Improvement of rheological properties, bioactive compounds content and antioxidant activity in soft dough biscuits with the incorporation of prickly pear peels powder

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Abstract: Prickly pear peel considered as a waste by-product which obtained during processing/eating of prickly pear, huge amount of peel is generated, and its disposal is a major problem and causes environmental pollution. It constitutes about 22.5% of prickly pear fruit. In the present study, prickly pear was dehydrated under vacuum at 70^{0}C for 4 hrs to obtain prickly pear powder (PPP) with 6.06% moisture content. PPP was chemically analyzed, incorporated into biscuits at two different levels, 5.0 and 10.0% as a potential source of bioactive compounds and natural antioxidants. Chemical analysis indicated that PPP contains high levels of many valuable antioxidants such total phenolics, (411.87 mg EGA.100g^{-1} DW) and carotenoids (269.65 mg.100g^{-1} DW) as well as total dietary fiber (36.67 g.100g^{-1}DW). The total dietary fiber, carotenoids and total phenolics content in biscuit increased from 6.92 to 10.74 g.100g^{-1}, 3.49 to 30.94 mg.100 g^{-1} and 111.87 to 158.98 mg EGA.100g^{-1} with 10% incorporation of PPP, respectively. Also, the antioxidant activity (AA) in control biscuits was 30.65% which increased to 36.87 and 44.45% with the incorporation of PPP by 5 and 10%, respectively. Also, significant ($P \leq 0.05$) improvements in rheological properties of biscuits dough including farinograph and extensograph parameters were reported by PPP incorporation. In conclusion, the results suggest that by PPP incorporating up to level 10%, it is possible to enhance the nutritional quality, rheological properties, bioactive compounds content and antioxidant activity of biscuit without affecting on its sensory characteristics.

Keywords: Prickly pear powder, biscuit, incorporation, dietary fiber, total phenolics, phenolics, carotenoids, antioxidant activity, sensory characteristics.

Introduction

Prickly pear (*Opuntia ficus-indica*), commonly known as prickly pear, belongs to the family *Cactaceae*. This family is reported to contain about 130 genera and nearly 1500 species, which were originally native to the New World. Being so water-use efficient, they are highly useful in arid and semiarid environments, particularly during prolonged dry spells or failure of the monsoon (Sing, 2003). The prickly cactus pear is widely distributed in Latin America, South Africa and the Mediterranean area including Egypt, (Hassan, 2011). It has been used in traditional folk medicine because of its role in treating a number of diseases and conditions, including anti-inflammatory effects (Park *et al*, 1998), hypoglycemic effects (Frati *et al*, 1990), inhibition of stomach ulceration (Galati *et al.*, 2003), neuroprotective effects (Dok-Go *et al.*, 2003). Through antioxidant actions and also used for treating diabetes, burns, bronchial, asthma and indigestion in many countries over the world (Kim *et al.*, 2006). One of the most frequently utilized fruit and vegetable technologies is juice production. Juices, in general, are represent a good source of sugars, vitamins and minerals; all valuable components to human health. Also, Pontiac fruits and young stems have been traditionally used in folk medicine to treat diabetes, hypertension, asthma, burns, edema, and indigestion (Cardador-Martinez *et al.*,2011 and Abou-Elella and Ali, 2014). In addition to their nutritional and medicinal properties, these plants contain compounds which have several commercial applications. In addition, the phenolic constituents of the of peels prickly pear cactus were isolatedand identified using different chromatographic techniques (Huseain, 2013). Studies aims to magnify the using of prickly pear peel in food and nutritional applications are still a dearth, and more research is required.

Bakery products such Biscuits are the most popularly consumed bakery items in almost countries all over the world including Egypt because of their ready to eat nature, affordable cost, good nutritional quality, availability in different tastes and longer shelf life (Gandhi *et al.*, 2001). Many studies were carried out on the use of oat bran, wheat bran, rice bran as a source of dietary fiber content in bread and other bakery products as well as the influence of these different cereal brands on sensory characteristics of biscuits (Leelavathi and Haridas, 1993, Sidhu *et al.*, 1999 and Sudha *et al.* (2007). But other studies reported that fruit dietary fiber concentrates have better nutritional quality than those found in cereals due to higher proportion of soluble dietary fiber (SDF) and significant content of dietary fiber associated antioxidant compounds (Chau and Huang, 2003 and Vergara-Valencia *et al.*, 2007 and Ajila *et al.*, 2008).

According to our knowledge studies on the prickly pear peel as dietary fiber and bioactive compounds source are limited. Therefore, the aim of the present study is to prepare prickly pear peels powder (PPP) which will be used as a potential source of phenolics, carotenoids and dietary fiber in biscuits preparations. Also, rheological properties of the ppp mixing flour biscuits will be in the scope of this investigation.

Materials and Methods

Materials

Fresh prickly pear fruits were purchased from local market at Benha city during the summer season of the year, 2017. Wheat Flour (72%) was purchased from El Doha for Food Stuff Packaging, 10th of Ramadan, El Sharkeya, milk powder (skim) from Nestlé, sugar and margarine from Savola Foods, corn oil from ARMA Oils, 10th of Ramadan, vanillin and baking powder from Tag El- Melouk for Food Industries 6th October City and fresh egg from supermarket hypermarket at Benha city, Egypt. Phenolic standards and α-tocopherol were purchased from Sigmae-Aldrich Chemical Co agent, Egypt. All other chemicals and solvents were of analytical Grade and purchased from AlGhomhoria Co for Trading Drugs, Chemicals and Medical Instruments, Cairo, Egypt.

Methods

Prickly pear peels powder (PPP) preparation

Fresh prickly pear fruits were washed with cold water and fractionated to separate the peels. The obtained peels were subjected to dehydrate under vacuum (Vacutherm Vacuum Ovens, Leicestershire, UK) at 70 0C for 4 hrs. Dried peels parts were milled in electrical blender (Philips, France).The final peels powder was packed in polyethylene bags and stored at 40C until using.

Processing of biscuit samples

Biscuit were prepared using the formula suggested by Omobuwajo (2003) as follows: 500 g flour, 150 g fat, 160 g sugar, 10g milk powder, 5.4g sodium chloride, 2 g sodium bicarbonate or baking powder, 100 g shortening and 150-500 ml water. Blends of 5.0 and 10% were prepared by substituting wheat flour with PPP. The ingredients were formed into dough in a z-blade mixer (Moulinex mixer model super mix 150, France). The fat and sugar were first blended for 2 min. Then the Sodium bicarbonate or Baking powder and salt, which were dissolved in some of the water, was added followed by the reconstituted milk. The flour was fed into the mixer and as it started to blend with the other ingredients, the remaining water was added. Mixing time was between 5 and 7 min. By using semiautomatic biscuits machine (Measure 10, China), the dough was rolled into a continuous sheet of approximately (0.8 cm) thickness and cut using a (3.7cm) diameter round cutter with a molding shell. Biscuits were transferred to baking tray and baked tray and baked at 190 ˚C for 8-10 min in a Michael Wenze Ideal oven (Michael Wanze, Arnstein, Netherlands). After baking, biscuits were left from baking tray with a wide spatula, left to cool at room temperature, packed in polypropylene pouches and sealed until further analysis.

Chemical analysis of PPP and biscuits samples

PPP and biscuits samples were analyzed for moisture, protein (TN× 6.25, micro - kjeldahl method using semiautomatic apparatus, Velp company, Italy) , fat (soxhelt semiautomatic apparatus Velp company, Italy , petroleum ether solvent), ash and fiber contents were determined using the methods described in the AOAC. (1995). Carbohydrates calculated by differences:

$$\text{Carbohydrates (\%)} = 100 - (\text{\% moisture} + \text{\% protein} + \text{\% fat} + \text{\% Ash} + \text{\% fiber})$$

Water (WHC) and oil (OHC) holding capacity of PPP

Water (WHC) and oil (OHC) holding capacity were determined according to the method of Larrauri *et al.*, (1996). Twenty-five milliliters of distilled water or commercial corn oil were added to 0.5 g of PPP, shacked vigorously for 1 min and then centrifuged for 15 min at 10,000g. The residue was weighed and the WHC and OHC were calculated as g water or oil per g of dry sample, respectively.

Rheology properties measurements

Both wheat flour control sample and samples with additions of PPP were determined by using of farinograph and extensograph tests according to the methods of A.A.C.C. (1969) as the following:

Farinograph

Farinograph test was carried out on a Brabender R Farinograph (Brabender R GmbH & Co, Duisburg, Germany) to determine the water absorption, dough development time, dough stability and dough weakening of wheat flour control sample and samples with additions of PPP according to the following procedure: A 300 grams of wheat flour were placed in the farinograph bowel and the burette filled with water at room temperature and set at zero adjustment. The machine was set at high speed and was run for one minute until zero minute line was reached. Water was added immediately to the side of the bowel from the burette nearly to the volume expected to be the right absorption of flour. When the dough was beginning to be form, sides of the bowel were scraped down. When the mixing curve leveled off at a value larger then 500 Brabender unit (B.U), more water was added and the bowel was covered with a glass plate tp prevent evaporation. Subsequent titration were needed to adjust the absorption curve at 500 B.U for final titration the total volume of water was added within 25 seconds after opening burette's stopcock. Absorption values were corrected to the nearest 0.1% and were calculated on 14% moisture basis by means of the following equation:

$$\text{Absorption } \% = (x + y - 300) / 3$$

Where:
x, ml of water required to produce curve with maximum consistency entered on 500 B.U. line and y, grams of flour equivalent to 300 grams 14% moisture basis.

Extensograph

Extensograph test was carried out on a Brabender R Extensograph (Brabender R GmbH & Co, Duisburg, Germany) to determine the maximum resistance to extension extensibility and strength of the dough (energy) of wheat flour control sample and samples with additions of PPP according to the following procedure: A normal run of a farinograph was made in order to estimate the water absorption capacity of the flour. The estimated water containing 6 grams of salt was added to 300 grams of flour to form dough having consistency of 500 B.U. The ingredients were then mixed for one minute and the mixing was stopped after 5 minutes of rest mixing was resumed and continued until the full development time of the farinograph. When mixing was completed dough of 150 grams was scaled off and was given 20 revolution in the extensograph rounder. The dough ball was carefully centered on the shaping unit and rolled into a cylindrical test piece, which was then clamped in a lightly greased dough holder and stored in humified chamber for testing. After rest period of nearly 45 minutes from the shaping operation, the test sample was placed on the balance arm of the extensograph and pen was adjusted horizontally of zero line on chart. At exactly 45 minutes from the end of the shaping operation, the stretching hook was started. It was stopped when the test piece broke. Afterthat, the dough was removed from its holder, reshaped and allowed a rest period of 45 minutes, and then stretched again. By repeating this procedure, the dough was tested at 45 minutes, 90 minutes and 135 minutes total time. The following measurements were made on the extensograms, resistance to extension, extensibility and energy (area under curve, cm^2), to evaluate the results of the extensograph.

Determination of total phenolics, carotenoids, total dietary fiber and antioxidant activity

Total phenolics, carotenoids and Total dietary fiber in PPP and biscuits samples were analyzed as follow: PPP was extracted with 80% acetone and centrifuged at 10,000g for 15 min. For biscuits samples, one gram of biscuit powder was extracted with 20 ml of 80% acetone and centrifuged at 8000g at room temperature. The supernatant obtained from both samples were used for the analysis of total phenolics, carotenoids and antioxidant activity.

Total phenolics were determined using Folin-Ciocalteu reagent (Singleton and Rossi, 1965). Two hundred milligrams of sample was extracted for 2 h with 2 mL of 80% MeOH containing 1% hydrochloric acid at room temperature on an orbital shaker set at 200 rpm. The mixture was centrifuged at 1000g for 15 min and the supernatant decanted into 4 mL vials. The pellets were combined and used for total phenolics assay. One hundred microliters of extract was mixed with 0.75 mL of Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) and allowed to stand at 22 0C for 5 min; 0.75 ml of sodium bicarbonate (60g/L) solution was added to the mixture after 90 min at 22 0C, absorbance was measured at 725 nm. Results are expressed as ferulic and equivalents. The total carotenoids in 80% acetone extract were determined by using the method reported by Litchenthaler (1987). Total dietary fiber content in the MPP was estimated according to the method described by Asp *et al.*, (1983).

Antioxidant activity of PPP, biscuits samples extract and standards (α-tocopherol, BHA, ans BHT; Sigma Chemical Co., St. Louis, Mo) was determined according to the β-carotene bleaching method following a modification of the procedure described by Marco (1968). For a typical assay, 1mL of β-carotene (Sigma) solution, 0.2 mg/mL in chloroform, was added to round-bottom flasks (50 mL) containing 0.02 mL of linoleic acid (J.T. Baker Chemical Co., Phillipsburg, NJ) and 0.2 mL of Tween 20 (BDH Chemical Co., Toronto, On). Each mixture was then dosed with 0.2 mL of 80% MeOH (as control) or corresponding plant extract or standard. After evaporation to dryness under vacuum at room temperature, oxygenated distilled water (50 ml) was added and the mixture was shaken to form a liposome solution. The samples were then subjected to thermal auto-oxidation at 50 0C for 2 h. The absorbance of the solution at 470 nm was monitored on a spectrophotometer (Beckman DU-50) by taking measurements at 10 min intervals, and the rate of bleaching of β-carotene was calculated by fitting linear regression to data over time. All samples were assayed in triplicate. Various concentrations of BHT, BHA, and α-tocopherol in 80% methanol was used as the control.

Antioxidant activity was calculated in four different ways. In the first, absorbance was plotted against time, as a kint curve, and the absolute value of slope was expressed as antioxidant value (AOX). Antioxidant activity (AA) was all calculated as percent inhibition relative to control using the following equation (Al-Saikhan *et al*., 1995).

$$AA= (R_{control} - R_{sample}) / R_{control} \times 100$$

Where: $R_{control}$ and R_{sample} were the bleaching rates of beta-carotene in reactant mixture without antioxidant and with plant extract, respectively.

The third method of expression based on the oxidation rate ratio (ORR) was calculated according to the method of Marinova *et al*., (1994) using the equation:

$$ORR = R_{sample} / R_{control}$$

Where: $R_{control}$ and R_{sample} are the same in the previous equation.

In the fourth method, the antioxidant activity coefficient (AAC) was calculated as described by Mallet *et al*., (1994).

$$AAC = (Abs_{S\ 120} - Abs_{C\ 120}) / Abs_{C\ 0} - Abs_{C\ 120}) \times 1000$$

Where: $Abs_{S\ 120}$ was the absorbance of the antioxidant mixture at time 120 min, $Abs_{C\ 120}$ was the absorbance of the control at time 120 min, $Abs_{C\ 0}$ was the absorbance of the control at zero time.

Sensory evaluation of biscuits

The sensory characteristics of control biscuits and that incorporated with PPP were conducted to determine the acceptability of the product. Biscuit samples were presented in a sealed pouch coded with different numbers to twenty panelists who were asked to rate each sensory attribute. Biscuits were evaluated for crust appearance, crust colour, texture, crispness, taste and flavor, mouth feel and overall acceptability on a 10-point hedonic scale.

Statistical analysis

All data of antioxidant activity tests was the average of triplicate analyses. The data were recorded as mean± standard deviation (SD). Significant differences between means were determined by student's-t test, p values ≤ 0.05 were regarded as significant.

Results and Discussion

Chemical analyses of prickly pear peels powder (PPP)

The proximate chemical composition of PPP is shown in Table (1). The results showed that the moisture content was recorded 6.06 ± 0.96%, total protein was 2.84 ± 0.42%, crude fat was 1.05 ± 0.11%, crude fiber was 8.51 ± 1.02%, ash content was 2.98 ± 0.44% and total carbohydrate content was 78.56 ± 4.51%. Such data confirmed that PPP could be a good source of fiber and minerals. Also, it could be used successfully in food technology applications due to its high nutritional value. The present data are in accordance with that observed by Mashaal (2016). Also, Kunyanga et al., (2012) reported that the chemical composition of PPP including moisture content, total ash, protein, fat content, total fiber and carbohydrates were 81.73, 2.90, 0.80, 0.42, 7.74 and 7.21% on wet weight basis. According to our knowledge, there is a dearth of information related to PPP chemical composition which makes the comparison and confirmation the present data is relatively difficult. In general, the present data with the other reflected the effect of prickly varieties on the chemical composition of peel (Vasso and Constantina, 2007 and Mashaal, 2016).

Table 1. Proximate composition (g.100 g^{-1} dry sample) of PPP

Component	Content
Moisture	6.06 ± 0.96
Total protein	2.84 ± 0.42
Crude fat	1.05 ± 0.11
Crude fiber	8.51 ± 1.02
Ash	2.98 ± 0.44
Carbohydrates (by difference)	78.56 ± 4.51

Each value represents the mean of three replicates ±SD.

Physical properties of PPP

The water (WHO) and oil (OHC) holding capacity of PPP was listed in Table (2). From such data it could be noticed that PPP recorded high WHC and OHC being 6.01 ± 0.43 g $H_2O.g^{-1}$ and 2.41 ± 0.15 g oil.g^{-1}, respectively. Such data are in accordance with Mashaal (2016) who reported that that the PPP high WHC is mainly attributed to high fiber content. In similar study, the WHO and OHC of some food processing by-products indicated that onion skin powder recorded the highest WHO followed by cauliflower leaves powder, potato peel powder and mango peel powder being 9.13, 8.39, 8.24 and 6.03 g $H_2O.g^{-1}$, respectively. Also, Ashoush and Gadallah (2011) found that mango peel powder was higher than that of mango kernel powder being 5.08 and 2.08 g water/g, respectively indicating that the higher fiber content in mango peel powder hold more water compared to mango kernel powder. This observation is agreed with those reported by Abdalla *et al.* (2007) and Ajila *et al.*, (2010).

Table 2. Physical properties of PPP

Parameters	Value
Water holding capacity (WHC, g $H_2O.g^{-1}$)	6.01 ± 0.43
Oil holding capacity (OHC, g $oil.g^{-1}$)	2.41 ± 0.15

Each value represents the mean of three replicates ±SD.

Effect of PPP on the rheological parameters of flour biscuits

Farinograph parameters

The results showed that all farinograph parameters were determined for wheat and wheat flour substituted with 5 and 10% PPP and the results are presented in Table (3) and Figure (1). The incorporating of tested PPP in dough increased the water absorption from 56.98 ± 1.23 for control to 58.02 ± 0.99 and 62.11 ±1.07% for dough contained 5 and 10% PPP, respectively. In similar study, Ahmed (2016) reported that the incorporating of food by-products in dough increased the water absorption from 61,21% for control to 66.91, 67.03, 65.32 and 63.65% for dough contained 5% potato, cauliflower , onion and mango peels powder, respectively. This increment dough water absorption may be due to high content of dietary fiber in these by-products which with significant difference with control. It was also substantiated by the chemical composition of PPP (See Table 1). Sudhakar and Maini, (2000) reported that by-products are rich in pectin (such PPP) which is a soluble dietary fiber and it had water holding capacity (See Table 2) more than cellulose. The increase in water absorption in PPP incorporated wheat flour is mainly due to the interaction between water and hydroxyl groups of polysaccharides through hydrogen bonding (Rosell *et al.*, 200; Chaplin, 2003 and Dikeman and Fahey, 2006). The dough development time and dough stability increased from 2.9 ± 0.25 to 3.3 ± 0.31and 4.2 ± 0.40 min with 5 and 10% incorporation of PPP, respectively this may be due to high content of dietary fibers in PPP and pectin which act as a food hydrocolloid. The increasing dough development time illustrates that the dough with the addition of PPP a longer relaxation time (the dough is tougher). Our data are in agreement with that mentioned by Ali, (2013) and Ahmed (2015). Such as mentioned by Khalil *et al.*, (1976) and Nasr (1998) the peak dough development time was affected and varied proportionally with the protein content of the flour and its quality. Consequently, the affecting on the peak dough development of wheat flour as the result of PPP addition can comes through changes occurred in wheat flour protein quality. Dough stability in minutes is the most important index for dough strength. Addition of PPP to flour samples showed markedly longer stability periods than the control samples (flour without addition of PPP). This affect was significantly with the addition of 5 and 10% of PPP for wheat flour. This affect could be attributed to the effect of PPP addition on the quality of protein and dietary fiber flour in particular the binding force property. From the viewpoint of dough farinograph quality number (FQN), statistically significant difference was found between the control sample (flour without the addition of PPP and the dough with additions of 5 and 10% of PPP ($P < 0.05$). It is meaning that an improvement in the quality of the dough occurred after the addition of 5 and 10% of PPP, when the FQN value significantly increased in comparison with the control sample. Such as mentioned by Pecivova *et al.,* (2011), FQN determines the quality of dough and thus influences the quality of the final bakery products. Therefore, in order to improve the quality of bakery products such biscuits, additions of the PPP by 5 and 10% to dough are recommended.

Extensograph parameters

Data in Table (4) and Figure (2) show the extensograph results of wheat flour control dough and dough's with additions of PPP. Dough strength (Extensibility) determined by the area under the curve and is proportional to energy needed to bring about rupture. The incorporating of PPP in dough increased the extensibility from 167 ± 3.7 mm for control to 175 ± 4.1 and 184 ± 2.8 mm for dough contained 5 and 10% of PPP, respectively. In similar study by Sayed-Ahmed, (2016) reported the incorporating of food by-products in dough increased the extensibility from 181 mm for control to 196, 201, 185 and 187 mm for dough contained 5% Potato, cauliflower, onion and mango peels powder, respectively. Dough resistance to extension in BU is the most important index for dough ability to retain gas. Addition of PPP to flour samples showed markedly increasing resistance to extension than the control samples (flour without the addition of PPP). The effect of PPP on increasing the extensibility of the wheat flour may be due to the alteration of the viscosity (Kent-Jones and Amos, 1967) and forced the gluten network (Abdel-Hamid *et al.*, 1986). Additionally, several reports suggest that all tested food by-products (PPPP and PPP) have antioxidant activity (See Table 4) (Mohmed, 2012; Elhassaneen *et al.*, 2013; Abou-Elella and Ali (2014); Osuna-Martínez et al.,2014) which could be easily prevented the oxidation process usually decreases dough extensibility (Khalil *et al.*, 1976). Also, PPP have scavenging of free radical species including reactive oxygen species (ROS) (Vasso and Constantina, 2007; Osuna-Martínez *et al.*, 2014). Oxygen from air oxidizes -SH groups forming disulfide linkage and thus, increases the cross linkage between the protein molecules responsible for the decreasing of the dough extensibility.

Table 3. Farinograph parameters of the control and composite flour biscuits

Treatment	Water absorption (WA, %)	Arrival time (AT, min)	Dough development time (DDT, min)	Dough stability (DS, min)	Farinograph quality number (FQN)
Control crackers (CC)	56.98 ± 1.23 [b]	1.4 ± 0.21 [b]	2.9 ± 0.25 [b]	4.7 ± 0.39 [b]	142 ± 4.2 [c]
CC + 5% PPP	58.02 ± 0.99 [b]	1.9 ± 0.32 [b]	3.3 ± 0.31 [b]	5.6 ± 0.53 [ab]	151 ± 2.1 [b]
CC + 5% PPP	62.11 ±1.07 [a]	2.14 ± 0.11 [a]	4.2 ± 0.40 [a]	6.7 ± 0.46 [a]	159 ± 1.8 [a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at level p≤0.05.

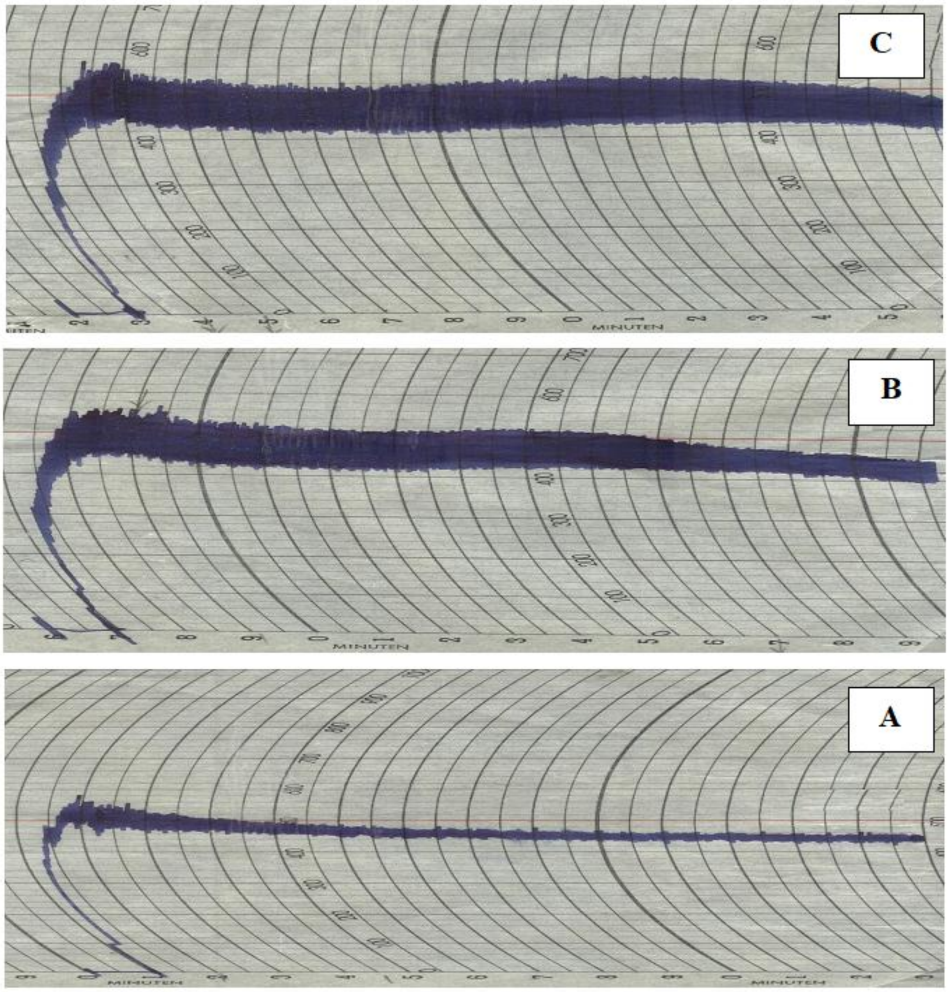


Figure 1. Farinograms of wheat flour control dough and dough's with additions of PPP [A: control dough, B: 5% PPP and B: 10% PPP]

Table 4. Extensograph of the control and composite flour biscuits

Treatment	Extensibility (mm)	Relative resistance to extension (BU)	Proportional number	Energy (cm^2)
Control crackers (CC)	167 ± 3.7 [c]	511 ± 5.5 [c]	2.83 ± 0.34 [a]	107 ± 4.7 [b]
CC + 5% PPP	175 ± 4.1 [b]	521 ± 3.1 [b]	2.70 ± 0.12 [b]	112 ± 3.1 [b]
CC + 5% PPP	184 ± 2.8 [a]	532 ± 2.9 [a]	2.76 ± 0.44 [b]	120 ± 5.9 [a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at level p≤0.05.

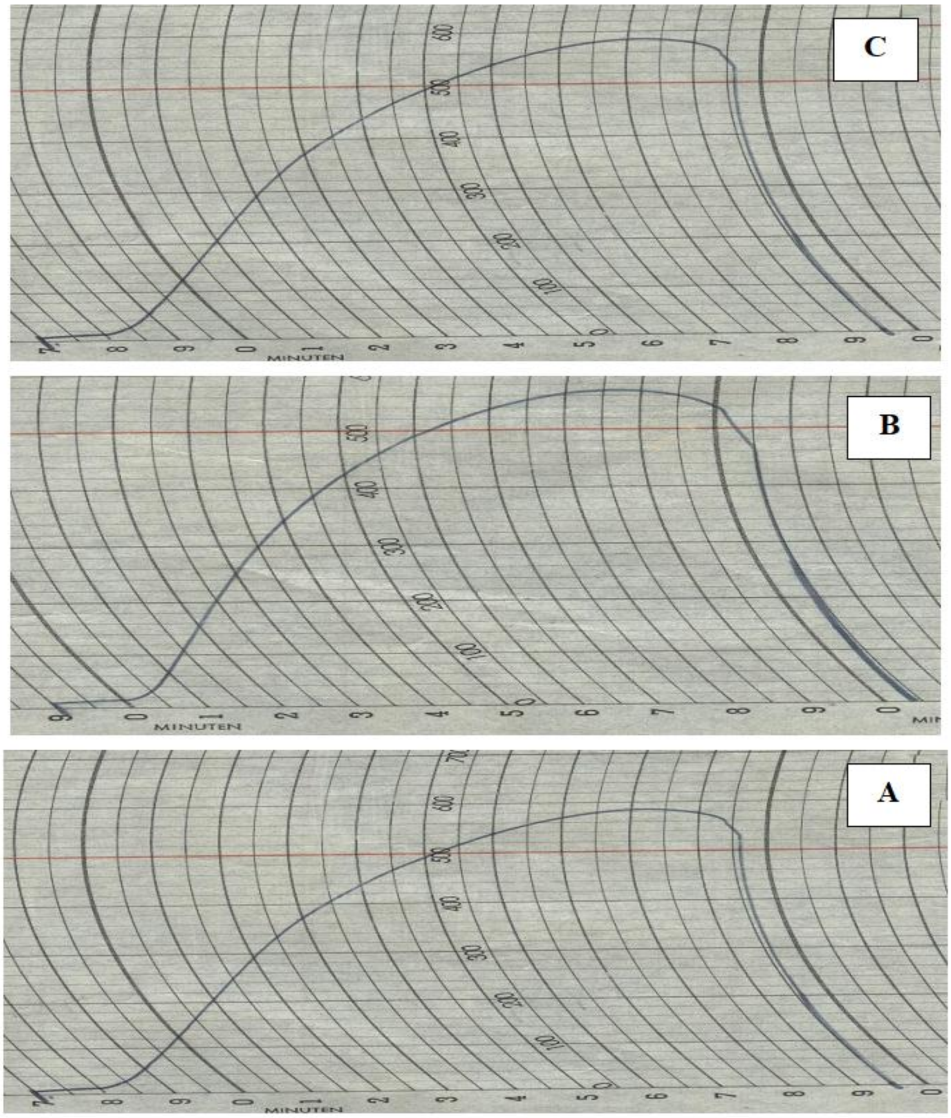


Figure 2. Extensograms of wheat flour control dough and dough's with additions of PPP [A: control dough, B: 5% PPP and B: 10% PPP]

Content of dietary fiber, carotenoids and total phenolics in PPP incorporated biscuits

Data in Table (5) indicated that biscuits formulated with PPP exhibited increased total dietary fiber (TDF) content. The TDF content in control biscuits was 6.92±1.65 $g.100g^{-1}$ which increased to 10.74±0.48 $g.100g^{-1}$ with the incorporation of PPP by 10%. The present data are in accordance partially with that reported by Mashal, (2016) and Elhassaneen, (2016). On the other side, data indicated that the increase in TDF is more than the dietary fiber contributed by the PPP. Like of that increasing could be attributed to the baking process. During baking process some of the components present in PPP might have contributed to the formation of additional dietary fiber. In this attention, Kutos *et al.*, (2003), Agustiniano *et al.*, (2005) and Kim *et al.*, (2006) indicated that the formation of resistant starch sucg as found in PPP, wheat flour and soybean during baking, extrusion or cooking was observed. Oxidative enzymes like peroxidase and polyphenol oxidase catalyse the formation of cross-links between carbohydrates like arabinoxylans, also between carbohydrate and side chains of amino acids in protein via phenolic molecules like ferulic acid. All of these factors could be participated in raising the TDF in biscuits beside PPP incorporated.

Table (5): Content of dietary fiber, carotenoids and total phenolics in PPP incorporated biscuits

Treatment	Total dietary fiber ($g.100g^{-1}$)	Total carotenoids ($mg.100\ g^{-1}$)	Total phenolics ($mg\ EGA.100g^{-1}$)
Prickly pear peel powder (PPP)	36.67 ± 4.75	269.65 ± 14.92	411.87 ± 26.31
Control biscuits (CB)	6.92±1.65 [c]	3.49± 0.76 [c]	111.87±10.65 [c]
CB + 5% PPP	8.81±0.62 [b]	18.86±1.89 [b]	135.86±0.64 [b]
CB + 10% PPP	10.74±0.48[a]	30.94±3.76 [a]	158.98±1.01 [a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

The total carotenoids content in control biscuits was 3.49± 0.76 $mg.g^{-1}$ which increased to 30.94±3.76 $mg.g^{-1}$ with the incorporation of PPP by 10%. The increasing in total carotenoids content in biscuits is partially due to the total carotenoids content contributed by the PPP. Regarding the total phenolics content in the control and treated biscuits, data showed that incorporation of PPP increased the content of total phenolics in the treated biscuits samples. The total phenolics content in control biscuits was 111.87±10.65 $mg.g^{-1}$ which increased to 158.98±1.01 mg $EGA.g^{-1}$ with the incorporation of PPP by 10%. Data reported that a great loss in total carotenoids and phenolics content during baking process which highly increased in biscuits as the result of incorporation with PPP. Many studies indicate that conventional and microwave cooking significantly decreased the phenolics content in different vegetables (El-Sadaney, 2001and Roy *et al.*, 2007). Finally, our data declared enrichment of prickly pear peel increased the content of natural antioxidant compounds subsequently increasing the nutritional significance of the products such biscuits.

Antioxidant activity of PPP enriched biscuits

Table (6) shows the antioxidant activities of control and enriched PPP biscuits. The antioxidant activity (AA) in control biscuits was 30.65 ± 3.87% which increased to 36.87 ± 2.99 and 42.45 ± 4.09% with the incorporation of PPP by 5 and 10%, respectively. PPP enriched biscuits showed strong activity probably due to its high bioactive compounds content including carotenoids and phenolics. Many similar studies indicated that there was a positive and significant ($p \leq 0.01$) relationship between total phenolics and antioxidant activity in different plant parts (El-Mokadem, 2010; ElSafty, 2008; Hegazy, 2009 and Ahmed, 2010). Plant-based foods generally are considered important sources of antioxidants in the diet. Antioxidants help protect cells from the potentially damaging physiological process known as "oxidative stress" (damage to healthy cells or DNA by unpaired electrons known as free radicals). Oxidative stress is thought to be associated with the development of chronic diseases including cancer, heart disease, conditions of ageing including neurodegenerative diseases such as Parkinson's and Alzheimer's disease. There are a variety of plant antioxidants with different chemical structures. There are the antioxidant nutrients such as vitamins C, E, *β*-carotene and the trace element selenium (found in PPP) for which there are Dietary Reference Values (DRVs). However, there are thousands of other bioactive compounds in foods that have antioxidant activity but are not classified as "nutrients." These "non-nutrient antioxidants" include phenolic compounds, found PPP, (Ajila *et al.*, 2008).

Table 6. Antioxidant activity of PPP enriched biscuits

Treatment	Antioxidant activity			
	Antioxidant value[a] AOX (A/h)	Antioxidant activity[b] AA (%)	Oxidation rate ratio[c] (ORR)	Antioxidant activity coefficient[d] (AAC)
Prickly pear peel powder (PPP)	0.148 ± 0.079	73.87 ± 5.98	0.261 ± 0.076	764 ± 45
Control biscuits (CB)	0.392 ±0.097	30.65 ± 3.87	0.692 ± 0.124	13 ± 17
CB + 5% PPP	0.357 ± 0.103	36.87 ± 2.99	0.630 ± 0.210	121 ± 19
CB + 10% PPP	0.325 ± 0.098	44.45 ± 4.09	0.574 ± 0.023	218 ± 26
α-tocopherol, 50 mg/L	0.016 ±0.007	97.08 ± 1.11	0.029 ± 0.008	1168 ± 231

[a] Antioxidant value (AOX, A/h) = The absolute value of slope (Abs was plotted against time).
[b] Antioxidant activity (AA, %) = (R control - R sample) / R control x 100 where: R control and R sample were the bleaching rates of beta-carotene in reactant mixture without antioxidant and with plant extract, respectively.
[c] Oxidation rate ratio (ORR) = R sample / R control
[d] Antioxidant activity coefficient (AAC) = (Abs S 120 - Abs C 120) / Abs C 0 - Abs C 120) x 1000 where: .Abs S 120 was the absorbance of the antioxidant mixture at time 120 min, Abs C 120 was the absorbance of the control at time 120 min, Abs C 0 was the absorbance of the control at zero time.
Each value represents the mean of three replicates ±SD.

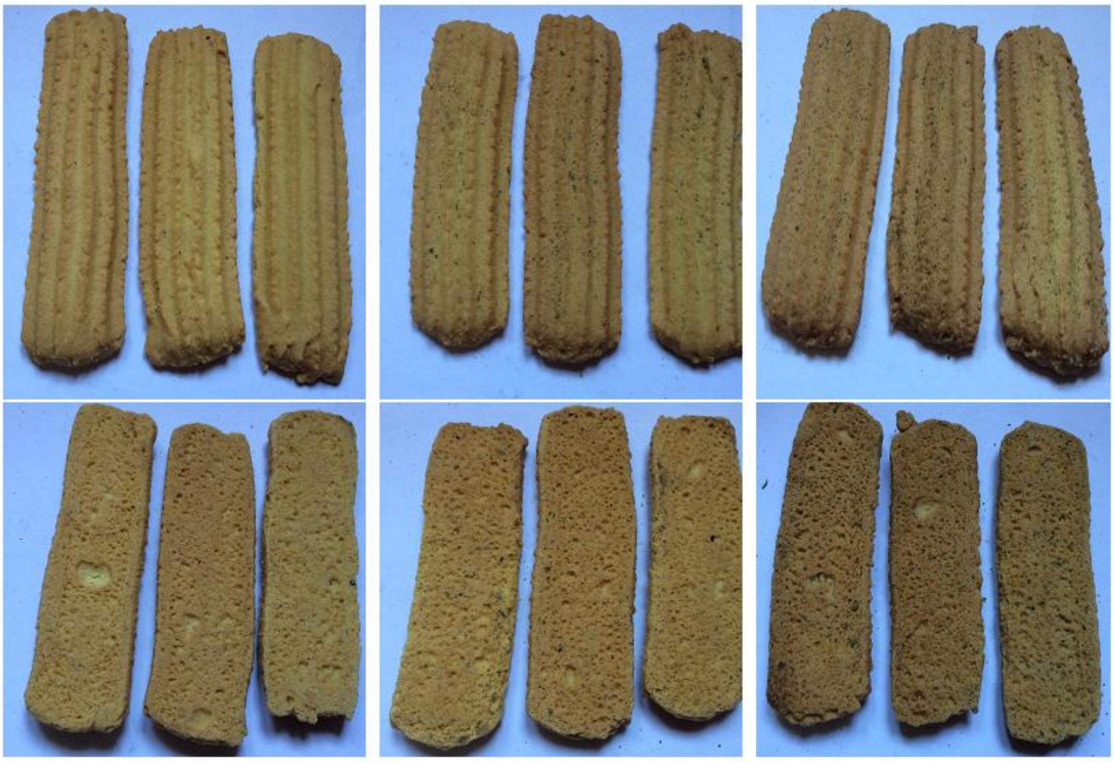
Sensory evaluation of biscuits enriched with PPP

Results of sensory evaluation of biscuits enriched with PPP in terms of colour, crunchiness, taste and overall acceptance are presented in Table (7) and Figure (3). Colour was not significantly different between the control and PPP biscuits. Broyart *et al*. (1998) reported that the initial acceptance of baked products is much influenced by colour, which can also be an indicator of baking completion. In similar study, among the tested food by-products, the colour of PPP crackers was rated the highest (7.10) by the panelists. The desirable colour of biscuits is mainly due to the Millard browning during baking. However, in PPP biscuits, the colour could be partially contributed by the carotenoid in PPP flour which imparts a yellowish colour to the biscuits. Similar findings were reported in a study by Brannan *et al*. (2001) who observed that an increased flour and thus muffin visual lightness (with more yellowness and brownness rather than dark and yellow green) yield a higher aroma, texture and colour acceptability scores. Crispiness is perceived when food is chewed between molars, and is usually expressed in terms of hardness and fracturability. In this study, there was no significant difference in crispiness amongst the different samples with different composite flour biscuits types. This observation could be due to the small percentage of wheat flour substitution in the biscuits formulation, which did not affect the gluten network in the dough nor the development of an open internal structure upon baking. In similar study, Sudha *et al.*, (2007) reported that in biscuits prepared from different cereal fiber and found to be crispy at incorporation level of 40% oat bran, with a very small increase in hardness. No significant difference was observed in terms of taste between the control and PPP biscuits. This could probably be due to the nature of PPP which did not impart any additional flavour to the biscuits. There was no significant difference in term of overall acceptability among the control and PPP biscuits. This could be attributed to the close resemblance of the biscuits types in terms of the colour, crispiness and taste of the commercial biscuits in the market. In similar study of Ashoush and Gadallah, (2011) investigated the effect of mango peels powder at different replacing levels (5, 10, 15 and 20%) and mango kernels powders at 20, 30, 40 and 50% on sensory properties of biscuits were evaluated. Acceptable biscuits with mango flavor were obtained by incorporating up to 10% mango peel powder and with mango kernel powder up to 40%. Recently, Mashal (2016) acceptable breads with PPP were obtained by incorporating up to 10%.

Table 7. Sensory evaluation of biscuits enriched with PPP

Treatment	Crust appearance	Crust colour	Texture	Crispness	Taste and Flavor	Mouth feel	Overall acceptability
Control biscuits (CB)	9.61±0.44[a]	8.40±1.11[a]	8.97±0.32[a]	8.71±0.61[a]	8.54±0.46[a]	8.53±0.42[a]	9.18±0.23[a]
CB + 5% PPP	8.71±0.21[a]	8.21±1.06[a]	7.89±0.51[b]	8.21±0.19[a]	8.38±0.33[a]	8.24±0.84[a]	8.75±0.73[a]
CB + 10% PPP	7.54±1.04[b]	7.91±0.34[a]	7.07±0.30[bc]	8.05±0.22[bc]	8.01±0.56[a]	6.95±0.72[b]	8.55±0.54[a]

[e] Each value represents the mean of ten replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.



Control biscuits (CB) CB + 5% PPP CB + 10% PPP

Figure 3. Photo of biscuits enriched with PPP

In conclusion, the chemical composition of PPP showed that it is a good source of dietary fibers and bioactive compounds such as carotenoids and phenolics. Incorporation of PPP with biscuit flour improved the rheological properties of the dough including farinograph and extensograph parameters subsequently their baking characteristics. Biscuit samples enriched with PPP showed higher TDF, carotenoids and total phenolics content than the control biscuits. Increasing of such bioactive compounds in PPP incorporated biscuits exhibited improving of antioxidant activity. The PPP incorporated biscuits up to 10% doesn't affect on their overall quality.

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تحسين الخصائص الريولوجية ومحتوى المركبات النشطة حيويا والنشاط المضاد للأكسدة لعجين البسكويت بإضافة مسحوق قشور التين الشوكى

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الملخص

يعتبر قشر ثمار التين الشوكى (PPP) أحد النواتج الثانوية المتخلفة أثناء تصنيع االتين الشوكى/التغذية عليه، حيث تنفصل كميات كبيرة من هذا المخلف، حيث يشكل هذا المخلف والتخلص منها مشكلة كبيرة مسببا التلوث البيئي، حيث يشكل هذا المخلف حوالي ٢٢.٥ % من إجمالى فاكهة التين الشوكى المصنعة. وللتغلب على تلك المشكلة فقد تم تجفيف هذا المخلف تحت تفريغ على ٧٠ درجة مئوية لمدة ٤ ساعات للحصول على مسحوق قشر التين الشوكى (PPP) بمحتوى رطوبة ٦.٠٦٪، كما تم تحليل هذا المسحوق كيميائيا ثم أضيف الى الدقيق أثناء صناعة البسكويت في مستويين مختلفين، ٥ ، ١٠٪ كمصدر محتمل للمركبات النشطة حيويا ومضادات الأكسدة الطبيعية فى صناعة البسكويت. ولقد أشار التحليل الكيميائي أن PPP يحتوي على مستويات عالية من المواد المضادة للاكسدة عالية القيمة مثل الفينولات الكلية والتى بلغ قيمتها (٤١١.٨٧ ملجم حامض الجاليك المكافئ /١٠٠جرام مادة جافة)، والكاروتينات (٢٦٩.٦٥ ملجم/ ١٠٠جرام مادة جافة)، إضافة الى الألياف الغذائية (٣٦.٦٧ جم ل/١٠٠ جرام مادة جافة). كذلك ارتفع إجمالي محتوى الألياف الغذائية، والكاروتينات، الفينولات الكلية في البسكويت من ٦.٩٢ الى ١٠.٧٤ جم /١٠٠ جرام مادة جافة ، ٣.٤٩ الى ٣٠.٩٤ ملجم/ ١٠٠جرام مادة جافة، ١١١.٨٧ الى ١٥٨.٩٨ ملجم حامض الجاليك المكافئ /١٠٠جرام مادة جافة على التوالى. كذلك سجلت عينات البسكويت الضابطة قيمة مقدارها ٣٠.٦٥% فيما يتعلق بالنشاط المضاد للأكسدة والتى إرتفعت الى ٣٦.٨٧ ، ٤٤.٤٥ % مع إضافة مستويات ٥، ١٠% من مسحوق قشر التين الشوكى على الترتيب. كما أدى إضافة مسحوق التين الشوكى الى دقيق البسكويت الى حدوث تحسن معنوى ($p \leq 0.05$) فى الخصائص الريولوجية والتى تشمل مقاييس الفارينوجراف والإكسنسوجراف. والخلاصة ، تقترح الدراسة إضافة مسحوق قشر التين الشوكى حتى مستوى ١٠% الى الدقيق (العجين) والذى يؤدى الى حدوث تحسن واضح فى الخواص الغذائية والخصائص الريولوجية والمحتوى من المركبات النشطة حيويا وزيادة درجة النشاط المضاد للأكسدة للبسكويت دون أن يؤثر ذلك على خصائصه الحسية.

الكلمات المفتاحية: مسحوق قشر االتين الشوكى – البسكويت– الخلط – الألياف الغذائية– الفينولات الكلية– الكاروتينات– النشاط المضاد للأكسدة – الخصائص الحسية.