolics in the banana flour, pumpkin seed flour, chickpea, and raisins. Food materials rich in phenolics exhibit a high DPPH inhibition level as reported by Abu El-Baky, who studied phenolic compounds in spirulina and their protective properties [44]. In our research, the mixed flour nutrition bar demonstrated the highest DPPH inhibition level (45.35 ± 0.10%) and, consequently, better antioxidant activity. The lowest one was found to be 38.25 ± 0.45% (pumpkin seed flour).

The textural properties of the bar samples were measured using a texture analyzer and included hardness and fracturability (Table 4). The mix sample had the highest hardness, while the pumpkin seed flour bar showed the lowest hardness. Fracturability of banana flour bar was the lowest but it did not significantly differ from that of the banana sample, so their textural properties were close. Among the other samples, the pumpkin seed flour bar had the least hardness.

The color of food products is a critical parameter, especially for bars, which are potentially targeted on children and women. Figure 3 shows the color parameters for the nutrition bars. There was a significant difference ($P < 0.05$) in *L** values among all the samples. This could be due to the presence of polyphenols in banana flour, pumpkin seed flour, and chick pea. The pumpkin seed flour bar showed a lower *L** value than the other bars.

All the nutrition bars demonstrated positive *a** (redness) and *b** values (yellowness). The pumpkin seed flour sample had significantly ($P < 0.5$) higher *a** value than the other nutrition bars, which can be explained by the presence of higher polyphenol concentrations in the raw materials such as pumpkin seed flour and chick pea. The positive *b** value of all the nutrition bars could be due to the presence of cornflakes, chickpea, and pumpkin seed flour.

Table 5 Sensory evaluation of nutrition bars

Nutrition bars	Sensory attributes				
	Color	Flavor	Texture	Taste	Overall acceptability
Banana flour	6.60[a] ± 0.50	5.80[a] ± 0.65	5.80[a] ± 0.85	5.20[a] ± 0.50	5.20[a] ± 0.85
Pumpkin seed flour	6.90[b] ± 0.43	7.20[b] ± 0.50	6.80[b] ± 0.65	6.20[a] ± 0.80	6.60[b] ± 0.95
Mixed flour	7.80[c] ± 0.72	8.20[c] ± 0.95	7.20[b] ± 0.45	7.60[b] ± 0.75	7.80[c] ± 0.55
LSD value	0.96	0.94	0.94	1.16	0.96

Values are expressed as mean ± SD. Means in the same column with different superscripts were significantly different ($P \leq 0.05$)

Table 6 Changes in moisture, peroxide value, free fatty acids, and thiobarbuturic acid in the bar with banana and pumpkin seed flours stored at 25°C and packed in low density polyethylene (LDP) and high density polyethylene (HDP)

Attributes	Packaging materials	Storage periods, days		
		0	30	60
Moisture, %	LDP	6.82^{c}	7.37^{bA}	7.76^{aA}
	HDP		6.93^{cdB}	7.01^{cB}
Peroxide value, meq O_2/kg fat	LDP	0.9^{e}	4.2^{cA}	7.5^{aA}
	HDP		3.8^{B}	6.7^{bB}
Free fatty acids, % oleic acid	LDP	1.7^{c}	2.1^{bA}	2.5^{aA}
	HDP		2.0^{bA}	2.1^{bB}
Thiobarbituric acid value, MA/kg sample	LDP	0.19^{d}	0.25^{bA}	0.30^{aA}
	HDP		0.23^{cB}	0.26^{bB}

Different uppercases in columns lowercases in rows indicate significant difference ($P \leq 0.05$). Values are mean ± SD of three measurements

Sensory assay of the newly nutrition bars included color, flavor, texture, taste, and overall acceptability (Table 5). The analysis showed that there was a significant ($P < 0.5$) difference in the sensory attributes among banana flour, pumpkin seed flour, and mixed flour bars. However, the sample with mixed flour demonstrated better sensory properties compared to the other nutrition bars.

We assessed changes in lipid peroxidation in the nutrition bar with the mix of banana flour and pumpkin seed flour during two months of storage at room temperature (25°C). Peroxide value, free fatty acids, and thiobarbuturic acid values of the bar sample are demonstrated in Table 6.

On day 60, the moisture content in the sample slightly increased, regardless of the packaging material used. Between the packaging materials (low-density polyethylene and high-density polyethylene), a significant difference ($P < 0.5$) was observed in the moisture content. Chemical changes in the mixed bar were found low in the samples packed in the high-density polyethylene compared to those packed in the low-density polyethylene. After two months of storage, peroxide value, free fatty acids, and thiobarbuturic acid in the mixed nutrition bar became 7.5, 2.1., and 1.5 times higher, respectively.

CONCLUSION

We evaluated the quality of nutrition bars containing banana flour, pumpkin seed flour, and mixed flour. The samples with both banana flour and pumpkin seed flour (mixed flour) showed good nutritional quality, with higher amount of protein (14.25 ± 1.55%), fat (11.50 ± 0.75%), and calcium (4.90 ± 0.75 mg/100 g) content compared to the other bars. However, the sample based on pumpkin seed flour demonstrated higher amount of ash (1.46 ± 0.35 mg/100 g), magnesium (153.45 ± 5.00 mg/100 g), potassium (450.75 ± 2.55 mg/100 g), and phosphorus (220.45 ± 5.55 mg/100 g) content.

Antioxidant activity (45.35 ± 0.10% DPPH inhibition), total phenolic content (8.55 ± 0.05 mg GAE/bar), and textural properties (47453 ± 195.70 gf hardness and 18.95 ± 2.45 s fracturability) were significantly the highest in the mixed flour nutrition bar. Sensory analysis found that the mixed flour nutrition bar was attributed as the best formulation.

Thus, banana flour and pumpkin seed flour showed considerable potential as ingredients in the formulation of nutrition bars and improved their nutrient value. Further studies are needed to determine the shelf life and *in vivo* metabolism of nutrition bars enriched with banana flour and/or pumpkin seed flour.

CONTRIBUTION

U. Habiba: conceptualization, methodology, investigation, visualization, and drafting manuscript. M.A. Robin: conceptualization, investigation, visualization, and drafting manuscript. M.M. Hasan: conceptualization, investigation, and drafting manuscript. M.A. Toma: data analysis, methodology, drafting manuscript, and writing. D. Akhter: data analysis and writing. M.A.R. Mazumder: conceptualization, methodology, project administration, writing, and supervision.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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