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Evaluation of the quality parameters of wheat flour and banana peel powder-formulated cakes

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Abstract

This research aimed to demonstrate the nutritional value of banana peel powder (BPP) by emphasizing its antimicrobial and antioxidant properties and its use (BPP) as a cost-effective substitute for wheat flour in a cake. The findings of BPP at various concentrations (1%, 4%, 7% and 10%) were compared to critical quality properties such as the cake's physical, chemical, and microbial properties, as well as its sensory properties. More than 50.7% of the total weight of the banana fruit as waste can be used as a good source of macro and micronutrients, antimicrobials, and antioxidants in food processing, according to the present findings. In addition, the BPP is an excellent source of protein (15.10%) and ash (25.19%). The substitution of wheat flour with BPP resulted in the addition of significant quantities of natural antioxidants to the cake production process, particularly in samples containing 7 and 10% BPP. These antioxidants have a variety of positive effects on human health and act as antimicrobial agents to extend the shelf life of the cake product. The organoleptic consistency characteristics of the cake revealed a marginally significant difference between the control sample and those containing up to 4% BPP for all organoleptic properties measured and designated as excellent in comparison to the control sample. As a result of this discovery, it is suggested that cakes containing up to 10% BPP have numerous health benefits and improve their flavor.

1. Introduction

The banana is recognized as the most antioxidant-rich fruit. The most common and readily accessible banana cultivars in Bangladesh are *Musa acuminata* (Sabri kola), *Musa paradisica* (Sagor kola), and *Musa* spp. (Dudhsagor kola).

Many byproducts of agricultural waste that are abandoned produce phenolic compounds that can be employed as antioxidants and disease preventatives. Recent research has recommended fruit and vegetable byproducts as natural food additives due to their high polyphenol, carotenoid, and other bioactive chemical content (Ayalazavala *et al.*, 2011; O'Shea *et al.*, 2012). These wastes can create disposal and environmental problems and deplete vital biomass and nutrients. Agro-degradable materials can be turned into useable products and even raw materials for other businesses (Pazera *et al.*, 2015). Utilizing leftovers from fruit and vegetable production as a source of useful components is a potential area of research (Schieber *et al.*, 2001). In addition, the food business has substantial obstacles, such as decreasing waste generated during processing. Bioconversion of agricultural wastes is gaining significant attention since these materials offer potential and usable resources to produce useful products (Martin, 1998). All foods containing bioactive substances are useful due to their physiological health advantages related to the prevention and control of several chronic diseases, such as type 2 diabetes (Alkhatib *et al.*, 2017).

The banana fruit consists of two distinct components: the peel and the pulp. The fruit's principal byproduct, the peel, contributes to around 40% of the fruit's total weight. Until recently, banana peels served no purpose and were discarded, generating vast amounts of organic trash that must be managed (Sheikh *et al.*, 2017). Since scientists began analyzing the chemical makeup of banana peels, numerous possible applications have emerged (Agama-Acevedo *et al.*, 2012). The banana peel is rich in minerals, bioactive compounds, and dietary fiber. Specially harvested banana peels from

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Musa paradisiaca are rich in phenolic compounds, a type of antioxidant that protects against heart disease and cancer (Someya *et al.*, 2002).

Consumer approval of bakery products such as sponge cakes indicates that they could be utilized to inject bioactive chemicals into the human diet (Moraes *et al.*, 2010). While cakes, unlike bread, are not considered necessary foods, people of all ages enjoy and consume them (Borges *et al.*, 2006).

Consequently, this study aimed to incorporate banana peel powder (BPP) as a cost-effective component with wheat flour in the production of cakes and analyze the influence of varying quantities of banana peel powder (BPP) on many cake quality criteria, including physical, chemical and microbiological qualities.

2. Materials and methods

2.1 Experimental samples

Musa paradisiaca (Sagor Kola) peel and wheat flour. All the samples were purchased from the local market of Churamonkathi, Jashore, Bangladesh.

2.2 Ingredients

Sucrose, butter, fresh eggs, baking powder, vanilla essence, oil, water, and crude cacao, are used in preparing the cake dough. These materials were obtained from the local market, Churamonkathi, Jashore, Bangladesh.

2.3 Collection and preparation of banana peels powder

Bananas of the *Musa paradisiaca* species that were fully ripe, somewhat ripe, and unripe were gathered from the local market in the Jashore district in Bangladesh. This banana's color intensity ranges from green (unripe), through less yellow (moderately ripe), to yellow (completely ripe). Bananas were washed to eliminate dirt, then the peels were separated from the pulp and weighed (Ahmed *et al.*, 2021). The peels were cut into small pieces (about 3 cm) and blanched at 60°C for four mins before being combined with 0.3 g of sodium metabisulfite per kilogram of solution water. After blanching, they were dried at 65°C for 24 hrs. The peels were then ground and weighed. A total of 5 kg of wet peel from each maturity stage produced 0.365 kg, 0.337 kg, and 0.382 kg of powder, which was put in high-density plastic bags and kept at -18°C until further treatment.

Ingredients for the preparation of a cake were obtained from commercial sources. All ingredients except sugar were combined. The butter and additional ingredients were mixed with a mixer at medium speed for three mins, sugar was added, and the mixture was beaten for three mins, beaten eggs and vanilla were added and mixed for 2 mins, and then the mixture was attached to the creamed fat-carbohydrate mixture and easily beaten at low speed for five cycles. The previous mixture was gradually supplemented with wheat flour (WF) and other ingredients, and then beaten for 5 mins. The 250 g of cake was measured into the greased mug and baked in a preheated oven at 180°C for 25 mins. The resulting cakes were refrigerated for 2 hrs. The samples are then placed in polyethylene bags and refrigerated (4° C) until formula analysis. The samples followed the following ratio:

Here, C = 100% wheat flour, R_1 = (99% wheat flour + 1% Banana peel powder), R_4 = (96% wheat flour + 4% Banana peel powder), R_7 = (93% wheat flour + 7% Banana peel powder), R_{10} = (90% Wheat flour + 10% Banana peel powder), MR_1 = (99% wheat flour + 1% Banana peel powder), MR_4 = (96% wheat flour + 4% Banana peel powder), MR_7 = (93%wheat flour + 7% Banana peel powder), MR_{10} = (90% Wheatflour + 10% Banana peel powder), UR_1 = (99% wheat flour + 1% Banana peel powder), UR_4 = (96%wheat flour + 4% Banana peel powder), UR_7 = (93%wheat flour + 7% Banana peel powder), UR_{10} = (90%Wheatflour + 10% Banana peel powder)

2.4 Proximate analysis

Moisture content, crude protein, crude fat, crude fiber, total ash, and pH were all determined using the AOAC (1990) method, whereas carbohydrate was determined by subtracting the sums of other nutrients.

2.5 Physical and chemical analysis

Each cake's weight (in grams) was determined individually within one hour of baking. The mean was documented. According to Türker *et al.* (2016), the density of the cake was determined by calculating its volume (in cm^3) and specific volume.

2.6 DPPH radical scavenging assay

Following the method outlined by Shimada *et al.* (1992) DPPH-RSA was evaluated by measuring the inhibition rate. In this assay, 2 mL of extract solution at different concentrations was added to 2 mL of 0.1 mM DPPH solutions and the contents were stirred vigorously for 15 s. Then the solutions were allowed to stand in a dark place at room temperature for 30 mins for reaction to occur. After 30 mins, absorbance was measured against a blank at 517 nm using a double beam Scientific UV-Vis Spectrophotometer (AnalyticJena Specord 205). The percentage of DPPH radical-scavenging activity of each plant extract was calculated as DPPH radical-

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scavenging activity (%I).

$$\% \text{ of inhibition } = \frac{A_0 - A}{A_0}$$

Where, A_0 is the absorbance of the control solution (containing all reagents except vegetable extracts); A is the absorbance of the DPPH solution containing plant extract. The DPPH radical-scavenging activity (%) was plotted against the sample extract concentration to determine the concentration of extract necessary to decrease DPPH radical by 50% (called IC_{50}). All determinations were performed in triplicate. Ascorbic acid was used as positive control standard extract the sample by this procedure: Firstly,10 g sample added to 30 mL methanol and was shaken for 30 mins then centrifuged for 20 mins at 4000 rpm and filtered.

In a test tube, 0.5 mL DPPH working solution was mixed with 450 µL plant extract (1 mg/mL) or the standard solution and left for 30 mins. The absorbance was measured at 517 nm for a period of 30 mins. The% antioxidant or radical scavenging activity was calculated using the following formula:

$$\% \text{ Antioxidant activity} = \frac{Ac - As}{Ac}$$

Where Ac = is the absorbance of blank, As = is the absorbance of sample extract. The control contained 100 µL methanol in place of the plant sample. All tests were carried out in triplicate.

2.7 Determination of total phenolic content

Determination of the total phenolic content in the extracts of the banana fruit peels of each three varieties was determined according to Folin-Ciocalteu method (Ough and Amerine, 1988) with some modification. Approximately 200 µL of FC reagent and 600 µL 10% Na_2CO_3 were mixed with 300 µL sample. The reaction mixture was incubated at 40°C for 30 mins with intermittent shaking for color development. The absorbance of the colored solution was measured at 765 nm using double-beam UV-VIS Spectrophotometry. Total phenolic content was determined from the linear equation of a standard curve prepared with gallic acid as the standard and expressed (mg) as gallic acid equivalents (GAE)/g of extract.

2.8 Microbiological analyses

Using plate count method depicted in Figure 1, after 0, 3, 6, 9, and 12 days of room temperature storage, complete bacteria, molds, and yeasts were counted in cake samples; all experiments were conducted in triplicate. Complete plate bacterial counts were calculated using the plate counts technique on nutrient agar medium, as outlined in (American Society for Microbiology, 1957). All the plates were incubated between 20 and 25°C for five days to find for bacteria, mold and yeast count (Murray *et al.*, 2007).

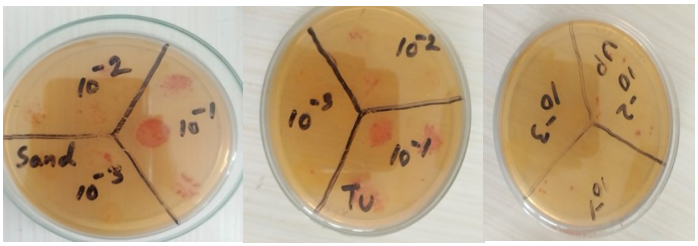

Figure 1. Microbial plate count.

2.9 Determination of energy values

The energy value was calculated as equation (cal/100 g-1) of RDC., (2021). i.e., energy value, cal/100 g = [(4 ×% protein) + (4 ×% carbohydrate) + (9 ×% total lipids)].

2.10 Sensory evaluation

The quality of freshly baked cakes was determined using the method described by Salama *et al.* (2013). The evaluated characteristics included appearance, texture, flavor, palatability and acceptability. On a nine-point hedonic scale, panelists rated the similarity of the product's attributes as follows: 1-dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like or dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely. Ten panelists with cake experience who were neither ill nor allergic to baked goods participated in the evaluation.

2.11 Statistical analysis

To provide a more comprehensive explanation, all experimental data from the characters were measured and statistically analyzed. Each experiment was performed three times (n = 3). The results are expressed as mean ± standard deviation (SD), and statistical significance was determined using analysis of variance (ANOVA). When $p < 0.05$, differences were considered to be statistically significant.

3. Results and discussion

3.1 Nutritional composition

Results of proximate composition of cakes produced from BPP and wheat flour blends are given in Table 1. There were significant differences ($p < 0.05$) in the proximate composition of the various cakes produced in this study when compared to the control. With the increase of banana peel powder (BPP), the moisture content of the samples significantly decreased. Again, among the three maturity stages of the peel, for the samepercentage of the BPP, the cake prepared from ripe peel powder has a moisture content that is almost similar

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Table 1. Nutritional composition of banana peel powder incorporated cake.

Samples	Moisture content (%)	Crude ash (%)	Crude fat (%)	Crude fiber (%)	Total protein (%)	Carbohydrate (%)	pH	Energy value
C	25.97±0.98^{a}	2.01±0.06^{d}	15.03±0.42^{b}	7.8±0.65^{a}	6.00±0.76^{c}	43.96±0.83^{c}	7.00±0.87^{b}	335.11±0.22^{c}
R_1	26.18±0.97^{a}	2.23±0.25^{d}	19.35±0.83^{c}	1.1±0.76^{b}	7.45±0.56^{a}	43.77±0.06^{c}	7.48±0.76^{b}	379.06±0.31^{c}
R_4	23.97±0.88^{b}	4.42±0.33^{a}	20.01±0.45^{c}	2.67±0.06^{d}	5.78±0.97^{b}	43.14±0.42^{c}	8.05±0.08^{a}	375.81±0.06^{c}
R_7	18.52±0.83^{c}	2.78±0.23^{c}	20.01±0.97^{c}	3.687±0.23^{c}	4.35±0.33^{c}	50.64±0.21^{b}	8.07±0.81^{a}	400.09±0.67^{a}
R_{10}	16.961±0.26^{c}	3.54±0.42^{c}	22.45±0.23^{a}	3.54±0.06^{c}	4.012±0.05^{b}	49.49±0.97^{b}	7.90±0.09^{b}	416.05±0.42^{a}
MR_1	24.84±0.95^{b}	2.11±0.22^{d}	18.15±0.81^{c}	1.90±0.07^{b}	9.13±0.81^{a}	43.86±0.06^{c}	8.34±0.06^{a}	375.34±0.45^{c}
MR_4	22.61±0.87^{b}	2.45±0.67^{d}	17.72±0.97^{d}	3.45±0.81^{c}	8.99±0.33^{a}	44.76±0.23^{c}	8.18±0.40^{a}	374.54±0.33^{c}
MR_7	17.37±0.81^{c}	1.61^{e}±0.56	20.56±0.03^{a}	3.56±0.33^{c}	7.04±0.08^{a}	49.84±0.33^{b}	6.87±0.97^{c}	412.61±0.33^{a}
MR_{10}	13.52±0.22^{d}	2.9±0.89^{c}	21.15±0.33^{a}	3.87±0.03^{c}	6.20±0.33^{c}	52.34±0.42^{b}	7.54±0.25^{b}	424.54±0.33^{a}
UR_1	16.32±0.91^{c}	2.06±0.45^{d}	16.12±0.33^{d}	2.97±0.08^{d}	8.90±0.45^{a}	53.61±0.03^{b}	8.30±0.23^{a}	394.14±0.45^{b}
UR_4	14.69±0.87^{c}	1.02±0.78^{b}	14.32±0.83^{b}	4.56±0.45^{a}	7.23±0.03^{a}	58.16±0.03^{a}	7.95±0.42^{b}	390.47±0.83^{b}
UR_7	9.96±0.83^{d}	1.04±0.12^{e}	15.23±0.22^{b}	4.01±0.42^{a}	5.87±0.45^{b}	63.10±0.42^{a}	7.62±0.45^{b}	413.6±0.09^{a}
UR_{10}	9.767±0.22^{d}	1.78±0.09^{d}	17.76±0.45^{d}	6.23±0.42^{a}	4.08±0.22^{b}	60.37±0.45^{a}	7.91±0.09^{b}	417.68±0.42^{a}

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

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to the control sample. Again, with the increase in BPP, the ash content doesn't change linearly. The fat content of the samples does not follow a linear scale as the percentage of the BPP increases. Among the samples, R_{10} (10%), MR_7 (7%), and MR_{10} (10%) have the highest fat content which is the standard fat content for cakes. The unripe BPP sample, UR_{10} (10%) had higher fiber content than the control sample. Similar observations have been reported by Olushola (2006). The higher fiber of the BPP incorporated cakes is a justification of the nutritional importance of *Musa paradisiaca* peel. The utilization of fiber-rich plant food is to help in the traffic movement through the intestinal tract (laxative) and in the lowering of cholesterol in the blood (American Academy of Pediatrics, 2012). Also, an increase in the intake of dietary fiber supplies greater amounts of vitamins and minerals (American Academy of Pediatrics, 2012). As the amount of wheat flour decreases, the protein content of the cakes decreases as well. A similar observation has been reported by Olushola (2006). The study observed that the amount of protein content of MR_1 (1% BPP) is 9.13%, which is higher than the other samples. Values with the same letter are not significantly different. The amount of carbohydrate content of the cakes decreased with the addition of BPP. A similar observation has been reported by Olushola (2006). The study found that the amount of carbohydrate content of UR_7 (7% banana peel powder) is 63.10%, which is the highest amount. The value also meets the standard value of the cakes.

3.2 Determination of phenolic content

Total phenolic content was determined as mg of Gallic acid equivalent per kg of fresh extract using the equation obtained from a standard gallic acid calibration curve $y = 0.0074x + 0.4075$, $R^2 = 0.9982$. Figure 2 represents the standard calibration curve for the determination of total phenolic content in the ethanol extract of the banana peel powder. Shahidi *et al.* (1992) reported that the antioxidant effects of phenolic compounds come from the reducing power of the aromatic hydroxyl group, which gets rid of reactive free radicals and can chelate transition metals. Total phenolic content in different treated samples was found between 3.674 mg GAE/kg fresh weight and 4.552 mg GAE/kg fresh weight (Table 2). Total phenolic content of the unripe samples is the highest.

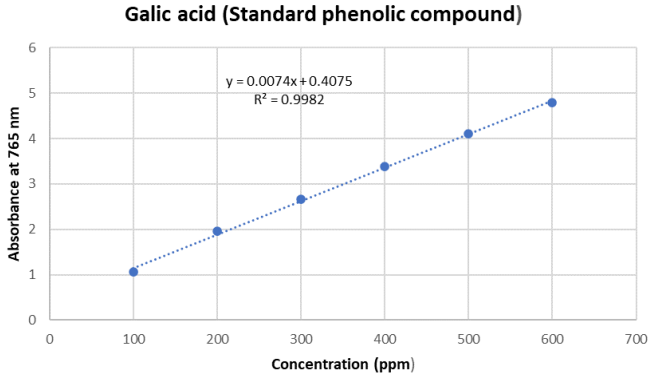

Figure 2. Concentration versus absorbance (at 765 nm) curve of gallic acid.

3.3 Determination of DPPH content

DPPH concentration was used to measure antioxidant activity. Absorbance values for antioxidant activity testing of banana peel powder at different concentration are mentioned in Table 3. Antioxidant

Table 2. Total phenolic content of banana peel powder incorporated cake.

Sample	Concentration (g/mL)	Absorbance at 765 nm	Total phenolic content (mg GAE/kg fresh weight)
Blank		0.041	
Ripe		1.808±0.01[a]	3.674±0.001[a]
Moderately ripe	50 g/mL	2.133±0.02[b]	4.485±0.001[b]
Unripe		2.108±0.02[b]	4.552±0.001[b]

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

Table 3. Absorbance values for antioxidant activity testing of banana peel powder at different concentration.

Serial No.	Samples (µg/mL)	Absorbance of ripe	Absorbance of moderate ripe	Absorbance of unripe
1	DPPH	1.321	1.321	1.321
2	DPPH + Extract 1 µg/mL	0.452	0.515	0.450
3	DPPH + Extract 2.5 µg/mL	0.441	0.477	0.442
4	DPPH + Extract 5 µg/mL	0.395	0.455	0.396
5	DPPH + Extract 10 µg/mL	0.359	0.354	0.385
6	DPPH + Extract 20 µg/mL	0.324	0.339	0.314
7	DPPH + Extract 30 µg/mL	0.231	0.252	0.270
8	DPPH + Extract 40 µg/mL	0.159	0.215	0.261
9	DPPH + Extract 50 µg/mL	0.163	0.185	0.259

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activity was detected in the following Table 4 samples. Antioxidant activity is significantly higher in the 2.5 µg sample extract for the ripe, moderately ripe, and unripe banana peel powder sample, while the lowest levels were found in 50 µg samples. As the antioxidant activity of sample 2.5 µg is greater than the other samples extract, 15 µg extract has a longer shelf life. The result is depicted in Figure 3. For 2.5 µg sample extract, the ripe, moderately ripe, and unripe banana peel powder showed 88.88%, 83.61% and 80.01% antioxidant activity respectively. Also, these values decreased as the sample extracts tended to reduce.

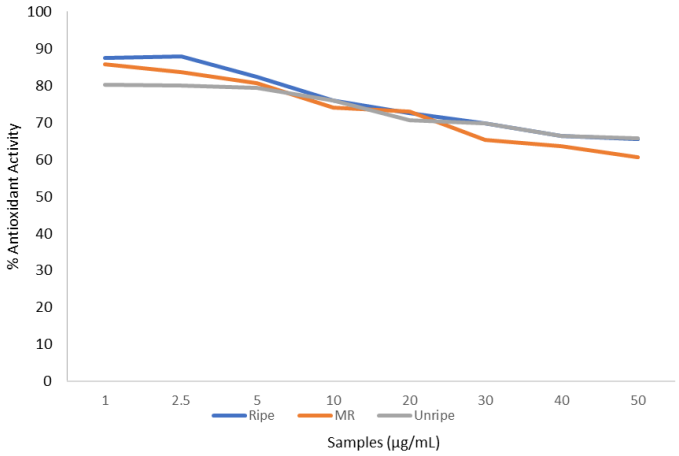

Figure 3. Antioxidant activity testing of banana peel of *Musa paradisiaca* at different concentrations.

3.4 Color values of cake samples

Color value of cake samples mentioned in Table 5 indicates that the total intensity of the samples increases with the increase in BPP percentage.

3.5 Physical characteristics of cake samples

The physical characteristics of cakes were found to be varied significantly ($p < 0.05$) with the increasing substitution of BPP and the changes are depicted in Table 6. The weight of the samples did not show significant changes compared to control. On the contrary, BPP substitution in cake decreased its volume. For example, the control sample has a volume of 346.00 cm^3, but for R_1 (1% ripe BPP), R_4 (4% ripe BPP), R_7 (7% ripe BPP) and R_{10} (10% ripe BPP), the volumes were 343.00 cm^3, 333.2 cm^3, 323.4 cm^3 and 319.30 cm^3. The trend is true for powders obtained both from the moderately ripe and unripe samples. But the specific volume shows a decreasing pattern with the increase in BPP. On the other hand, the density of cakes shows an ambivalent pattern with the increase in BPP substitution. The density of the moderately ripe BPP substituted cakes showed a wide range of variation than those of ripe and unripe samples.

Table 4. Antioxidant activity testing of banana peel powder at different concentrations.

Serial No.	Samples (µg/mL)	% Antioxidant activity (Ripe BPP)	% Antioxidant activity (Moderate ripe BPP)	% Antioxidant activity (Unripe BPP)
1	DPPH + Extract 1 µg/mL	87.57	85.89	80.25
2	DPPH + Extract 2.5 µg/mL	87.88	83.61	80.01
3	DPPH + Extract 5 µg/mL	82.39	80.79	79.42
4	DPPH + Extract 10 µg/mL	76.06	74.16	76.06
5	DPPH + Extract 20 µg/mL	72.63	73.01	70.65
6	DPPH + Extract 30 µg/mL	69.89	65.32	69.81
7	DPPH + Extract 40 µg/mL	66.38	63.64	66.31
8	DPPH + Extract 50 µg/mL	65.54	60.74	65.70

Table 5. Color values of cake containing substituted flour with different levels of banana peel powder (BPP).

Sample	% BPP in samples	L	a	b	Total intensity
Controlled		27.3 ± 0.43^{b}	8.5 ± 0.06^{b}	9.5 ± 0.32^{c}	2.71 ± 0.10^{d}
Ripe	1	26.2 ± 0.06^{b}	6.6 ± 0.06^{c}	10.4 ± 0.02^{b}	2.371 ± 0.10^{d}
	4	20.5 ± 0.07^{c}	5.8 ± 0.09^{c}	5.8 ± 0.06^{e}	8.61 ± 0.05^{a}
	7	23.2 ± 0.12^{c}	8.6 ± 0.34^{b}	8.2 ± 0.02^{d}	4.30 ± 0.06^{c}
	10	21.6 ± 0.34^{c}	7.2 ± 0.09^{c}	10.4 ± 0.06^{b}	5.86 ± 0.09^{b}
Moderate Ripe	1	27.7 ± 0.34^{b}	11.1 ± 0.54^{a}	12.4 ± 0.06^{b}	3.91 ± 0.23^{d}
	4	25.4 ± 0.67^{b}	10.1 ± 0.06^{a}	9.6 ± 0.06^{c}	2.48 ± 0.45^{d}
	7	26.6 ± 0.86^{b}	6.3 ± 0.49^{c}	6.2 ± 0.11^{d}	4.02 ± 0.06^{c}
	10	26.7 ± 0.07^{b}	5.1 ± 0.06^{c}	4.30 ± 0.26^{e}	6.24 ± 0.34^{b}
Unripe	1	25.7 ± 0.09^{b}	12.3 ± 0.08^{a}	10.50 ± 0.04^{b}	4.24 ± 0.46^{c}
	4	23.6 ± 0.06^{c}	10.0 ± 0.06^{a}	8.00 ± 0.06^{c}	4.26 ± 0.36^{c}
	7	31.4 ± 0.02^{a}	11.3 ± 0.04^{a}	16.40 ± 0.02^{a}	8.50 ± 0.16^{a}
	10	25.80 ± 0.02^{b}	8.70 ± 0.03^{c}	10.70 ± 0.16^{b}	1.93 ± 0.06^{d}

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

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Table 6. Physical characteristics of cake samples containing substituted flour with different levels of banana peels powder (BPP).

Samples	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Density (g/cm^3)
C	253±0.02[a]	346.00±0.45[a]	1.367±0.45[a]	0.731±0.02[d]
R_1	250±0.34[a]	343.00±0.67[a]	1.372±0.02[a]	0.728±0.12[d]
R_4	250±0.02[a]	333.2±0.10[a]	1.332±0.45[b]	0.758±0.32[c]
R_7	250±0.76[a]	323.4±0.25[b]	1.293±0.56[b]	0.773±0.54[c]
R_{10}	250±0.34[a]	319.3±0.45[b]	1.277±0.34[b]	0.782±0.11[c]
MR_1	250±0.02[a]	311.4±0.65[b]	1.245±0.25[c]	0.802±0.65[c]
MR_4	250.09±0.64[a]	301.1±0.34[c]	1.204±0.34[c]	0.830±0.02[b]
MR_7	250±0.34[a]	290.2±0.64[c]	1.160±0.67[c]	0.861±0.09[b]
MR_{10}	250±0.65[a]	285.8±0.43[c]	1.143±0.65[c]	0.874±0.04[b]
UR_1	250±0.23[a]	280.7±0.34[d]	1.122±0.26[c]	0.890±0.03[b]
UR_4	250±0.64[a]	275.8±0.02[d]	1.103±0.62[c]	0.906±0.02[a]
UR_7	250±0.22[a]	270.5±0.02[e]	1.082±0.42[c]	0.924±0.09[a]
UR_{10}	250±0.82[a]	260.1±0.34[e]	1.042±0.02[c]	0.961±0.07[a]

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

Table 7. Total plate count for bacteria (log CFU/g).

Samples	Storage time (days)				
	0	3	6	9	12
Control	N.O.	N.O.	2.40±0.98[a]	3.50±0.43[a]	5.40±0.98[a]
R_1	N.O.	N.O.	2.37±0.76[a]	3.29±0.13[b]	5.32±0.56[a]
R_4	N.O.	N.O.	2.37±0.34[a]	3.34±0.43[a]	5.33±0.43[a]
R_7	N.O.	N.O.	2.39±0.76[a]	3.41±0.34[a]	5.43±0.32[a]
R_{10}	N.O.	N.O.	2.40±0.09[a]	3.38±0.98[a]	5.22±0.76[b]
MR_1	N.O.	N.O.	2.35±0.76[b]	3.22±0.76[b]	4.90±0.09[b]
MR_4	N.O.	N.O.	2.35±0.13[b]	3.19±0.09[b]	4.83±0.76[b]
MR_7	N.O.	N.O.	2.32±0.34[b]	3.12±0.98[c]	4.43±0.34[c]
MR_{10}	N.O.	N.O.	2.30±0.98[b]	3.10±0.13[c]	4.32±0.98[c]
UR_1	N.O.	N.O.	N.O.	3.09±0.09[c]	4.24±0.13[c]
UR_4	N.O.	N.O.	N.O.	3.05±0.34[d]	4.10±0.98[c]
UR_7	N.O.	N.O.	N.O.	3.02±0.13[d]	4.00±0.13[d]
UR_{10}	N.O.	N.O.	N.O.	3.00±0.98[d]	4.08±0.09[c]

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). N.O.: Not observed.

Table 8. Mold and yeast count (log CFU/g) of BPP incorporated cake.

Samples	Storage time (days)				
	0	3	6	9	12
Control	N.O.	N.O.	2.60±0.34[a]	3.72±0.78[s]	6.40±0.61[a]
R_1	N.O.	N.O.	2.43±0.05[b]	3.64[a]±0.6[a]	6.32±0.78[b]
R_4	N.O.	N.O.	2.49±0.43[a]	3.61[a]±0.24[a]	6.33±0.61[b]
R_7	N.O.	N.O.	2.52±0.27[a]	3.57[b]±0.6[b]	6.43±0.78[a]
R_{10}	N.O.	N.O.	2.55±0.78[a]	3.53[b]±0.6[b]	6.33±0.27[b]
MR_1	N.O.	N.O.	2.43±0.24[b]	3.55[b]±0.24[b]	5.90±0.6[c]
MR_4	N.O.	N.O.	2.32±0.61[c]	3.50[b]±0.78[b]	5.83±0.78[c]
MR_7	N.O.	N.O.	2.32±0.27[c]	3.43±0.61[c]	5.43±0.24[d]
MR_{10}	N.O.	N.O.	2.20±0.05[c]	3.34±0.89[c]	5.32±0.27[d]
UR_1	N.O.	N.O.	0	3.12±0.78[c]	5.25±0.61[d]
UR_4	N.O.	N.O.	0	3.06±0.05[d]	5.10±0.58[d]
UR_7	N.O.	N.O.	0	2.94±0.27[d]	5.00±0.78[e]
UR_{10}	N.O.	N.O.	0	3.00±0.27[d]	4.08±0.78[e]

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). N.O.: Not observed.

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3.6 Microbiological analyses

Bacteria, mold, and yeast were detected through microbiological analysis of BPP-incorporated cakes stored for up to 12 days on various days. From Table 7 and Table 8, it can be found that, on day 3, no evidence of microorganism presence was detected. From the sixth to the twelfth day of bacterial growth, an increase in the number of colonies was observed. And among the samples, most colonies are found in the ripe variety. In the case of ripe varieties, the incorporation of BPP also increased the number of colonies. However, this number decreased for moderately ripe and unripe samples. In the case of mold and yeast, however, no colonies were observed on day 3 in samples containing ripe and moderately ripe BPP. Unripe BPP-incorporated samples were discovered to be an exception. On the sixth day, there was no growth of mold, yeast, or bacteria. Thus, it can be stated that, among the samples, the unripe samples containing BPP have a longer shelf life than the others.

3.7 Energy values

The energy values of BPP incorporated cakes were indicated in Table 1.

3.8 Sensory evaluation of cake samples

Table 9 displays the mean scores of cake samples' sensory evaluation for appearance, texture, flavor, palatability, and overall acceptability. The research revealed that the means of columns with the same letter do not differ significantly ($p < 0.05$). None of the cake samples scored below the minimum acceptable rating of 7 on a 9-point hedonic scale, as shown by the results of the sensory evaluation (Table 9). According to the study, the addition of 4%, 7%, and 10% BPP to cake had a significant ($p < 0.05$) effect on all sensory parameters of the cake samples S_3 (4% ripe BPP), S_4 (7% ripe BPP), S_5 (10% ripe BPP), S_6 (1% moderately ripe BPP), S_7 (4% moderately ripe BPP), S_8 (7% moderately ripe BPP) and S_9 (10% moderately ripe BPP). According to ANOVA, the taste and texture of S_2, S_{10}, S_{11}, S_{12}, and S_{13} were not significantly different.

4. Conclusion

According to the findings of this study, the addition of banana peel powder to wheat flour significantly increases the fat and total dietary fiber content of banana peel powder-containing cakes. As thepercentage of banana peel powder (BPP) increased and the amount of wheat flour decreased, the protein content of cakes decreased. In addition, the addition of banana peel powder to flour at levels (1, 4, 7 and 10%) improved cakes' increasingly important quality characteristics, such as their physical, chemical, and microbial properties, resulting in an increase in the cake's content of essential nutrients for human health, such as protein, fiber, fat and mineral elements. Moreover, the addition of banana peel powder provided the cakes with large quantities of beneficial antioxidants which delay the rancidity of the fat within the product and act as an antimicrobial, thereby positively extending the shelf life of the product. By substituting up to 10% of the wheat flour with banana peel powder, cakes of acceptable quality can be made. Thus, banana peel powder (BPP) can be utilized as a partial replacement for wheat flour in cake formulation. It can also be used as a functional ingredient in bakery products due to its low cost, ability to improve nutritional quality, and ability to preserve the physical quality of cakes containing banana peel. Therefore, the incorporation of banana peel powder into cakes is an effective and promising technique that may open new avenues in the field of bakery product fortification.

Conflict of interest

The authors declare no conflict of interest.

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Table 9. Sensory evaluation of cake samples produced as affected by different replaced level of banana peel powder (BPP).

Samples	Sensory properties				
	Appearance	Texture	Flavor	Palatability	Overall acceptability
S_1	7.7±0.483^a	7.9±0.737^a	8±0.816^a	8.2±0.788^a	8.4±0.625^a
S_2	7.6±0.966^b	7.3±0.483^b	7.9±0.567^b	7.8±0.918^b	8.1±0.737^a
S_3	7.7±0.948^a	7.7±0.674^b	7.6±1.074^b	7.8±1.032^b	7.5±0.737^b
S_4	7.7±1.059^a	8.1±0.994^a	8±0.666^a	7.0±1.054^c	7.6±0.707^b
S_5	7.7±1.059^b	7.7±0.674^b	7.7±0.948^b	8.2±0.788^a	7.9±0.699^b
S_6	7.7±0.948^a	7.8±1.032^b	8.1±0.567^a	7.4±0.843^b	7.9±0.737^a
S_7	7.5±0.707^b	7.8±0.632^b	7.9±1.100^b	7.5±1.080^b	7.6±0.843^b

Values are presented at mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

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paper.

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