Biochemical characterization of some bakery products supplemented by banana peels.

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Abstract

Bananas are one of the most important crops of tropical plants with great nutritional and biomedical values. The byproducts banana peels (**BPs**) represent about 40% of total weight of the fresh fruit. This study was conducted to evaluate the effect of addition banana peel flour (**BPP**) as a partial replacement for 72% extraction wheat flour (**WF**) on the biochemical properties of biscuits and cakes. **WF** were used to produce biscuits and cakes with replacement of 5 and 7.5% **BPP**. Different biochemical parameters were determined in control, and partially substituted with 5 and 7.5% of **BPP** biscuits and cakes. The results showed that the addition of 7.5% **BPP** increased the moisture percentage of partially substituted biscuits and cakes. **BPP** showed the highest ash content while the **WF** showed the highest crude fiber content. The highest levels of calcium, magnesium, and phenolic contents were reported in **BPP**. The addition of 5% or 7.5% of **BPP** to **WF** in biscuits did not change the weight but increased the volume, while the addition of the same percentages of **BPP** to **WF** in cake decreased the weight and did not change the volume. Collectively, the addition of 7.5% **BPP** to **WF** enhanced the nutritional value, antioxidant properties, led to improvement of shape, taste, color, and increased the volume of cakes and biscuits.

Keywords: Banana peels, Bakery products, Cake, Biscuits, Biochemical, Phytochemicals, Antioxidants.

التوصيف البيوكميائي لبعض منتجات المخابز المدعمة بقشور الموز المستخلص

يعتبر الموز من أهم محاصيل النباتات الاستوائية ذات القيم الغذائية والطبية الحيوية. تمثل المنتجات الثانوية (قشور الموز) حوالي ٤٠٪ من الوزن الإجمالي للفاكهة الطازجة. أجريت هذه الدراسة لتقييم تأثير إضافة دقيق قشر الموز كبديل جزئي لدقيق القمح المستخرج ٧٢٪ على الخواص البيوكيميائية للبسكويت والكيك.

تم استخدام دقيق القمح لإنتاج البسكويت والكيك مع استبدال ٥٪ أو ٧,٥٪ من دقيق قشر الموز وتم تحديد متغيرات كيميائية حيوية مختلفة في البسكويت والكيك المتحكم والمعالَج .أظهرت النتائج أن إضافة ٧,٥٪ من دقيق قشر الموز تزيد من نسبة الرطوبة في البسكويت والكيك المعالج. أظهر دقيق قشر الموز أعلى محتوى في الرماد بينما أظهر دقيق القمح أعلى محتوى من الألياف الخام. تم الحصول على مستويات محتوى الكالسيوم والمغنيسيوم والفينول في دقيق قشر الموز.

إضافة ٥٪ أو ٧,٥٪ من دقيق قشر الموز إلى دقيق القمح في البسكويت لم يغير الوزن بل زاد الحجم، في حين أن إضافة نفس النسب المئوية من دقيق قشر الموز إلى دقيق القمح في الكيك قلل الوزن ولم يغير الحجم. بشكل جماعي ، أدت إضافة ٧,٥٪ من دقيق قشر الموز إلى دقيق القمح إلى تحسين القيمة الغذائية وخصائص مضادات الأكسدة ، وأدى إلى تحسين الشكل والمذاق واللون وزيادة حجم الكيك والبسكويت.

Introduction

Bakery products such as bread, cakes and biscuits are one of the most important staple foods in many countries and cultures **(Zhou and Hui, 2014)**. They are increasingly becoming famous due to their convenience, affordability, availability, and nutritional ability, and are being consumed in large quantities daily **(Azizi *et al*., 2003** and **Martins *et al*., 2017)**. Banana is one of the most popular fruits in the tropical and sub-tropical regions. It is related to the family Musaceae and the genus *Musa sapientum* **(Vazhacharickal *et al*., 2021)**. The growth of banana fruits occurs within clusters. Bananas are among the ten most important crops produced by conventional cultivation systems **(Bezerra *et al*., 2013)**. Whole banana plants are useful in food, feed, pharmaceuticals, packaging, and many other industrial applications **(Mohapatra *et al*., 2010)**. There are various by-products from banana such as leaves, fruit stalks, and peels. These by-products have potential application for food additives, nutraceuticals, food supplements, renewable fuel, fibers, fertilizers as well as contaminant absorbers **(Vazhacharickal *et al*., 2021)**.

Banana has a great nutritional value due to its contents of protein, vitamins, and minerals; it is a good source of calories due to low water content **(Carr and Maggini, 2017)**. Notoriously, banana’s potassium content is very effective to prevent raising blood pressure and muscle cramps and resist venereal diseases **(Ekesa *et al*., 2015)**. Furthermore, banana does not contain even trace amounts of fat, cholesterol, or sodium which makes it a healthy food option even for restrictive diet plans **(Sampath Kumar *et al*., 2012)**.

Ferreira *et al*., (2013) stated that fruits and vegetable flour are rich in crude fiber, protein and minerals and have a high-water holding capacity and oil holding capacity. Thus, it can be used in new low-calorie and cost products. By-products recovery from fruit wastes can also improve the overall economics of processing units **(Karthikeyan and Divakar, 2018)**.

Banana peels (BPs) represent about 40% of total weight of the fresh fruit **(Anhwange *et al*., 2006)**. These peels are not being used for any other purposes and are mostly dumped as solid waste at large expense. Thus, it is significant and even essential to find application for these peels as they can contribute to real environmental problems **(Zhang *et al*., 2005)**. The total amount of phenolic compounds in **BPs** has been ranged from 0.90 to 3.0 g/100 g dry weight and gallocatechin is identified at a concentration of 160 mg/100 g dry weight **(Someya *et al*., 2002)**. Other phytochemicals such as anthocyanin, delphinidin, cyaniding, and catecholamines have been identified in ripe **BPs (Kanazawa and Sakakibara, 2000)**. As industrial by-products, **BPs** waste is normally disposed in municipal landfills, however, the problem can be recovered by utilizing its high-added value compounds, including the dietary fiber fraction that has a great potential in the preparation of functional foods **(Wachirasiri *et al*., 2009** and **Karthikeyan and Divakar, 2018)**. The aim of this study was evaluation substitution of **BPP** as a partial replacement for wheat flour on the biochemical properties of biscuits and cakes.

Materials and Methods

Materials:

Banana fruits (*Musa acuminate*) were obtained from a local market, Tanta city, Egypt. Banana fruits were stored at room temperature and all fruits were fully ripe (nearly all black skin) before usage. Banana peels (**BPs**) were removed from the flesh and submitted to drying. Peel samples were dried at 50 $^{\circ}$C in a hot air oven for 12 h and ground to obtain the particle size of less than 1.0 mm **(Adejuyitan *et al*., 2008)**.

The yield of banana peel powder (**BPP**) was calculated by dividing the amount of flour produced by the number of **BPs** fresh used and the results were converted to g of powder /kg of banana. **BPs** powder was stored in plastic packs in cold storage (4 ± 2°C) until used **(Rodriguez-Ambriz *et al*., 2008).** Wheat flour (72% extraction) and other ingredients were obtained from the local market, Tanta city, Egypt. All the chemicals and solvents used in this study are of analytical grade and were purchased from El-Gomhoria Company for Chemicals and Drugs, Tanta city, Egypt.

Methods:

Preparation of biscuits:

Ingredients used in preparation of biscuits included 65.1% mix flour, 21.4% sugar, 9.3% shortening (corn oil), 0.93% skimmed milk powder, 1.86% high fructose, 0.37% sodium bicarbonate, 1.02% ammonium bicarbonate, 0.02% vanilla and required amount of water. Fat and sugar were first creamed using the mechanical mixer for 10 min. Sodium bicarbonate and ammonium bicarbonate were dissolved in a part of water and added to the prepared creamed mixture, then high fructose was added. As the creaming process was continued, flour, skimmed milk powder and vanilla were added and stirred well together. The fully prepared dough was laminated, sheeted, extruded, molded, and formed to the required form. The formed biscuits were baked at 230 $^{\circ}$C for 7 min. according to **AACC (2000)**. After cooling for 30 min. biscuits were packaged in cellophane and subjected for sensory evaluation.

Preparation of cakes:

The cake batter was formulated from 100 g mix flour, 85g whole egg, 85 g sucrose, 55 g shortening, 3g dry milk, 3.8 g baking powder and 0.6 g vanilla. Shortening and sucrose powder were creamed together using a kitchen machine until light for 5-10 min. Flour, dry milk and baking powder were mixed, then the mixture was added gradually to shortening, sucrose, egg, vanilla and beaten for 3 min using the mixing machine at low speed. The batter was scaled at 70 g into baking pans and baked at 180 °C for 35 min. Baked cakes were left to cool for one hour at room temperature until analysis **(Bennion and Bamford 1997)**.

Determination of moisture, ash, and fibers content:

The moisture ash, and fibers contents of BPF were determined according to the methods described by **A.O.A.C. (2012)**.

Determination of total proteins, lipids, and carbohydrates content:

Total protein of plant materials was determined according to the method described by **A.O.A.C, (2005)** using Kjeldahl (Gerhardt, laboratory instrument) method. Total lipids were determined according to the method described by **A.O.A.C. (2005)** as follows: The dried sample (1.5 dry weight) was weighted and placed in Soxhlet apparatus with petroleum ether (40 - 60 °C) for 24 hrs. Finally, the solvent was removed, and the percentage of total lipid was calculated.

$$\text{Lipid (\%)} = (\text{Wt. of extracted lipid /wt. of the sample}) \times 100$$

The total carbohydrates were calculated by differences according to FAO (2008) using the following equation:

$$\text{Total carbohydrates (\%)} = 100 - (\text{moisture} + \text{ash} + \text{fat} + \text{protein})$$

Phytochemicals analysis:

Total polyphenols and flavonoids contents were spectrophotometrically determined by Folin Ciocalteu's reagent assay using Gallic acid as a standard according to **Vuong *et al*. (2015)**. Free radical diphenyl picryl hydrazl (DPPH) scavenging activity was determined by the method of **Singh *et al*. (2015)** to evaluate the antioxidant activity spectrophotometrically.

Statistical analysis:

Group's data expressed as means ± S.D. were analyzed by t-test while percentage data were analyzed by SPSS software. $p \leq 0.05$ was considered as significant value for all statistical analyses in this study.

Results and discussion

Moisture, ash, and crude fiber contents:

The moisture percentage of BPP and WF were 4.44 ± 0.28 and 11.69 ± 0.53%, respectively. While these percentages of control cake and substituted cake (**WF / 7.5% BPP**) were 8.88 ± 0.45 and 6.54 ± 0.82%, respectively. The moisture % of control biscuits and substituted biscuits (**WF / 7.5% BPF**) were 7.97 ± 0.30 and 6.17 ± 0.39%, respectively (**Figure 1A**). A previous study showed that the moisture content of **BPF** was close to 6.39% DW **(Emaga *et al*., 2007)**. Another study showed that wheat flour had 10.90% moisture content **(Singh *et al*., 2015)**. The substitution of **BPF** led to an increase in the moisture content and this could explain the presence of high moisture content in the substituted cake (**WF / 7.5% BPP**). Also, this could be due to the water binding capacity of **BPP** found quite higher than the water binding capacity of wheat flour **(Bertagnolli *et al*., 2014).**

The % of ash of **BPs** and **WF** were 8.59 ± 0.36 and 0.53 ± 0.06%, respectively. While these percentages of control cake and substituted cake (**WF / 7.5% BPP**) were 0.92 ± 0.12 and 3.97 ± 0.23%, respectively. The ash % of control WF and biscuits (**WF / 7.5% BPP**) were 0.91 ± 0.11 and 1.92 ± 0.19%, respectively (**Figure 1B**). Among all the tested conditions, the **BPs** showed the highest percentage of ash followed by cake (**WF / 7.5% BPP**). It has been reported that ripe banana peel contain a higher concentration of ash than green banana peel **(Da Mota *et al*., 2000)**. This may be due to the migration of moisture from the pulp to the skin during the ripening process, serving as a vehicle for the minerals present in the pulp **(Casallas, 2014)**.

Aydin *et al*. (2009) reported that wheat flour contains a percentage of ash below 1%. These findings were consistent with the obtained results. The % of crude fiber of **BPP** and **WF** were 53.61 ± 2.07 and 71.49 ± 3.12%, respectively. While these percentages of control cake and substituted cake (**WF / 7.5% BPP**) were 48.58 ± 2.44 and 35.17 ± 1.98%, respectively. The crude fiber % of control biscuits and substituted biscuits (**WF / 7.5% BPF**) were 68.61 ± 2.76 and 57.97 ± 2.56%, respectively (**Figure 1**). The highest crude fiber content was found in WF, while the lowest content was in the substituted cake (**WF / 7.5% BPP**). Banana peel is characterized by its high content of crude fiber. The crude fiber content was also significantly higher in banana peel flour (8.82%) than banana (1.34%) and wheat flour (0.34%). The high fiber content in banana peel flour (11.81g/100g dry peel) was also observed by **Romelle *et al*., (2016).**

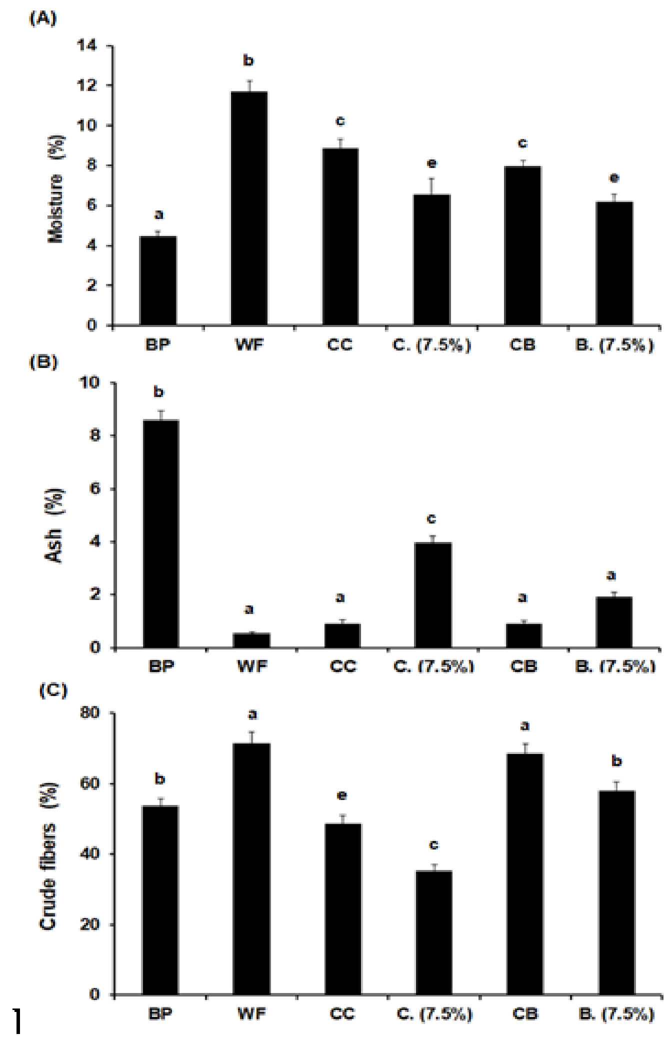

Figure (1): Moisture, ash, and crude fiber contents of banana peel (BP), wheat flour (WF), control cake (CC), cake (C) with BPP 7.5%, control biscuits (CB), and biscuits (B) with BPP 7.5%. The values represented mean ± SD. Mean that do not share a letter showed significant difference (P ≤0.05).

Total protein, lipid, and carbohydrate contents:

The results showed that the total protein contents of BP, WF, control cake and substituted cake (**WF / 7.5% BPP**) were 8.71 ± 0.47, 11.62 ± 0.65, 7.91 ± 0.32, and 7.92 ± 0.24 mg/g, respectively. While the contents of the total protein in control biscuits and substituted biscuits (**WF / 7.5% BPP**) were 7.70 ± 0.41 and 8.63 ± 0.29 mg/g, respectively (**Table 1**). A previous study reported that **BPP** had potent antioxidants and antifungal properties can be useful in commercial food or feed operations when using BPF **(Zou *et al*., 2022)**. The protein content was comparable to 10.44% **(Ohtani, 2020).** It could be seen that as the levels of the **BPP** increased in cake formula, the caloric value was increased. These results may be due to a gradual **BPP.** Increased protein and fat as the results of replacement of **BPP**. Generally, it could be concluded that cake containing the **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 **(Al-Sayed and Ahmed, 2013)**.

The total lipids content of **BP**, **WF**, control cake and substituted cake (**WF / 7.5% BPP**) were 11.45 ± 0.86, 3.37 ± 0.46, 30.24 ± 1.75 and 25.94 ± 1.42 mg/g, respectively. While the contents of the total lipids in control biscuits and substituted biscuits (**WF / 7.5% BPP**) were 14.08 ± 0.9 and 24.48 ± 1.53 mg/g, respectively (**Table 1**). Different values of lipids content in **BPP** were found due to both the differences in varieties and geographical factors **(Ohtani, 2020)**. The highest content of lipids was found in control cake, followed by substituted cake (**WF / 7.5% BPP**), then substituted biscuits (**WF / 7.5% BPP**). Carbohydrates are a significant class of naturally occurring organic molecules. The total carbohydrate contents of **BPP**, **WF**, control cake and substituted cake (**WF / 7.5% BPP**) were 53.61 ± 2.07, 71.49 ± 3.12, 250.58 ± 12.44, and 245.17 ± 11.98 mg/g, respectively. While the content of the total protein in control biscuits and substituted biscuits (**WF / 7.5% BPP**) were 68.61 ± 2.76 and 57.97 ± 2.56 mg/g, respectively (**Table 1**). Carbohydrates content was 44.64 % in the samples, indicating a good source of energy. A previous report evaluated the nutritional value of **BPP** and reported the peel as a very good potential source of carbohydrates, the peel can be used as ruminant feed **(Hikal *et al*., 2022)**.

Table (1): Total protein, lipids, and carbohydrate contents.

Parameters	Protein (g/100g)	Lipid (g/100g)	Carbohydrate (g/100g)
BPP	8.71 ± 0.47 [a]	11.45 ± 0.86 [a]	79.84 ± 2.07 [a]
WF	11.62 ± 0.65 [b]	3.37 ± 0.46 [e]	85.01 ± 3.12 [e]
Control cake	7.91 ± 0.32 [a]	30.24 ± 1.75 [c]	61. 85 ± 12.44 [f]
Cake (7.5% BPP)	7.92 ± 0.24 [a]	25.94 ± 1.42 [c]	66.14 ± 11.98 [f]
Control biscuits	7.70 ± 0.41 [a]	14.08 ± 0.98 [a,d]	78.22 ± 21.76 [f]
Biscuits (7.5% BPP)	8.63 ± 0.29 [a]	24.48 ± 1.53 [c]	33.11 ± 20.56 [f]

The values represented mean ± SD; **BPP:** Banana peel flour; **WF**: Wheat flour. Mean that do not share a letter in each column showed significant difference (P ≤0.05).

Phytochemicals analysis:

Quantitative analysis of phytochemical content in **BPP**, control cake, substituted cake (**WF / 7.5% BPP**), control biscuits, and substituted biscuits (**WF / 7.5% BPP**) were performed. The total phenolic contents of BPF, control cake, and substituted cake (**WF / 7.5% BPP**) were 963.87 ± 98.7, 565.82 ± 50.0, and 385.2 ± 26.62 mg/100g, respectively. While, the total phenolic contents of control biscuits, and substituted biscuits (**WF / 7.5% BPP**) were 92.09 ± 7.39 and 552.72 ± 43.69 mg/100g, respectively (**Table 2**). These results disagreed with that of **Aboul-Enein (2016)** and **Oguntoyinbo (2020)** who revealed that the total phenols content of **BPP** was 17.89 and 26.96 GAE/g respectively, total flavonoids was 21.04 mg/g. The flavonoid contents of **BPP**, control cake, and substituted cake (**WF / 7.5% BPP**) were 57.16 ± 7.8, 5059.5 ± 203.23, and 741.43 ± 61.86, respectively. While, the flavonoid contents of control biscuits, and substituted biscuits (**WF / 7.5% BPP**) were 1194.85 ± 64.86 and 26.57 ± 8.33 mg/100g, respectively (**Table 2**). The percentages of antioxidants activities of **BPP**, control cake, and substituted cake (**7.5%)** were 95.07 ± 6.38, 42.17 ± 3.91, and 92.53 ± 4.32%, respectively.

While, the flavonoids content of control biscuits, and substituted biscuits (**WF / 7.5% BPP**) were 44.55 ± 5.66 and 98.46 ± 3.12 %, respectively (**Table 2**).

The increase in total phenolics content (TPC) might be due to the presence of polyphenols in BPF, which increased with the increase in the BPF concentration level during the formulation of cookies. TPC of all cookies in general increased positively upon baking. It may be a result of the generation of Millard reaction of products during baking **(Lindenmeier and Hofmann, 2004)**. However, the TPC of the cookies supplemented with BPF was observed to remain higher in comparison to the control samples during the storage period, which determined their highantioxidant potential **(Asima *et al*., 2022)**. Generally, it can be announced that the addition of BPF to food products will be led to increasing amounts of natural antioxidants, so this addition will cause the prolongation of its shelf-life as well as the maintenance or enhancement its original quality properties of foods containing the BPs, beside healthy beneficial functions to food consumption **(Ahmed *et al*., 2021).**

Table (2): Phytochemicals analysis

Parameters	Phenolics (mg/100g)	Flavonoids (mg/100g)	Antioxidants (%)
BPP	963.87 ± 98.7 [a]	57.16 ± 7.83 [a]	95.07 ± 6.38 [a]
Control cake (WF)	565.82 ± 50.09 [d]	59.5 ± 203.23 [a]	42.17 ± 3.91 [b]
Cake (WF/ 7.5% BPP)	385.2 ± 26.62 [e]	74.13 ± 61.86 [c]	92.53 ± 4.32 [a]
Control biscuits	552.72 ± 43.69 [d]	114.85 ± 64.86 [e]	44.55 ± 5.66 [b]
Biscuits (WF/7.5% BPP)	425.09 ± 7.39 [f]	126.57 ± 8.33 [e]	98.46 ± 3.12 [e]

The values represented mean ± SD; **BPP:** Banana peel flour. Mean that do not share a letter in each column showed significant difference ($P \leq 0.05$).

Weight, relative weight, volume, and relative volume of the basic and manipulated cake (5%, and 7.5%).

The quality assessment of cake makes use of determinations of its physical properties, among which the most frequently tested are the volume, weight, and specific weight (true density) of cakes. The effects of BPP substitution levels on physical characteristics (Weight, volume, and specific volume) **(Ahmed *et al*., 2021)**. As shown in **Table (3A)**, the weight, relative weight, volume, and relative volume of the basic and substituted cakes (**5%, and 7.5% BP**P) were determined. The results showed that the weight of basic cake, 5% BPF cake, and 7.5% BPP cake were 40.85 ± 2.35, 28.97 ± 2.68, and 34.16 ± 1.44 g, respectively. The data showed that the relative weight of the basic and substituted cakes (**5%, and 7.5% BPP**) were 0.34 ± 0.02, 0.24 ± 0.03, and 0.28 ± 0.01 g/cm^3, respectively. The volumes of the basic and substituted cake (**5%, and 7.5% BPP**) were 122.75 ± 0.9, 119.01 ± 1.15, and 119.75 ± 0.95 cm^3, respectively. The relative volumes of the basic and substituted cake (**5%, and 7.5% BPP**) were 3.01 ± 0.18, 4.13 ± 0.34, and 3.51 ± 0.12 cm^3/g, respectively. The former results were consistent with that of who discovered that composites contain less volume than pure wheat. This can be attributed to low levels of gluten network in the dough, which results in a decreased dough's ability to grow, as well as a weak cell wall structure. The density of the cake, which is known as the weight of a unit case volume (g/cm^3), was increased by substituting ascending **BPP**. Contrary to volume and basic volume values of cakes, there were variations in density between control and different percentages of **BPP** substituted cakes **(Ahmed *et al*., 2021).** Furthermore, it has been reported that in case of cake volume, data indicated that the replacing 10 % of **WF** with **BPP** recorded a significant decrease in volume and crust color of cake as compared with control cake **(Chaiya and Pongaswatmanit, 2011).**

Thickness, diameter, and spread ratios of the basic and manipulated cake (5%, and 7.5% BPF):

The data showed that the thickness (T) of basic cake, WF/5% BPP cake, and WF/7.5% BPP cake were 3.87 ± 0.25, 3.53 ± 0.01, and 3.52 ± 0.02 cm, respectively. As shown in **Table 5,** the data showed that the diameter (D) of basic cake, **WF/5% BPP** cake, and **WF/7.5% BPP** cake were 6.75 ± 0.51, 6.01 ± 0.03, and 6.12 ± 0.25 cm, respectively. Furthermore, the spread ratio (D/T) of basic cake, **WF/5% BPP** cake, and **WF/7.5% BPP** cake were 1.75 ± 0.01, 1.72 ± 0.01, and 1.75 ± 0.01 cm, respectively (**Table 3B**). These findings agreed with **Ahmed *et al*. (2021)** 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 **(El-Kholie *et al*., 2021)**.

Table (3A): Weight, relative weight, volume, and relative volume of the basic and manipulated cake with BPP 5%, and 7.5%.

Cake	Weight (g)	Relative weight (g/cm^3)	Volume (cm^3)	Relative volume (cm^3/g)
Basic (WF)	40.85 ± 2.35 [a]	0.34 ± 0.02 [a]	122.75 ± 0.95 [a]	3.01 ± 0.18 [a]
WF/5% BPP	28.97 ± 2.68 [c]	0.24 ± 0.03 [b]	119.01 ± 1.15 [a]	4.13 ± 0.34 [a]
WF/7.5 % BPP	34.16 ± 1.44 [b]	0.28 ± 0.01 [a]	119.75 ± 0.95 [a]	3.51 ± 0.12 [a]

Table (3B): Thickness, diameter, and spread ratios of the basic and manipulated cake with BPP 5%, and 7.5%.

Cakes	Thickness (T) (cm)	diameter (D) (cm)	Spread ratio (D/T)
Basic (WF)	3.87 ± 0.25 [a]	6.75 ± 0.51 [a]	1.75 ± 0.01 [a]
WF/5%	3.53 ± 0.01 [a]	6.01 ± 0.03 [a]	1.72 ± 0.01 [a]

BPP			
WF/7.5% BPP	3.52 ± 0.02 [a]	6.12 ± 0.25 [a]	1.75 ± 0.01 [a]

Weight, relative weight, volume, and relative volume of the basic and manipulated biscuit (5%, and 7.5% BPP):

As shown in Table (4A), the weight, relative weight, volume, and relative volume of the basic and substituted biscuits (5%, and 7.5% BPP) were determined. The results showed that the weight of basic biscuit, WF/5% BPP biscuits, and 7.5% biscuit were 7.37 ± 0.02, 7.41 ± 0.03, and 7.32 ± 0.08 g, respectively. The data showed that the relative weight of the basic and substituted biscuits (**5%, and 7.5% BPP**) were 0.46 ± 0.007, 0.68 ± 0.009, and 0.66 ± 0.006 g/cm^3, respectively. The volumes of the basic and substituted biscuit (**5% and 7.5% BPP**) were 16.12 ± 0.21, 10.86 ± 0.12, and 10.93 ± 0.11 cm^3, respectively. The relative volumes of the basic and substituted biscuit (5%, and 7.5% BPP) were 2.16 ± 0.03, 1.46 ± 0.02, and 1.49 ± 0.03 cm^3/g, respectively.

Thickness, diameter, and spread ratios of the basic and substituted biscuit (5%, and 7.5%):

The data showed that the thickness (T) of basic biscuit, 5% BPF biscuit, and 7.5% BPF biscuit were 1.31 ± 0.12, 1.22 ± 0.11, and 1.35 ± 0.13 cm, respectively. As shown in **Table (5),** the data showed that the diameter (D) of basic biscuit, 5% BPP biscuits, and 7.5% BPP biscuit were 4.00 ± 0.00 cm.

Furthermore, the spread ratio (D/T) of basic biscuit, 5% BPF biscuit, and 7.5% BPP biscuit were 3.02 ± 0.27, 3.34 ± 0.28, and 3.01 ± 0.26 cm, respectively (**Table 4B**). The increase in hardness of cookie samples could be due to the increase in the amount of fiber content upon the incorporation of **BPP** when compared to control cookie samples **(Ajila *et al*., 2008)**.

A similar inclination was observed by **Alam *et al*. (2021)** where the highest spread ratio was found in 10% **BPP** cookies, but the lowest spread ratio was observed in control cookies which was found to be quite different from the present study, in which the lowest spread ratio was observed. It might be due to variations in the diameter and thickness during sheeting and cutting of dough. Water absorption capacity could also be the factor, as increasing the **BPF** concentration increases the fiber content of dough which absorbs more water, thereby decreasing its viscosity. The decrease in the diameter and thickness of cookies might be due to the dilution of gluten because the same trend was reported by **Ajila *et al*. (2008)**.

Alam *et al*. (2021) found that the cookies were also analyzed for their physical properties such as thickness, diameter, and spread factor shown in **Table(4**.A) significant variation observed in diameter and thickness of the cookies. The cookies' diameter was ranged from 5.75 cm to 5.86 cm., while thickness of the cookies was ranged from 1.22 cm to 1.42 centimeter. The highest thickness was found in cookies made without addition of **BPP**. The inclusion of BPP has a noticeable effect on the spread ratio of biscuits. The spread ratio of biscuits containing 10% **BPP** was greater than the spread ratio of other samples containing **BPP**, ranging from 7.02 to 7.15 **(Sobhan, 2013)**. The high spread ratio of prepared biscuits indicates less hydrophilic starch added from plant by-products. However, an increase in the biscuit spread ratio might indicate a lack of interaction between the protein and carbohydrate networks in the biscuits **(Mahloko *et al*., 2019).**

Table (4A): Weight, relative weight, volume, and relative volume of the basic and manipulated biscuits with BPP 5%, and 7.5%.

Biscuits	Weight (g)	Relative weight (g/cm^3)	Volume (cm^3)	Relative volume (cm^3/g)
Basic (WF)	7.37 ± 0.02 [a]	0.46 ± 0.007 [a]	16.12 ± 0.21 [a]	2.16 ± 0.03 [a]
WF/5% BPP	7.41 ± 0.03 [a]	0.68 ± 0.009 [b]	10.86 ± 0.12 [e]	1.46 ± 0.02 [c]
WF/7.5 % BPP	7.32 ± 0.08 [a]	0.66 ± 0.006 [b]	10.93 ± 0.11 [e]	1.49 ± 0.03 [c]

Table (4B): Thickness, diameter, and spread ratios of the basic and manipulated biscuits with BPP 5%, and 7.5%.

Biscuits	Thickness (T) (cm)	diameter (D) (cm)	Spread ratio (D/T)
Basic (WF)	1.31 ± 0.12 [a]	4.00 ± 0.00 [a]	3.02 ± 0.27 [a]
WF/5% BPP	1.22 ± 0.11 [a]	4.00 ± 0.00 [a]	3.34 ± 0.28 [a]
WF/7.5% BPP	1.35 ± 0.13 [a]	4.00 ± 0.00 [a]	3.01 ± 0.26 [a]

Conclusion

The results obtained from this study concluded that BPP has the highest contents of phenolic compounds, and minerals. Therefore, due to the potent antioxidant properties of BPP, the addition of 7.5% of BPP led to improvement in the nutritional values and antioxidative properties of the manipulated cakes and biscuits.

different opinions

All researchers declared that there is no conflict of research interests**.**

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