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Quality Characteristics of Fortified Cupcake by Pomegranate Peels Powder as Natural Source of Antioxidants and some Bioactive Components

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Abstract

This research was carried out to study the effect of partial replacement of wheat flour (72% extraction) with different levels of 5%, 10% and 15% of pomegranate peels powder (PPP) on the chemical, physical and sensory characteristics of cupcake. Results indicated that pomegranate peel powder addition caused a significant increase in fiber, ash, minerals, total phenolic, and total flavonoid contents of produced cupcakes, as well as enhancing antioxidant activity. While, carbohydrates content and energy value were decreased by increasing the PPP substitution levels. However, weight, volume and specific volume of produced cupcake decreased with an increasing substitution level of PPP. Moreover, crust and crumb Hunter *L *, a** and *b** values of produced cupcakes decreased with increasing the substitution amount from 5 to 15% PPP. All fortified cupcakes with PPP had a excellent sensory characteristic. Finally, PPP could be used up to 15% in cake recipes as a wheat flour substitute to produce a functional cake with high nutritional value.

KEYWORDS: Pomegranate peels; Fortified; Bioactive components; Cupcake

1. Introduction

In recent years, the production of vegetables and fruits has increased significantly due to the growing population and changes in eating habits, with more people shifting to vegetarian-based diets **[1]**. Nevertheless, it is estimated that nearly half of the horticultural produce (fruits, vegetables, and root crops) is wasted globally, reaching up to 60% **[2]**. Consumption and processing of fruits and vegetables account for almost 25-30% of waste from their peels, seeds and inedible parts **[3].** Processing wastes from fruits and vegetables are generally considered an excellent source of bioactive compounds with antioxidant activity such as vitamins, phenols and carotenoids **[4].** The protective effects of these phytochemicals on human health have been widely documented and concern the antioxidant, anti-inflammatory and anticarcinogenic action **[5].**

Pomegranate *(Punica granatum),* belonging to the family of Punicaceae, is one of the oldest known edible fruits **[6]** that is grown in the Mediterranean region and many countries of the world **[7]**. The edible part of pomegranate fruits represents about 50% (consisting of 40% juice and 10% seeds) while, peels comprise about 50% of the total fruit weight **[8].** One ton of pomegranate fruits would produce 669 kg of by-products containing 78% peel and 22% seeds **[9].** Pomegranate peels (Pericarp + mesocarp) are a rich source of dietary fiber **[10]**, minerals **[11]**, vitamins **[12]** and several bioactive compounds **[13].** The major class of pomegranate phytochemicals include; polyphenols, flavonoids, terpenes and hydrolystable tannins (punicalin, pedunculagin, punicalagin, gallic acid and ellagic acid) **[14]**. These compounds have been shown to hold heightened antioxidant and pleiotropic biological activities **[15]**.

The cake is one of the most common bakery products consumed all over the world. Cupcake is produced from different ingredients such as wheat flour, eggs, butter, sugar, milk and baking powder **[16]**. A common ingredient is wheat flour. Replacement of the type of flour can change the cake's properties and improve the nutritive value **[17]**. Previous studies indicated that using pomegranate peel powder as a source of bioactive components in bakery products could increase shelf life and improve the

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product's quality properties and nutrition value. **[18, 19, 20]**.

The current study was performed to evaluate the effect of replacement pomegranate peels powder (PPP) at different concentrations (5, 10 and 15%) on some quality properties such as chemical, physical, and sensory characteristics of the produced cupcake.

2. MATERIALS AND METHODS

2.1. MATERIALS

2.1.1. Raw materials and ingredients:

Pomegranate fruits *(Punica granatum L.)* [Manfaloty]were purchased from the local market, Mansoura, Egypt. Wheat flour (72% extraction) was provided by The Egyptian-French Company for Trade and Mills, Helwan, Cairo, Egypt. Sugar, salt, skim milk powder, eggs, corn oil, baking powder, cacao powder and vanilla were obtained from the local market, Cairo, Egypt.

All chemicals and reagents used in this study were of pure analytical grade and brought from Delta Aromatic Trading Chemicals and Drugs, Giza, Egypt.

2.2. METHODS

2.2.1. Preparation of pomegranate peels powder (PPP):

Pomegranate fruits were washed and peels were separated by a sharp knife and then cut into small pieces. After that pomegranate peels were dried at 60 ^{o}C for 48h until **[21]**. Finally, dried pomegranate peels were powdered in a laboratory disc mill (Braun AG Frankfurt Type: KM 32, Germany) to pass through 80 mesh sieves and stored in high density polyethylene bags at -18 ^{o}C until further analysis and used.

2.2.2. Preparation of cupcake samples:

Composite cupcake blends were formulated by partially substituting wheat flours with the pomegranate peel powder at proportions of 0%, 5%, 10%, and 15%. The cupcake batter was prepared with composite wheat flour (72%), white sugar, fresh eggs, corn oil, baking powder, cacao, salt, skim milk powder, tap water, and vanilla and then blended with a hand mixer. The formulation of the cupcake batter is exhibited in Table 1. The prepared blended cupcake batter was then baked in an electrical oven (Vipinho 0448, Perfecta, Curitiba, Brazil) at 180˚C ± 5˚C for 35 min. After baked, the cupcakes were left to cool to ambient temperature **[22]**.

2.3. Analytical Methods

2.3.1. Chemical Analysis

Proximate composition and energy value:

Moisture, crude protein, crude fat, crude fiber and ash were determined according to the method described in **[23]**. Total carbohydrates were calculated by difference. Energy value (Kcal) was calculated theoretically according to **[24]** as follows:

Total Energy = (protein ×4 + fat×9 + total carbohydrate×4).

Determination of some minerals content:

Ca, K, Mg, Mn, Fe and Zn content were determined in WF, PPP, and cupcake samples using Atomic Absorption Spectrophotometer-Atomic1100B Perkin-Elmer as described in **[23]**.

Table 1: Cupcake batter blends

Ingredients (g)	Cupcake blends			
	1	2	3	4
	Control	Replacement levels with PPP		
		5% PPP	10% PPP	15% PPP
Wheat flour (72% extraction)	250.00	237.50	225.00	212.50
Pomegranate peels powder (PPP)	0	12.50	25.00	37.50
Fresh eggs	110.00	110.00	110.00	110.00
Sugar	125.00	125.00	125.00	125.00
Corn oil	53.50	53.50	53.50	53.50
Baking powder	12.50	12.50	12.50	12.50
Cacao	10.00	10.00	10.00	10.00
Salt (sodium chloride)	3.50	3.50	3.50	3.50
Vanilla	2.00	2.00	2.00	2.00
Skim milk powder	25.00	25.00	25.00	25.00

Determination of total phenolic content:

The total phenolic contents of the methanolic extracts of WF, PPP, and cupcake samples were determined using the Folin Ciocalteau reagent and gallic acid was used as a standard equivalent (in mg/g) as described by **[25]**. Approximately, 500 µl of Folin–Ciocalteu reagent (Merck, Germany) were mixed to 100 µl diluted methanolic extracts. After 3 or 5 min, 400 µl 7.5% sodium carbonate were added to the mixture and allow for 30 min in room temperature and the absorbance was measured at 765 nm.

Determination of total flavonoids:

The total flavonoids were assessed by Aluminium chloride colorimetric method. One milliliter of the methanolic extract of WF, PPP, and cupcake samples was mixed well with 0.5 ml Aluminium chloride (2%), and then 3 ml potassium acetate (5%) was added. The mixture was left for 40 min at 25 C, and the absorbance of the reaction mixture was measured at 415 nm. The calibration curve was plotted by different concentrations of rutin equivalents (in mg/100g) **[26]**.

Identification of phenolic compounds:

Phenolic compounds in pomegranate peel powder extract were performed by HPLC analysis using the method described by **[27]**. Using High-Performance Liquid Chromatography (HPLC) Beckman model equipped by double piston pump 126 with Fluorescence detector LC 240 (Perkin Elmer); pump for reaction (Dioxin); Derivatisering tube 10 × 0.33mm; Data handling system (Software Gold); Column Supelcosil LC-18-DB, 25cm × 4.6 mm, 5µm; Injector 20µl (Beckman). The injection was carried out at wavelengths 280 nm for separation.

Determination of antioxidant activities:

Determination of the free radical scavenging activity was done using 2, 2-diphenylpicrylhydrazyl (DPPH) as a substrate according to **[28]** with minor modifications. Substrate-methanol stock solution (0.004% w/v) was freshly prepared for all samples, controls, and standard curve. One mg of each sample was dissolved in 100 µl methanol solution (including negative controls); then, 3.9 ml of methanol stock solution (0.004% w/v) was added to all samples for dilution. Vigorous shaking was done at room temperature for 15 min, and then all samples were allowed to stand in the dark for 30 min for the color development. The absorbance of all samples (including samples, blank, controls, and standard) was measured at 517 nm using UV-Vis spectrophotometer. The percentage of DPPH was calculated according to this equation % DPPH = [(A1–A2)/A2×100]; where A1 is control absorbance, and A2 is sample absorbance (samples) **[28].**

2.3.2. Physical properties

Weight, volume and specific volume:

The average weight (g) of prepared cupcake samples was determined individually within one hour after baking using a semi-analytical balance (PB 3002, Mettler Toledo, Greifensee, Swiss). The volume (cm^3) was determined by rapeseed displacement. While, specific volume (cm^3/g) was calculated according to the method of **[29]** using the following equation:

Specific volume (cm^3/g) = volume (cm^3) / weight (g).

Loss of mass upon baking:

The physical properties of uncooked dough and the bread were determined. The loss of mass upon baking (% LM) was determined according to **[29]** and calculated by using the following equation:

$$\textbf{LM (\%)} = \frac{M_{\text{dough}} - M_{\text{bread}}}{M_{\text{dough}}} \times 100$$

Where: M dough corresponds to the mass of the dough and M bread corresponds to the mass of the bread.

Color determination:

The color was determined according to the color system described by **[30]**. To corresponding Hunter $L*$, $a*$, and $b*$color According to the International Commission on Illumination parameter $L*$ was responsible for lightness. The values $+a*$, $-a*$, $+b*$, and$-b*$, respectively, represented the colors: red, green, yellow, and blue.

2.3.3. Sensory evaluation

Pomegranate peel powder fortified cupcakes were evaluated for sensory characteristics i.e appearance, crust color, crumb color, taste, aroma, and overall acceptability on 9-poin Hedonic scale **[29]**. Ten panelists of staff of Food Science and Technology Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt were evaluated the sensory quality of cupcake samples. The panelists were given an evaluation form to write their comments. Randomly coded samples were served to panelists individually. Scores were based on a hedonic scale of 1 to 9, where;1 = dislike very much (very bad) and 9 = like very much (excellent).

2.3.4. Statistical analysis:

All results were expressed as mean values ± standard error by using one-way analysis of variance (ANOVA) followed by Duncan test using the SPSS version 20 statistical computer program according to **[31]**.

3. RESULTS AND DISCUTIONS

3.1. Proximate chemical composition:

The mean value of proximate chemical composition and energy content (Kcal) of WF, PPP and fortified cupcake with different concentrations (5, 10 and 15%) of PPP are shown in Table 2. As shown in the obtained data Table 2, WF had higher levels of protein, fat, and carbohydrates content than PPP, while PPP had higher levels of crude fiber and ash content than WF. Also, data revealed that ash and fiber content of produced cupcake increased significantly *($p<0.05$)* with increasing the PPP substitution levels and the values ranged from 1.85% and 1.65% in 5% PPP to 2.25% and 2.37% in 15% PPP; respectively compared with control cupcake which contained (1.43% and 0.75%); respectively, Also, an increase in the percentage of moisture was observed with an increase in the percentage of replacement. On the other side, a gradual decrease in protein, fat and carbohydrates contents were noticed in the same samples and reached 8.25%, 8.23% and 56.30% %); respectively, in cupcake samples containing 15% PPP, against 8.69%, 9.12% and 58.25% of the control cupcake sample; respectively. From the same Table, it could be demonstrated that the energy value (Kcal/100g) was slightly and gradually decreased in tested samples and reached 332.27 Kcal in cupcake samples supplemented with 15% PPP compared with control (349.84 Kcal).

These results are in harmony with those that **[20]** found that adding pomegranate peels in cupcakes caused a significant increase in dietary fiber and crude ash. Also, **[32]** indicated that incorporating pomegranate peel powder into wheat flour improved the nutritional properties of produced cookies.

3.2. Minerals content

Minerals content of WF, PPP and cupcake samples containing substituted flour with different levels (5, 10 and 15%) of PPP were determined and recorded in Table 3The data in table Table 3 indicated that PPP contained the highest levels of Ca, K, Mg, and Fe compared to WF. Data also indicated that the content of Ca, K, Mg, and Fe increased significantly with the substitution levels of PPP from 5% to 15% in all the tested cupcake samples compared with control. In this concern, cupcake fortified with 15% PPP exhibited higher content of Ca (107.50 mg/100g), K (149.12 mg/100g), Mg (52.90 mg/100g), and Fe (4.83 mg/100g) than the control cupcake. On the other hand, the level of Zn and Mn was slightly decreased in cupcake samples with the replacement of PPP up to 15% of wheat flour. This increased mineral content of produced cake may be attributed to the high concentration of these minerals in pomegranate peels compared to wheat flour **[33, 18, 20]**.

Table 2: Proximate chemical composition and energy value of WF, PPP and cupcake fortified with PPP:

Samples	Proximate chemical composition (%)						Energy value (Kcal)
	Moisture	Protein	Fat	Ash	Fiber	Carbohydrates•	
WF (72%)	11.04±0.23^{b}	8.95±0.29^{a}	1.51±0.46^{a}	0.68±0.14^{b}	0.56±0.88^{b}	77.26±0.55^{a}	357.81±0.56^{a}
PPP	13.80±0.15^{a}	3.24±0.14^{b}	1.43±0.23^{ab}	3.56±0.88^{a}	17.43±0.12^{a}	59.52±0.53^{b}	267.91±0.50^{b}
Cupcake samples							
Control▲	21.75±0.02^{c}	8.69±0.07^{a}	9.12±0.01^{a}	1.43±0.05^{d}	0.75±0.05^{d}	58.25±0.01^{a}	349.84±0.70^{a}
5% PPP	21.85±0.08^{c}	8.50±0.05^{b}	9.02±0.05^{b}	1.85±0.08^{c}	1.65±0.01^{c}	57.13±0.05^{b}	343.70±0.50^{b}
10% PPP	22.24±0.11^{b}	8.33±0.02^{c}	8.64±0.11^{c}	1.92±0.07^{b}	1.96±0.06^{b}	56.87±0.1^{c}	338.64±0.20^{c}
15% PPP	22.60±0.08^{a}	8.25±0.01^{d}	8.23±0.23^{d}	2.25±0.05^{a}	2.37±0.01^{a}	56.30±0.06^{c}	332.27±0.30^{d}

Means of three replicates ± standard error; means with different superscripts within the same column differ significantly *($p<0.05$)*; • calculated by difference. WF: wheat flour; PPP: Pomegranate peels powder ▲: control cupcake made from 100% wheat flour.

Table 3: Minerals content (mg/100g) WF, PPP, and fortified cupcake with PPP (on dry weight basis):

Samples	Minerals content (mg/100g)					
	Ca	K	Mg	Fe	Zn	Mn
WF (72%)	124.30±1.64^{b}	48.10±1.20^{b}	57.35±0.14^{b}	4.10±0.04^{b}	0.87±0.01^{a}	0.91±0.05^{a}
PPP	340.75±1.80^{a}	164.30±1.15^{a}	77.33±0.08^{a}	10.25±0.08^{a}	0.83±0.05^{a}	0.50±0.06^{b}
Cupcake samples						
Control▲	109.03±0.08^{d}	89.26±0.14^{d}	36.50±0.29^{d}	2.56±0.05^{d}	1.37±0.03^{a}	0.45±0.08^{a}
5% PPP	125.2±0.43^{c}	97.10±0.57^{c}	43.05±0.57^{c}	4.13±0.04^{c}	1.21±0.02^{b}	0.43±0.02^{b}
10% PPP	146.6±0.88^{b}	103.62±0.18^{b}	48.60±0.88^{b}	4.52±0.05^{b}	1.14±0.05^{c}	0.40±0.05^{c}
15% PPP	149.1±0.20^{a}	107.50±0.28^{a}	52.90±0.52^{a}	4.83±0.04^{a}	1.22±0.01^{b}	0.37±0.05^{d}

Means of three replicates ± standard error; means with different superscripts within the same column differ significantly *($p<0.05$)*. WF: wheat flour; PPP: Pomegranate peels powder; ▲: control cupcake made from 100% wheat flour.

3.3. Total phenolics, total flavonoids and antioxidant activity of pomegranate peels powder:

Phytochemicals such as phenolics, flavonoids, and carotenoids from agri-food wastes may effectively reduce the risks of some cancer and cardiovascular disease because of their bioactivity as antioxidants and anticancer agents **[34]**. The mean value of total phenolics (mg gallic acid equivalent /100 g dry weight), total flavonoids (mg rutin equivalent /100g dry weight), and antioxidant activity (%) of pomegranate peels powder are shown in Table 4. The results in Table 4 showed that pomegranate peel powder contains high amount of total phenolics (1472.80 mg/100g); total flavonoids (350.24 mg/100g), and antioxidant activities (93.15%). These results are in harmony with **[35, 36]**.

Table 4: Total phenolics, total flavonoids and DPPH antioxidant activity of pomegranate peels powder.

Bioactive component	Pomegranate peels powder (M±SE)
Total phenolics (mg GAE/100g)	1472.80 ± 1.65
Total flavonoids (mg rutin /100g)	350.24 ± 0.96
Antioxidant activity by DPPH scavenging (%)	93.15 ± 0.52

Means of three replicates ± standard error**.**

3.4. Identification of phenolic compounds in pomegranate peels

The phenolic compounds in pomegranate peels powder were analyzed using the HPLC technique; the results are listed in Table 5 and Figure 1.

The obtained data in Table 5 indicated that PPP contains different types of phenolic compounds, the major phenolics fractions in PPP were ellagic, caffeic, isoferulic, pyrogallol, gallic and p-coumaric, which were found at the level of 16.57, 14.26, 8.33, 5.74, 4.89 and 2.66 µg/g; respectively. These results are nearly in accordance with those obtained by **[37, 12, 38]**.

3.5. Total phenolics, total flavonoids, and antioxidant activity of prepared cupcake

The mean value of total phenolics (mg GAE/100 g), total flavonoids (mg rutin /100g), and antioxidant activity (%) of the fortified cupcake with different levels (5, 10, and 15%) of PPP are shown in **Table (6)**. The results revealed a significant increase ($P < 0.05$) in total phenolics; total flavonoids and antioxidant activity among all treatments reflected that addition of PPP increases the former contents in cupcake samples. Total phenolics and total flavonoids content of produced cupcake were ranged from 646.10 mg/100g and 152.27 mg/100g in 5% PPP additives to reach (875.24 mg/100g and 194.50 mg/100g) in the fortified cupcake with 15% PPP; respectively comparing to control sample which was 206.40 mg/100g and 24.68 mg/100g; respectively. In this concern, the antioxidant activity of produced cupcakes increased from 56.56% in fortified cupcakes with 5% PPP to reach 68.26 % in fortified cupcakes with 15% PPP compared with control cupcake which recorded 15.0%.

Table 5: Quantification analysis of some phenolic compounds extracted (µg/g) from pomegranate peels powder.

Phenolic compounds	Concentration (µg/g)
Ellagic	16.57
Caffeic	14.26
Isoferulic	8.33
Pyrogallol	5.74
Gallic	4.89
p-coumaric	2.66

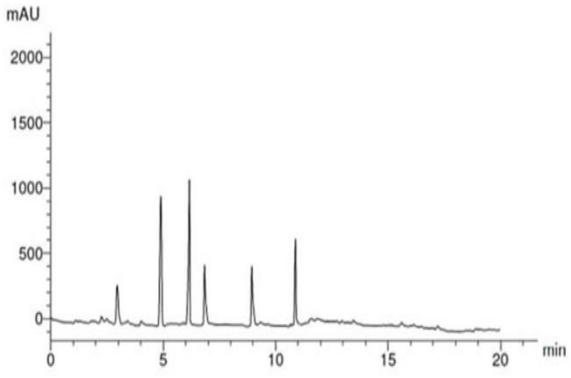

Fig 1: HPLC chromatogram of phenolic compounds in pomegranate peels extract

This increase in the content of total phenolics, total flavonoids and antioxidant activity values of the produced cupcake is most likely attributable to the fact that pomegranate peels are very rich in phenolics and flavonoids compounds **[12, 39]**. Several studies have noted significant increases in antioxidant activity and total phenolic content following the addition of pomegranate peels **[40, 41, 42]**.

Table 6: Total phenolics, total flavonoids and antioxidant activity of fortified cupcake with different levels of pomegranate peels powder (on dry weight basis)

Samples	Total phenolics (mg GAE/100g)	Total flavonoids (mg rutin /100g)	Antioxidant activity as DPPH scavenging (%)
Control	206.40 ± 0.88[d]	24.68 ± 0.32[d]	15.00 ± 0.57[d]
5% PPP	646.10 ± 0.19[c]	152.27 ± 0.20[c]	56.56 ± 0.29[c]
10% PPP	755.18 ± 0.12[b]	167.89 ± 0.97[b]	64.15 ± 0.57[b]
15% PPP	875.24 ± 0.46[a]	194.50 ± 0.25[a]	68.26 ± 0.21[a]

Means of three replicates ± standard error; means with different superscripts within the same column differ significantly *(p<0.05)*; PPP: Pomegranate peels powder ▲: control cupcake made from 100% wheat flour

3.6. Physical properties of fortified cupcake with different levels of pomegranate peel powder.

The physical properties of cupcake made from wheat flour and supplemented with 5, 10, and 15% PPP were measured in weight, volume, specific volume, and weight loss, and results are presented in Table 7.

Results indicated that there was a non-significant *(p<0.05)* difference in weight (g) of cupcake samples between all treatments. While, the volume (cm^3) of produced cupcake samples decreased significantly *(p<0.05)* with increasing replacement amount of PPP and ranged from 158 to 130 g. Results also revealed that increasing the substitution level (5%, 10%, and 15%) with PPP decreased the specific volume (cm^3/g) of fortified cupcakes compared with control samples. The specific volume was 2.864 cm^3/g for cupcake containing 5% PPP decreased to 2.380 cm3/g with an increasing substitution level of PPP to 15% compared with control samples (2.919 cm^3/g).

Our results are consistent with that of **[43]** found a significant decrease in weight and volume of sponge cake with increasing the supplementation level of pomegranate peels flour by up to 20%. Also, **[44]** indicated that the specific volume of cake gradually decreased with increasing banana peels powder substitution level from 3% to 15%.

3.7. Color values of fortified cupcake samples:

Crust and crumb color values of control cupcake and cupcake fortified with different levels 5, 10, and 15% of PPP are summarized in Table 8. Crust and crumb *L** (light/dark), *a** (green/red), and *b** (blue/yellow) values of produced cakes decreased significantly *(p<0.05)* with increasing the substitution amount from 5 to 15% PPP compared with control cupcake samples.

These changes in *L**, *a** and *b** values of PPP-fortified cupcake may be due to changes in anthocyanidin content in pomegranate peels or masked by Millard reactions that occurred during baking **[45]**. A significant decrease in *L** and *b** values in crumb color of biscuits were observed by **[46]** after replacing 5, 10%, and 15% of wheat flour with pomegranate peels powder.

3.8. Sensory characteristics

The sensory characteristics of the cupcake fortified with different concentrations of 5%, 10% and 15% of PPP were evaluated and presented in Table 9**.** The obtained results revealed that non-significant *(p<0.05)* difference between control cupcake and fortified cupcake with 5% and 10% PPP for most quality attributes (crust color, texture, appearance, odor, taste, and overall acceptability). Odor and taste for all tested cupcake samples were not affected significantly *(p<0.05)* by adding PPP up to 15% when compared with control cupcake samples. A significant ($p < 0.05$) decrease in the crust color, crumb color, texture, appearance, and overall acceptance scores was noted as the pomegranate peels levels were increased by over 10% in the formulations.

Table 7: Physical characteristics of cupcakes prepared by different replacement levels of PPP: -

Cake samples	Physical characteristics (M±SE)			
	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Weight loss (g)
Control▲	55.26±0.47[a]	161±0.88[a]	2.919±0.09[a]	1.085±0.09[a]
5% PPP	55.16±0.11[a]	158±0.57[b]	2.864±0.04[b]	1.087±0.02[a]
10% PPP	54.88±0.28[a]	138±1.15[c]	2.514±0.07[c]	1.093±0.05[a]
15% PPP	54.61±0.11[a]	130±1.15[d]	2.380±0.08[d]	1.098±0.01[a]

Means ± standard error; means with different superscripts within the same column differ significantly *(p<0.05)*; PPP: Pomegranate peels powder ▲: control cupcake made from 100% wheat flour.

Table 8: Color values of fortified cupcakes with different levels of pomegranate peels powder.

Cake Samples	Hunter-lab color values					
	Crust color			Crumb color		
	L*	****a***	****b***	***L****	****a***	****b***
Control ▲	47.49±0.29^{a}	5.82±0.03^{a}	6.82±0.04^{a}	36.85±0.03^{a}	4.41±0.05^{a}	3.55±0.08^{a}
5% PPP	41.82±0.03^{b}	5.34±0.02^{b}	4.90±0.02^{b}	36.09±0.04^{b}	3.97±0.01^{b}	3.41±0.02^{a}
10% PPP	41.48±0.02^{bc}	5.08±0.04^{c}	4.80±0.03^{bc}	35.26±0.08^{c}	3.93±0.02^{b}	2.93±0.02^{b}
15% PPP	36.11±0.072^{c}	3.50±0.02^{d}	2.55±0.08^{c}	34.88±0.04^{d}	3.37±0.03^{c}	2.49±0.04^{c}

Means ± standard error; means with different superscripts within the same column differ significantly *(p<0.05)*; PPP: Pomegranate peels powder ▲: control cupcake made from 100% wheat flour.

Table 9 Sensory analysis of cupcake samples produced as affected by different replacements of pomegranate peel powder (PPP).

Cake Samples	Crust color	Crumb color	Texture	Appearance	Odor	Taste	Overall acceptability
Control ▲	8.64±0.67^{a}	8.73±0.46^{a}	8.36±0.80^{a}	8.49±0.80^{a}	8.00±0.77^{a}	8.27±0.90^{a}	8.41±0.67^{a}
5% PPP	8.27±0.64^{ab}	8.09±0.83^{ab}	8.18±0.83^{a}	8.09±0.63^{ab}	7.92±0.66^{a}	8.25±0.63^{a}	8.10±0.40^{a}
10% PPP	8.18±0.75^{ab}	8.27±0.46^{b}	8.09±0.77^{a}	8.00±0.77^{ab}	7.90±0.40^{a}	8.24±0.94^{a}	8.06±0.80^{a}
15% PPP	7.92±0.60^{b}	7.98±0.87^{b}	7.55±0.80^{b}	7.64±0.80^{b}	7.89±0.55^{a}	8.25±0.50^{a}	7.62±0.52^{b}

Means ± standard error; values with different letters in the same column are significantly different *p<0.05* (n=20); PPP: Pomegranate peels powder ▲: control cupcake made from 100% wheat flour.

These results are in harmony with those results of **[46],** they noticed that there were no significant differences in sensory parameters except taste and overall acceptability of biscuits fortified with 6 and 12 % PPP, while biscuits fortified with 18% PPP received a significantly lower score that control and other treatments. Also, these results agree with the results of **[20]**. They studied the effect of partial replacement (5, 10, and 15%) of wheat flour by PPP on chemical, physical and nutritional properties of muffin cakes. The sensorial results revealed that increasing the PPP levels up to 15% caused a significant reduction in smell, flavor, and color score.

4. CONCLUSION

The replacement of wheat flour by different levels of pomegranate peel powders (0, 5, 10 and 15%) had a noticeable effect on prepared cupcake's chemical characteristics like improved dietary fiber, minerals content, and natural antioxidant activities in cupcake samples. Also, cupcake fortified up to 15% pomegranate peels powder was found to be the most accepted samples compared to the control samples. Overall, it could be recommended to utilize pomegranate peels in bakery products and other food products as a natural source of antioxidants and some bioactive components which have numerous beneficial effects on human health.

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