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Utilization of Mango and Banana Peels to Produce Cake

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Abstract

Mango and banana processing and eating leave behind considerable of peels which are generally discarded as waste. They are rich sources of natural bioactive compounds which play an important role in prevention of diseases. The study was carried out on mango peels powder (MPP) and banana peel powder (BPP) at different replacing levels in cake formulation. Additionally, to use the MPP and BPP as a low-cost substitute for wheat flour in a cake. In the present study, the effect of MPP and BPP at different replacing levels (10, 12, 30 and 40%) on chemical, rheological, physical, sensory and antioxidant properties of cake were evaluated. The results revealed that MPP has higher protein, carbohydrates and energy value than that of BPP, while BPP had higher moisture, fat, ash and crude fiber content than that of MPP. The highest total flavonoids and scavenging activity was recorded for MPP, while highest total phenolics contents recorded for BPP. Farinograph data of wheat flour incorporated with BPP showed an increase in water absorption than that of MPP. The cakes incorporated with MPP and BPP exhibited an improvement in their antioxidant properties. Acceptable cakes with mango and banana peel flavor were obtained by incorporating up to 10% MPP and BPP. Based on the results, it is recommended that MPP and BPP be used up to 10% to complement and improve the nutritional quality, antioxidant properties and quality attributes of cakes, at a level that has keep health benefits.

Key word: *Fruit by-product, Bakery products, Bioactive compounds, Quality attributes.*

Introduction

Food processing waste is a low-cost raw material for extracting beneficial compounds like dietary fiber, natural antioxidants, and natural food additives. Furthermore, fruit and vegetable waste and byproducts are often discarded at a loss to the producer. Using the waste as a source of polyphenols could save food processors money [(1)].

Peel is a considerable by-product. Around 15-20% of the fruit is made up of the peel. It is discarded as a waste and becomes a source of contamination because it is not actually used for any commercial purpose [2].

Industrial mango processing by products can account for 35–60% of the total fruit weight. Since these wastes are difficult to dispose of, efforts have been made to make better use of by-products [3].

Mango peel has been discovered to be high in polyphenols, carotenoids, dietary fiber, vitamin E, and vitamin C, as well as having significant antioxidant properties [4].

Phenolic acids play a significant role in the inhibition of free radicals, and the antioxidant capacity of mango and other fruits is not solely due to their presence. It may also be attributable to the presence of various bioactive compounds in mango pulp and peel, such as carotenoids, vitamins, and other polyphenols phytochemicals [5].

Raw Mango Peel (RMP) powder was added to fortify whole wheat bread at three different levels (1 percent, 3 percent, and 5 percent) to improve its antioxidant properties over control (0 percent RMP powder) bread. Increased RMP powder levels, percentage weight loss, loaf height, loaf volume, and whiteness index (WI) decreased, while crumb moisture and loaf density increased, with a noticeable shift in brownness index (BI). The rheological properties of the dough were also influenced by the addition of peel, which resulted in a stiffer dough. The addition of RMP powder increased the strength of descriptors including hardness, rubbery texture, fruity aroma, after taste, and decreased porosity and typical bread aroma, according to sensory assessment using quantitative descriptive analysis (QDA). according to [6].

Dessert bananas (Musa AAA) and plantains (Musa spp.) are two types of bananas (cooking banana, Musa BBB). It is one of the world's most widely grown and consumed food crops, with global demand on the rise. Unripe bananas are high in dietary fiber, resistant starch (RS2 type: un-gelatinized starch granule), antioxidants (especially catechin, epicatechin, and gallocatechin), total phenolics, minerals (Ca, Mg, P, k), and vitamins (pro-vitamin A, B1, B2, C) [7].

Despite the beneficial health benefits for humans and the potential to deliver new product with regular composition for various industrial and domestic uses, the banana peel, which accounts for around 40% of the total weight of the banana, has been underutilized [8].

Banana peel extract (Musa acuminata) was found to be a potential source of bioactive compounds such as flavonoids and polyphenols with a wide range of medicinal properties, including high free radical scavenging activity [9].

Several studies have been performed to look into the possibility of adding value to banana peels, such as the processing of banana peel flour and the effects of ripeness stage on dietary fiber components and pectin in banana peels [10].

Butter cakes containing 1.5, 3.0, and 4.5 percent banana peels cellulose (BPC) had similar odor, tenderness, and moistness properties. Overall, the butter cakes with commercial cellulose (CC) and BPC had moderate acceptance and had higher moisture and fiber contents, volume, and viscosity than the control. The butter cake with 1.5% BPC-added had more regular and even air bubbles than the other butter cakes. Therefore, the addition of 1.5% BPC was found to be the optimum level for improving the fiber content and quality of the butter cake [11].

An increase in Na, K, Mg, and Ca contents in bread made with 10% peeled yellow banana pseudo-steam flour. These findings suggested that green banana flour (GBF), especially that made by freeze-drying, could be used as a supplement to boost the essential minerals in bread products [12].

This work was conducted to study the effect of incorporating mango and banana peels powder at various concentrations on several critical cake quality properties such as chemical, physical, rheological antioxidant activity, as well as the effect of incorporating mango and banana peels powder on sensory attributes of the produce cake.

Materials and Methods

Materials

The fresh mango (Mangifera indica, L.) and banana (Musa acuminata) were obtained from local market, Menoufia Governorate, transferred frozen and stored at –18oC until analysis and processing.

Wheat flour:

Wheat flour (72% extraction) was obtained from the south Cairo mills company, Cairo government, Egypt.

Additives materials:

Sucrose, butter, fresh eggs, skim milk powder, baking powder, vanilla powder, water and crude cacao, used in preparing the cake dough. These materials were obtained from the local market, Cairo, Egypt.

Chemicals

Folin-Ciocalteu reagent and standard substances including gallic acid, were purchased from Sigma Chemical Company (St. Louis, MO). All reagents and standards were prepared using Milli-Q deionized water (Millipore, Bedford, USA). All other chemicals and reagents were of analytical reagent grade and purchased from Al-Ghomhoria Company for Trading Drugs, Chemicals and Medical Instruments, Egypt.

Methods

Preparation of mango and banana peel powder

To prepare mango and banana peels, peels were washed thoroughly under running tap water to remove dirt. The peels were removed from the fruit pulp. After cutting the peels into small pieces (approximately 2.5 cm), they were dried for 48 hours at 45°C. It grinds using an air mill, high speed mixture (Molunix, Al-Araby, company, Egypt, and weighs until the drying process is complete then serving as powder seize and packed in plastic bags and placed at -18 °C in a deep freezer until further treatments.

Analytical Methods

Moisture, Protein (N x 6.25 Kjeldahl method), fat (hexane solvent, Soxhielt apparatus), fiber and ash were determined according to the method recommended by (14).

Carbohydrates and energy value

Carbohydrate calculated by differences as follows:

% Carbohydrates = 100 - (% moisture + % protein + % fat + % ash + % fiber).

Energy value was estimated by the sum of multiplying protein and carbohydrates by 4.0 and fat by 9.0 according to (15).

Determination of total phenolics

The total phenols content of mango and banana peels powder was determined spectrophotometrically using the Folin Ciocalteu reagent assay with gallic acid according to (16).

Determination of total flavonoids

Total flavonoids content was analyzed according to the method described by (17).

Determination of DPPH radical scavenging activity

Antioxidant activity was determined according to the method described by (18). The percentage of antioxidant activity of the pine extracts and standard was calculated by determining the decrease in absorbance based on the following equation:

$$Antioxidant\ activity = \frac{\{A\ (ABTS+)\ -A\ (Sample\ or\ Standard)\} \times 100}{A\ (ABTS+)}$$

Preparation of cake samples:

Approved methods were slightly altered for cake preparation according to (13). To make dry cake ingredients were mixed except sugar. The butter and supplemented materials BPP were mixed by using mixing machine at a medium speed for 3 min, then sugar was added to the mixture and beaten for 3 min, and also the beaten eggs and vanilla were added then beaten for 2 minutes and affixed to the creamed fat- sugar mix and easily beaten at low speed for 5 transactions. Wheat flour (WF) and other ingredients were added to the previous blend gradually and beaten for 5 minutes. Thirty grams of cake were scaled into the greased mug and cooked at 180°C for 25 minutes in a preheated oven. The resulting cakes stayed 2 hours for chilling. Next, packed in polyethylene

packages and stored in the refrigerator (4°C) until formula analyses. Mango and banana peel powder was added at different levels 10,20, 30 and 40%.

Rheological parameters:

Farinograph test was carried out to determine the effect of substituting wheat flour with selected levels of mango and banana peel as powders on dough rheology using a farinograph (type 810107, Brabender OHG, Duisburg, Germany) according to the standard [19] method. Parameters measured were water absorption, arrival time, development time, dough stability, mixing tolerance index and degree of softening.

Physical properties of cake:

Weight: Cake was weight on Electronic Balance Model (Precisa 205 A Super Bal. series, Swiss Quality) and repeated triple diameter.

Volume: Cake volume was measured by rapeseed displacement after cooling the cake for 1hr. at room temperature (25ºC).

Height: The height (cm3) was measured by the ruler in the center of the cake.

Specific volume: Specific volume was determined as follows:

$$Specific\ volume = \frac{Cake\ volume\ (cm^3)}{Cake\ weight\ (g)}$$

Physical properties of cake as described by [20].

Sensory evaluation:

Cake was organoleptically evaluated for their sensory characteristics (color, flavor, taste, texture, crispness, appearance, mouth feeling and overall acceptability). The evaluation was carried out according to the method of [21].

Statistical analysis

Data were recorded as means and analyzed by SPSS (Ver.10.1). One–way analysis of variance (ANOVA) and Duncan comparisons were tested to signify differences between variable treatments [22].

Results and discussion

Data presented in Table (1) show the chemical composition of mango and banana peels. It is clear to notice that the mango peels powder (MPP) had higher contents of protein, carbohydrates and energy value than banana peels powder (BPP) as dry weight. The values were 7.14, 55.13 g/100g dry sample & 310.78 kcal/100g and 6.37, 50.55 g/100g dry sample & 300.85 kcal/100g, respectively.

While banana peels had higher moisture, fat, ash and crude fiber content that mango peels, the values were 7.30, 8.13, 9.22 & 18.43 g/100g dry sample and 5.10, 7.30, 7.47 & 17.89 g/100g dry sample, respectively. These findings are in line with [23], who reported that the content of fat, protein, ash, crude fiber and carbohydrates in mango peels was 3.36 ± 0.37

to 12.61 ± 0.63 %, 2.80 ± 0.17 to 18.96 ± 0.92 %, 1.39 ± 0.14 to 12.45 ± 0.38 %, 11.81 ± 0.06 to 26.31 ± 0.01 % and 32.16 ± 1.22 to 63.80 ± 0.16 %, respectively.

According to [24] they found that banana peels had percentages of protein, fat, carbohydrate, and crude fiber concentrations of 0.90, 1.70, 59.00, and 31.70%. Banana peels have a high nutritional value, suggesting that they are a good source of nutrients.

Table (1): Proximate chemical composition (g/100g dry sample), of MPP and BPP

Characteristics	MPP	BPP
Moisture (%)	5.10 ± 0.25^{b}	7.30± 0.41^{a}
Protein (%)	7.14±0.50^{a}	6.37±0.43^{b}
Fat (%)	7.30± 0.31^{a}	8.13± 0.37^{a}
Ash (%)	7.47± 0.52^{b}	9.22± 0.61^{a}
Crude fiber (%)	17.89± 0.42^{b}	18.43± 0.48^{a}
Carbohydrates (%)	55.13± 0.64^{a}	50.55± 0.55^{b}
Energy value (Kcal/100 g)	314.78± 0.78^{a}	300.85± 0.70^{b}

MPP= Mango peel powder BPP= Banana peel powder. Each value represents mean of three replicates± standard deviation. Means in the same line with different superscript letters is significantly different at P≤0.05.

Data tabulated in Table (2) show the total phenolics, total flavonoids and scavenging activity contents of mango and banana peels powder. It is clear to mention that the highest total flavonoids and scavenging activity (DPPH) was recorded for mango peels powder (MPP), the mean values were 40.57 mg QE/g and 90.46 %, respectively. While the lowest values recorded for banana peels powder (BPP) being 23.49 mg QE/g and 41.70 %, respectively.

On the other hand, the highest total phenolics contents recorded for banana peels powder (BPP), the mean value was 21.24 mg GAE/g DW, while the lowest total phenolics content recorded for mango peels powder (MPP), being 18.93 mg/g DW. The findings are in accordance with [25], they stated that MPP contain the highest total phenolics content being, 24.06 percent. A broad range of biological effects, including anti-bacterial, anti-inflammatory and antioxidant properties, have been documented in human phenolic compounds.

Also [26], reported that the MPP contained more polyphenols and flavonoids than flesh and showed strong antioxidant activity by scavenging various free radicals, such as DPPH radicals, hydroxyl radicals, and alkyl radicals, effectively. Moreover, it has been shown that a possible anti-proliferative agent is the MPP. MPP's antioxidant and anti-proliferative activities may be due to the synergistic behavior of the bioactive compounds in which they are present.

Data presented in Table (3) show the farinograph of wheat and wheat flour with 10 % mango and banana peels flour. The obtained results indicate that the highest water

absorption (%) and arrival time (min) recorded for wheat flour with 10 % banana peels sample. The values were 71 % and 1.5 min., respectively. While the highest dough development (min) was recorded for wheat flour with 10 % mango peels sample, being 10 min.

Table (2): Total phenolic, total flavonoids and scavenging activity of MPP and BPP

Characteristics	Total phenolic	Total flavonoids	Scavenging activity
MPP	21.24± 0.11a	23.49± 0.32b	41.70± 0.30b
BPP	18.93± 0.21b	40.50± 0.45a	90.46± 0.53a

MPP= Mango peel powder BPP= Banana peel powder. Each value represents mean of three replicates± standard deviation. Means in the same column with different superscript letters is significantly different at P≤0.05.

On the other hand, the highest dough stability and degree of softening (Brabender unit, B.U) recorded for control wheat flour. The value was 12 min and 90 B.U, respectively. These results agree with [27], they reported that mango peel is rich in pectin which is a soluble dietary fiber and it had water holding capacity more than cellulose. The increase in water absorption in MPP incorporated wheat flour is mainly due to the interaction between water and hydroxyl groups of polysaccharides through hydrogen bonding. These results are agreement with [28], reported that the dough development time and dough stability increased with 10% incorporation of MPP, this may be due to high content of dietary fibers especially pectin which act as a food hydrocolloid in MPP, while the dough development time and dough stability decreased when using MKP due to their high content of lipids.

Table (3): Effect of MPP and BPP on farinograph parameters of cake dough

Samples	Water absorption (%)	Arrival time (min)	Dough development (min)	Dough stability (min)	Degree of softening (B.U)
Wheat flour	59.00	1.00	1.50	12.0	90.0
Wheat flour + 10% mango peels	65.50	1.10	10.00	10.0	80.0
Wheat flour + 10% banana peels	68.00	1.10	9.00	9.0	75.0

Each value represents mean of three replicates± standard deviation.

The effect of replacing 10 % of wheat flour with MPP and BPP on physical properties of cake was studied and the data are presented in Table (4). The results showed that all selected MPP and BPP treatments caused a slight decrease with no significant difference (P≥0.05) in cake height. The mean values were 4.23, 4.02 and 3.70 cm3, respectively.

As for weight of cake, data indicated that the replacing 10 % of wheat flour with MPP and BPP recorded a significant increased (P≤0.05) in weight of cake as compared with control cake, which were 64.30, 66.80 and 67.10 g, respectively.
On the other hand, replacing 10 % of wheat flour with MPP and BPP recorded a significant decreased (P≤0.05) in specific volume of cake as compared with control cake, which were 2.57, 2.37 and 2.28 %, respectively.
In case of volume and crust color of cake, data indicated that the replacing 10 % of wheat flour with MPP and BPP recorded a significant decrease (P≤0.05) in volume and crust color of cake as compared with control cake. The mean values were 165.0, 155.0 and 151.0 cm3 and 50.40, 47.60 and 45.90, respectively. These results are in harmony with [29] they reported that the specific volume of baked cake indicates the amount of air that can remain in the final product. A higher gas retention and higher expansion of the product leads to a higher specific volume. These results are in harmony with [30] they found that the specific volume from 1.45 to 3.43 % and concluded that specific volume gradually decreased with increasing level of other flours substitution in developed cake which is complied with this study. Mango supplemental peel powder (MPP) to cake slightly affects crust color but even more addition could make slightly darker cakes.

Table (4): Physical measurements of incorporated cake with MPP and BPP

Type of cake	Height (cm3)	Weight (g)	Volume (cm3)	Specific volume (%)	Crust color
Cake control	4.23 ±0.2a	64.30 ±2.4b	165±5.0a	2.57 ±1.3b	50.40 ±6.2a
Cake + 10% MPP	4.02 ±0.4a	66.48 ±3.3a	155±3.2b	2.37 ±1.4a	47.60±5.3b
Cake + 10% BPP	3.70 ±0.4a	67.10±3.1a	151±2.0b	2.28 ±1.5a	45.90±4.1b

MPP= Mango peel powder BPP= Banana peel powder. Each value represents mean of three replicates± standard deviation. Means in the same column with different superscript letters is significantly different at P≤0.05.

Data tabulated in Table (5) show the chemical composition of cake incorporated with MPP and BPP as dray weight. It is clear to notice that highest moisture, fat, ash and fiber content was recorded for cake replacing with 10% banana peels powder with significant difference (P≤0.05). The mean values were 14.10, 13.05, 0.30 and 1.21%, respectively.
The highest protein and carbohydrate content was recorded for control cake (100% wheat flour) with significant difference (P≤0.05), which were 8.49 and 66.05 %, respectively.
On the other hand, the highest energy value was recorded for cake replacing with 10% mango peel flour with significant difference (P≤0.05), being 412.28 kcal/100g. These results are in agree with [31], they indicated that 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. Additionally, the banana peels powder (BPP) is considered a good source of protein (15.10%) and ash (25.19%). The

real amount of partially substituted cake BPP steadily decreased as the BPP concentration increased.

Also, [32], they found that the levels of the banana peels powder (BPP) increased in cake formula; the caloric value was increased. These results may be due to a gradually BPP: Increased of protein and fat as the results of replacement of banana peels powder (BPP). Generally, it could be concluded that cake containing the banana peels powder (BPP) had a good nutritional quality with regards protein and ash contents and this is means fortifies the product with essential substances, which amount insufficient in the daily diet.

Table (5): Chemical composition of cake incorporated with MPP and BPP as dray weight

Components	Control cake (100% wheat flour)	Cake with 10% mango peels flour	Cake with 10% banana peels flour	LSD (P≤0.05)
Moisture (g)	13.24±0.40a	12.12±0.30b	14.10±0.40a	1.360
Protein (g)	8.49±0.01a	8.21±0.04a	8.06±0.03a	1.150
Fat (g)	12.00±0.04a	12.90±0.03a	13.05±0.02a	1.342
Fiber (g)	0.18±0.02a	0.23±0.01a	0.30±0.50a	0.206
Ash (g)	0.04±0.03b	0.65±0.05b	1.21±0.06a	0.570
Carbohydrates (g)	66.05±0.60a	65.89±0.31a	63.37±0.50b	3.680
Energy value (Kcal)	405.52±0.48b	412.28±0.60a	403.17±0.53b	4.710

MPP= Mango peel powder BPP= Banana peel powder. Each value represents mean of three replicates± standard deviation. Means in the same line with different superscript letters is significantly different at P≤0.05.

The organoleptic properties of cakes made partially from wheat flour and banana peel powder (BPP), as influenced by the ingredients used in manufacturing treatments. Additionally, they were strongly associated with the physicochemical consistency requirements for these products. Sensory assessment, in conjunction with estimation, has been widely used to determine the consistency of cake. As a result, the organoleptic consistency parameters (general appearance, flavor, and taste, crust color, crumb color, crumb texture, and overall acceptability) of cakes partially substituted with banana peels powder (BPP) at levels of 10, 20, 30 and 40% were evaluated.

The sensory attributes of cake incorporated with MPP and BPP are shown in Table (6). It is clear to mention that all tested sensory properties (color, flavor, taste, texture, crispness, appearance, mouth feeling and overall acceptability) were recorded the highest score for control cake sample (100% wheat flour). The mean values were ranged between 9.0-9.5 score.

Data from Table (6) also showed that increasing replacement of mango peel powder or banana peel powder in cake samples recorded a decrease in all tested sensory properties

by different rates. The lowest sensory properties recorded for cake samples with 40% replacement levels. The mean values were ranged between 5.0-5.6 score.
On the other hand, 10 % replacement of mango peel powder or banana peel powder in cake samples recorded a slight decrease in all sensory properties with no significant difference compared with control cake, therefore, its applied in cake sample in this study. The mean values were ranged between 8.5-8.9 score. It was noticed that incorporation of 20% MPP or BPP or more in cake caused relatively dark color, which may be due to the enzymatic browning. The obtained results agreed with [33], they reported that the lower score values of mango peels crackers could be due to the unattractive color and the unpleasant taste. It could be concluded that biscuits with acceptable overall quality can be prepared by substituted of wheat flour with 10% MPP. These results agree with [31] found that the organoleptic consistency attributes of cake revealed a marginally important difference between the control sample and those containing BPP up to 6% for all organoleptic properties measured and designated as excellent when compared to the control sample. As a result of this discovery, it is recommended that BPP be used up to 15% to complement and improve the quality attributes of cakes, at a level that has numerous health benefits.

Table (6): Sensory attributes of cake incorporated with MPP and BPP

Storage period (weeks)	Color	Flavor	Taste	Texture	Crisp-ness	Appearance	Mouth feeling	Overall acceptability
Control	9.0± 0.14a	9.0± 0.16a	9.0± 0.15a	9.0±0.14a	9.0±0.13a	9.20± 0.17a	9.20± 0.25a	9.50± 0.30a
10%MPP	8.7± 0.13a	8.5± 0.14a	8.7± 0.12a	8.5±0.15a	8.6±0.14a	8.90± 0.15a	8.80± 0.13a	8.70± 0.21a
20% MPP	8.3± 0.11b	8.3± 0.15b	8.5± 0.13ab	8.2±0.11b	8.3±0.12b	8.80± 0.12a	8.60± 0.14b	8.50± 0.15b
30% MPP	6.5± 0.15c	6.5± 0.12c	6.6± 0.11b	6.5±0.13c	6.4±0.14c	6.70± 0.11c	6.70± 0.10c	6.60± 0.13c
40% MPP	5.5± 0.13d	5.6± 0.10d	5.7± 0.09c	5.6±0.08d	5.5±0.11d	5.60± 0.10d	5.50± 0.12d	5.50± 0.14d
10%BPP	8.7± 0.13a	8.5± 0.14a	8.7± 0.14a	8.5±0.13a	8.6±0.16a	8.90± 0.13a	8.80± 0.12a	8.70± 0.25a
20% BPP	8.1± 0.14b	8.3± 0.12b	8.5± 0.12ab	8.2±0.11b	8.3±0.14b	8.80± 0.14a	8.60± 0.10b	8.50± 0.22b
30% BPP	6.5± 0.12c	6.5± 0.10c	6.6± 0.10b	6.5±0.07c	6.4±0.12c	6.70± 0.09c	6.70± 0.09c	6.60± 0.14c
40% BPP	5.5± 1.12d	5.6± 0.10d	5.7± 0.08c	5.60±0.09d	5.5±0.10d	5.60± 0.07d	5.50± 0.11d	5.50± 0.13d

MPP= Mango peel powder BPP= Banana peel powder. Each value represents mean of three replicates± standard deviation. Means in the same column with different superscript letters is significantly different at P≤0.05.

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الاستفادة من قشور المانجو والموز لإنتاج الكيك

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الملخص:
تصنيع وتناول المانجو والموز يخلف بعد تناولهما قدرًا كبيرًا من القشور التي يتم التخلص منها بشكل عام كمخلفات. حيث انها مصادر غنية بالمركبات الطبيعية النشطة بيولوجيًا والتي تلعب دورًا مهمًا في الوقاية من الأمراض. أجريت الدراسة على مسحوق قشور المانجو (MPP) ومسحوق قشور الموز (BPP) بمستويات استبدال مختلفة في تركيبة الكيك. بالإضافة إلى ذلك، لاستخدامMPP ، BPPكبديل منخفض التكلفة لدقيق القمح في الكيك. في هذه الدراسة تم تقييم تأثير(MPP) ، (BPP) عند مستويات استبدال مختلفة (١٠، ٢٠، ٣٠، ٤٠٪) على التركيب الكيميائي، الخصائص الريولوجية ، الفيزيائية ، الحسية ومضادات الأكسدة للكيك. أوضحت النتائج أن (MPP) يحتوي على نسبة بروتين وكربوهيدرات وطاقة أعلى من تلك الموجودة في (BPP). بينما وجد أن BPP يحتوي على نسبة رطوبة ودهن ورماد وألياف خام أعلى من محتوىMPP . تم تسجيل أعلى نسبة من مركبات الفلافونيدات ونشاط مضادات الأكسدة لـ(MPP) ، بينما سجلت أعلى محتويات الفينولات الكلية لـ (BPP) . أظهرت بيانات الفارينوجراف لدقيق القمح المضاف إليه BPP زيادة في امتصاص الماء عنMPP . أظهر الكيك المضاف إليه (MPP) ، (BPP) تحسنًا في خصائص مضادة للأكسدة. تم الحصول على الكيك بنكهة مقبولة من قشور المانجو والموز باستبدال يصل إلى ١٠٪ (MPP)،BPP). بناء على النتائج، يوصى باستخدامMPP، BPP بنسبة تصل إلى ١٠٪ لتكملة وتحسين القيمة الغذائية وخصائص مضادات الأكسدة وجودة الكيك، بمستوى يحافظ على الفوائد الصحية العديدة.

الكلمة المفتاحية: المنتجات الثانوية للفاكهة، منتجات المخابز، المركبات النشطة بيولوجيًا، سمات الجودة