Zagazig J. Agric. Res., Vol. 44 No. (3) 2017 1073-1084

Food and Dairy Research

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

PHYSICOCHEMICAL CHARACTERISTICS OF BISCUITS FORTIFIED WITH CACTUS PEAR PEEL POWDER

Mohamed Sh. El-Shahat*, M. Ragab, H.A.I. Siliha and M.A. Rabie

Food Sci. Dept., Fac. Agric., Zagazig Univ., Egypt

Received: 11/04/2017 ; Accepted: 30/04/2017

ABSTRACT: The current study aimed to utilize the cactus pear peel powder in wheat biscuits fortification. Physicochemical properties and phenolic compounds of cactus pear peel powder were also determined. Wheat flour was fortified with 2.5%, 5%, 7.5% and 10% cactus pear peel powder. Likewise the effect of fortification with 7.5% cactus pear peel powder on physical and sensory properties of wheat flour biscuits was studied. The physicochemical properties indicated that the powder was characterized by 1.14 g/ml bulk density, 3.50 ml/g swelling capacity, 3.70 ml/g water holding capacity, 2.49 ml/g oil holding capacity, 11.2% moisture, 9.90% ash, 3.50% protein, 1.22% fat, 5.70 pH, 38% dietary fiber, 54.30% antioxidant activity and 2243.84 ppm total phenolic compounds. Potassium (K) represented the highest mineral concentration (22.07 g/kg) followed by calcium (16.66 g/kg) and magnesium (3.71 g/kg). The major phenolic components were pyrogallol, catechol and catechein representing 1088.95 ppm, 201.96 ppm and 149.99 ppm, respectively. Sensory evaluation showed that fortification with 7.5% cactus pear peel had the best sensory characteristics meanwhile biscuits fortified with 10% cactus pear peel powder was not acceptable. Results showed that the fortification of biscuits with 7.5% cactus pear peel powder increased its content of dietary fiber and antioxidant activity.

Key words: Cactus pear peel powder, physicochemical properties, fortification biscuits, sensory evaluation.

INTRODUCTION

Cactus pear fruit (*Opuntia ficus-indica*) have a great interest because of their nutritional and antioxidant properties mainly due to the presence of vitamins, fibers, minerals and poly phenols (El-Mostafa *et al.,* 2014). The total world crop of cactus pear was estimated to be 200000 tons of fruit (Lahsasni *et al.,* 2004). By-products from processing of fruits and vegetables include nutritional value suitable for production natural food additives or high number of compounds with supplements (Oreopoulou and Tzia, 2007; Lamsal and Faubion, 2009). The lipid, protein and ash content of the cactus pear peel were reported to be 2.43%, 8.30% and 12.1%, respectively (on dry weight basis) (El Kossori *et al.,* 1998). El-Said *et al.* (2010) reported that the chemical composition of cactus pear peel showed that moisture, protein, ash and pH were 18.5%, 4.5%, 8% and 4.4, respectively (on dry weight basis). Anwar and Sallam (2016) reported that the cactus pear peel contained protein, lipid, ash and total dietary fiber valued 4.56%, 3.66%, 8.66% and 32.67%, respectively. Habibi *et al.* (2004) found that cactus pear peel contained protein, fat and ash being 8.6%, 11% and 11.5%, respectively.

The *Opuntia ficus-indica* peel is particularly rich in total phenolic in comparison with other fruit and vegetable peels. Indeed, *Opuntia ficus-indica* peel phenolic content is 2 times higher than fruit peel of the related species *Opuntia stricta* and several times higher than commonly consumed fruits and vegetables like lemon (435.76 mg/100 g DM), pineapple (120.87 mg/100 g DM), potato (240 mg/100 g DM) and

* **Corresponding author: Tel. :** +201060682117
E-mail address: mohamed.shehta413@gmail.com

tomato (462 mg/100 g DM) (Chougui *et al.,* 2015). This makes *Opuntia ficus-indica* peel a very interesting source for bioactive compounds re-valorization. The antioxidant properties of the phenolic compounds in cactus pear plants make them an important product for preventing human health against degenerative diseases such as cancer, diabetes, hypercholesterolemia, arteriosclerosis or cardiovascular and gastric diseases (Abd El-Razek and Hassan, 2011; Yeddes *et al.,* 2013).

From the technological point of view, fruit peels rich in dietary fibers have been utilized in the formulation of some food products such as bakery products, snacks, sauces, drinks, biscuits, dairy products and meat products (Thebaudin *et al.,* 1997). Dietary fibers obtained from different sources have been used to replace wheat flour in the production of bakery products, where potato peel and pomegranate peel with high values of dietary fiber were used in bread making (Toma *et al.,* 1979; Ibrahim *et al.,* 2013). Also, using of hazelnut as a source of dietary fiber in bread making was evaluated by Anil (2007). Sudha *et al.* (2007) investigated the effect of apple pomace containing dietary fiber and polyphenols on cake making.

Biscuits are considered convenient food products and a very popular commodity worldwide both in rural and urban populations. The reasons behind the wide popularity of biscuits are it's low cost among other processed foods, varied taste, easy availability and longer shelf life (Gandhi *et al.,* 2001). On the other hand, fruit dietary fiber concentrates have better physicochemical properties than those obtained from cereals due to higher proportion of soluble dietary fiber (SDF) and significant content of dietary fiber associated with bioactive compounds (Larrauri *et al.,* 1996; Chau and Huang, 2003). Recently, Valencia *et al.* (2007) studied the improvement in nutritional properties of cookies and bread with the incorporation of mango dietary fiber obtained from unripe mango fruit (whole fruit). Nassar *et al.* (2008) reported that, incorporation of orange peel and pulp in biscuits formula increased dietary fiber from 2.73 to 15.31%. Reports are available on the use of oat bran, wheat bran, rice bran as a source of dietary fiber content in bread and other bakery products (Leelavathi and Haridas Rao, 1993; Laurikainen *et al.,* 1998; Sidhu *et al.,* 1999).

The aim of this study was to evaluate the physio-chemical properties of cactus pear peel powder, utilize it in fortification of biscuits at different levels (2.5%, 5%, 7.5% and 10%) and evaluate the effect of fortification on the properties of the resultant biscuits.

MATERIALS AND METHODS

Materials

Raw material

Mature fresh cactus pear fruit *(Opuntia ficus indica)* having yellow skin free from defects was harvested from a local private farm held in Al-Behayrah Governorate, Egypt at the summer season (June 2015) and transported to the laboratory at the cages in car.

Wheat flour Elsafa (72% extraction), sugar, margarine, egg and baking powder were purchased from local market, Zagazig, Egypt.

Methods

Peel samples

Fruits were cleaned by brush to remove glochids, then washed with water to remove any dirty particles. Cactus peels were separated by hand peeling using a sharp knife. Cactus pear peel were collected and divided into two portions, the first portion was stored directly at -18^{o}C until use. The second part was cut into slices and put in hot air oven and dried at 45^{o}C until constant weight. The dried peel pieces were ground using domestic coffee grinder then sieved.

Proximate chemical analyses

Moisture, ash, protein, fat, pH, dietary fiber and minerals were determined according to AOAC (2005). Total carbohydrate content was calculated by difference as follows: 100- (% moisture + ash + protein + fat).

Physical analyses

Bulk density of cactus peel powder was determined according to Parrott and Thrall (1978). Swelling capacity was determined according the method described by Kuniak and

Marchessault (1972), water holding capacity was determined according the method described by Borroto *et al.* (1995), oil holding capacity was determined according to Collins *et al.* (1982) and colour was measured with Hunter Lab method (Hunter, 1958).

Determination of antioxidants activity

Antioxidants activity was determined by DPPH (2.2-diphenyl-1picryl hydrazyle) method according to Su and Silva (2006).

Determination of phenolic compounds by HPLC

The phenolic compound fractionation of dried cactus pear peel powder was determined in Lab of Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Phenolic compounds were determined and fractionated by HPLC according to the method described by Pascale *et al.* (1999).

Biscuits manufacture

Biscuits were prepared according to the method and formula of Nnam and Nwokocha (2003). Cactus pear peel powder at levels of 2.5%, 5%, 7.5% and 10 (on wheat flour basis) was used as substitutes of wheat flour (72% extraction). Biscuits were produced from each of the six ingredients: 300 g of composite flour, 100 g of margarine, 100 g of granulated sugar, 35 ml of water, 6 g of double acting baking powder and 120 g of eggs. The ingredients required for the preparation of biscuits were weighed accurately. All the dry ingredients were blended together by stirring 12 strokes with a wooden spoon. Fat was rubbed into the flour mixture until the consistency of biscuits crumbs was achieved. The egg was whisked for 3 minutes and folded into the flour mixture. Water was added to the mixture and a wooden spoon was used to stir 12 strokes to get a homogenous dough. The dough was cut into shapes. The biscuits were baked on an aluminum baking pan slightly greased with margarine in a gas oven at 200^{o}C for 15 minutes. The samples were removed from oven and cooled at room temperature on a rack before the sensory evaluation.

Physical properties of biscuits

Weight (g), length (mm), thickness (mm) and spread ratio of biscuits were determined according to Shrestha and Noomhorm (2002). Colour was measured by Hunter (1958).

Sensory evaluation

Panelists were asked to rate sensory attributes of the biscuits according to it's appearance, colour, taste, flavour and overall acceptability. The samples were evaluated using hedonic scale of 1 to 9 point, where (1 =dislike extremely, 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8, like very much, 9= like extremely) as described by Hooda and Jood (2005).

RESULTS AND DISCUSSION

Chemical Composition of Cactus Pear Peel Powder

The chemical composition of cactus pear peel powder is presented in Table 1. The moisture content was 11.20%. Cactus pear peel powder had ash content of 9.90%. Ash content of cactus peel was reported to be 11.50% to 12.10% (El Kossori *et al.,* 1998; Habibi *et al.,* 2004). Higher ash content (19.12%) was reported by Namir (2014). In general, ash content of cactus peel was found to be considerably greater than those reported in pomegranate peel (2%) by Ibrahim *et al.* (2013), and by Ajila *et al.* (2008) in mango peel (3%).

Table 1 shows that protein content of cactus pear peel powder was 3.50% and found to be lower than that reported by El Kossori *et al.* (1998) who found protein content in cactus pear peel to be 8.3%. Namir (2014) reported high value of protein (5.71%) in cactus pear peel, while, Salim *et al.* (2009) presented lower values of protein content in cactus pear peel (1.45%). Compared to protein content of some fruit and vegetable wastes: such as watermelon dried peels (Laban, 2001), orange peels (Sulieman, 2000) and carrot peels (Chantaro *et al.,* 2008) the obtained values presented in this study are considered lower.

Table 1. Physicochemical characteristics of cactus pear peel powder (based on dry weight)

Components	Cactus peel powder
Chemical composition	
Moisture (%)	11.20
Ash (%)	9.90
Protein (%)	3.50
Fat (%)	1.22
pH	5.70
Total carbohydrate (%)	85.38
Dietary fiber (%)	38.00
Antioxidant activity (%)	54.30
Minerals (g/kg)	
Ca	16.66
K	22.07
Mg	3.71
Zn	0.01
Fe	0.03
Na	0.94
Se	0.02
Physical characteristics	
Bulk density (g/ml)	1.14
Swelling capacity (ml/g)	3.50
Water holding capacity (ml/g)	3.70
Oil holding capacity (ml/g)	2.49
Colour	
L*	60.02
a*	3.75
b*	27.58

Fat content was 1.22%, the presented results revealed lower value than that reported by Namir (2014) who found that fat content in the peel reached 3.33 g/100g. El Kossori *et al.* (1998) reported that fat content of the cactus pear peel was 3.43%. pH value was 5.70. Similar pH values for cactus pear peel powder (5.4 to 5.8) has been reported by Joubert (1993) and Cerezal and Duarte (2005). Total carbohydrate content was 85.38%. Total dietary fibre content was 38%. Total dietary fiber content in the peel ranged from 32.67 to 40.80% in cactus pear peel as reported by El-Kossori *et al*. (2000) as well as Anwar and Sallam (2016).

The antioxidant activity of cactus pear peel powder is shown in Table 1. The antioxidant activity DPPH in cactus pear peel was 54.30%. Several studies showed a good correlation between the phenols and antioxidant activity, as mentioned by Edwin and Meyer (2000) and Huang *et al.* (2005). Anwar and Sallam (2016) presented higher values of antioxidant activity content of DPPH (62.54%) in cactus peel.

As for the minerals content (Table 1) potassium (K) content was the highest (22.07 g/kg) followed by calcium (16.66 g/kg), magnesium (3.71 g/kg) and sodium (0.94 g/kg), while, the lowest value was found in iron (0.03 g/kg), selenium (0.02 g/kg) and zinc (0.01 g/kg). The obtained results are in agreement with those reported by El Kossori *et al.* (1998).

Physical properties of cactus pear peel powder

Physical properties of cactus pear peel powder are shown in Table 1. The bulk density was 1.14 g/ml; this result is higher than that of dehydrated tomato waste 0.68 g/ml (El-Nemr, 2008). Swelling capacity was 3.50 ml/g. A lower value (2.89 ml/g) of cactus pear peel snacks was presented by Namir (2014). On the other hand, El-Nemr (2008) reported a greater value (3.7 ml/g) of swelling capacity in dehydrated tomato waste. Water holding capacity (WHC) was 3.70 ml/g. Lower values of WHC have been reported by Namir (2014) and by Anwar and Sallam (2016). Oil holding capacity (OHC) was 2.49 ml/g. This value are in agreement with that obtained by Anwar and Sallam (2016) being 2.35 ml/g.

As illustrated in Table 1, the Lightness (L), redness (+a) and yellowness (+b) of cactus peel powder revealed values of 60.02, 3.75 and 27.58, respectively.

Phenolic compounds of cactus pear peel powder

Phenols are very important plant constituents because of their scavenging ability on free radicals due to their hydroxyl groups (Heim *et al.,* 2002). Table 2 shows the separation and identification of compounds including twenty four phenolic acids. The phenolic acids were identified according to their retention time in comparison with authentic samples. Total phenolic compounds content was 2243.84 ppm. The predominant components were pyrogallol, catechol and catechein representing 1088.95, 201.96 and 149.99 ppm, respectively. The sub-dominant phenolic components were alpha-coumaric, p-oh-benzoic, e-vanillic, ferulic, chlorogenic, epicatechein, gallic, benzoic, iso-ferulic and ellagic being 90.40, 88.32, 86.60, 85.41, 68.90, 56.06, 48.00, 44.14, 40.35 and 38.73 ppm, respectively. The lowest phenolic components were p-coumaric, caffeine, vanillic, salycilic, 4-amino-benzoic, caffeic, 3,4,5-methoxy-cinnamic, protocatchuic, cinnamic, reversetrol and coumarin representing 32.03, 31.32, 19.88, 18.15, 14.91, 14.32, 9.13, 7.77, 3.14, 3.13 and 2.25 ppm, respectively. Anwar and Sallam (2016) found that the phenolic compounds in prickly pear peels (in ppm) were: oleuro 1264.40, pyrogallo 1149.68, benzoic 982.37, 3-oH tyrosol 588.53, ellagic 413.26, chorogenic 271.10, protocatechuic acid 176.02, P-oH- benzoic 112.78, epicatechin105.99 and gallic acid 61.26 ppm.

Evaluation of biscuits fortified with cactus pear peel powder

Biscuits were fortified with different levels of cactus pear peel powder (2.5, 5, 7.5 and 10%) which were used as substitute of wheat flour. Sensory analysis of biscuits showed that substitution with 7.5% was the best sample. Therefor, evalution of biscuits charactestics was carried out on sample fortified with 7.5%.

Table 2. Phenolic compounds of cactus pear peel powder

Phenolic Compounds	(ppm)
Pyrogallol	1088.95
Catechol	201.96
Catechein	149.99
Alpha-coumaric	90.40
P-OH-benzoic	88.32
E-Vanillic	86.60
Ferulic	85.41
Chlorogenic	68.90
Epicatechein	56.06
Gallic	48.00
Benzoic	44.14
Iso-ferulic	40.35
Ellagic	38.73
P-coumaric	32.03
Caffeine	31.32
Vanillic	19.88
Salycilic	18.15
4-Amino-benzoic	14.91
Caffeic	14.32
3,4,5-methoxy-cinnamic	9.13
Protocatchuic	7.77
Cinnamic	3.14
Reversetrol	3.13
Coumarin	2.25
Total	2243.84

Dietary fiber and antioxidant activity

Total dietary fibre content of 7.5% cactus pear peel powder fortified biscuits is given in Table 3. Control biscuits had 3.08% total dietary fibre content. Biscuits fortified with 7.5% cactus pear peel powder contained high dietary fiber content being 14.2%. This is due to high dietary fibre contents of cactus pear peel powder. During baking some of the components present in cactus pear peel powder might have contributed to the formation of additional dietary fibre. The formation of resistant starch in mango starch, wheat flour and soybean during baking, extrusion or cooking was reported by Bjorck *et al.* (1986); Kutos *et al.* (2003); Agustiniano-Osornio *et al.* (2005); Kim *et al.* (2006). Hooda and Jood (2005) reported high value of total dietary fiber (8.81%) in wheat biscuits where all the dietary fibre constituents were increased significantly due to increasing the supplementation of wheat with raw and soaked fenugreek flour in biscuits. Biscuits content of dietary fiber increased with increasing levels of replacement of wheat flour with Jerusalem artichoke and cocoa bean shells (Kārklina *et al.,* 2012).

Table 3 shows that antioxidant activity of unfortified biscuits (13.44%). The antioxidant activity of fortified biscuit 7.5% was bound increased be considerably higher (33.2%) than that of unfortified biscuits. Phenolic compounds appear to be responsible for the high free radical inhibition activity because samples that showed the lowest contents of phenolics and flavonoids also showed the lowest percentage of radical inhibition (Ayala-Zavala *et al.,* 2010). This is mainly due to the high polyphenolic compounds of cactus pear peel powder. Study conducted by Paul and Bhattacharyya (2015) indicated that radical scavenging activities (measured by DPPH) of cookies fortified with pomegranate peel powder were significantly higher than unfortified cookies.

Physical characteristics of biscuit fortified with 7.5% cactus pear peel powder

Physical characteristics of cactus pear peel powder fortified biscuits are shown in Table 4. Physical characteristics of biscuits, such as weight, length, thickness and spread ratio, were affected by fortification with cactus pear peel. The mean weight of control biscuit was 12.1 g whereas that of fortified biscuits was 12.3 g. The length of fortified biscuits was 68.2 mm and that of unfortified biscuits was 67.9 mm. Similarly, thickness of fortified biscuits and unfortified biscuits were 7.3 mm and 7.1 mm, respectively. Spread ratio of control biscuit samples (9.56%) was not differ considerably than that of fortified biscuits (9.34%). In general it can be concluded that substitution of wheat flour by7.5% cactus pear peel powder in biscuit making did not affect its physical parameters. Incorporation of 20% mango peel powder decreased the diameter of the biscuits from 55.6 to 52.2 mm, but no significant difference was observed up to 10% level of incorporation. The thickness of biscuits incorporated with mango peel powder was comparable to the control up to a 10% level, decrease in diameter and thickness of biscuits with the addition of 15 and 20% mango peel powder may be due to dilution of gluten (Ajila *et al.,* 2008).

Colour of food is an important quality parameter in food products. It is related strongly to market and consumers acceptability as it controls the first impression of any food product. L*, a* and b* colour values of biscuits are presented in Table 4. Lightness (L value) was decreased from 57.10 in unfortified biscuits to 48.95 in biscuits fortified with 7.5% cactus pear peel powder. Redness (a value) was increased to 9.5 in 7.5% cactus pear peel powder fortified biscuits as compared to that observed in unfortified biscuits (8.71). On the other hand, the yellowness (b value) was declined from 26.05 in unfortified biscuits to 22.23 in biscuits fortified with 7.5% cactus pear peel powder.

Effect of fortification of biscuits with 7.5% cactus pear peel powder on the sensory evaluation

The effect of cactus pear peel fortification on sensory characteristics (appearance, colour, taste, flavour and overall acceptability) of wheat flour biscuits is shown in Table 5. The appearance, colour, taste, flavour and overall acceptability of control sample and biscuits fortified with 7.5% cactus pear peel were superior (probability level $P > 0.05$) to biscuits

Table 3. Dietary fiber content and antioxidant activity of cactus pear peel powder fortified biscuits

Sample	Dietary fiber (%)	Antioxidant activity (DPPH %)
Control	3.08	13.44
Cactus pear peel (7.5%)	14.2	33.2

Table 4. Physical characteristics of cactus pear peel powder fortified biscuits

Sample	Weight (g)	Length (L) (mm)	Thickness (T) (mm)	Spread ratio L/T (%)	Colour		
					L*	a*	b*
Control	12.1	67.9	7.1	9.56	57.10	8.71	26.05
Cactus pear peel (7.5%)	12.3	68.2	7.3	9.34	48.95	9.50	22.23

Table 5. Sensory evaluation of biscuits fortified with cactus pear peel powder

Sensory evaluation / Sample	Appearance (9)	Colour (9)	Taste (9)	Flavour (9)	Overall acceptability (9)
Control	8.15^{a}	8.05^{a}	8.1^{a}	8.1^{a}	8.15^{a}
Cactus pear peel					
2.5%	7.1^{bc}	7.25^{b}	7.2^{b}	7.25^{b}	7.1^{bc}
5%	7.5^{ab}	7.45^{ab}	7.5^{ab}	7.4^{ab}	7.1^{bc}
7.5%	8.1^{a}	8.15^{a}	8.15^{a}	8.1^{a}	8.1^{a}
10%	6.45^{cd}	6.5^{cd}	6.35^{d}	6.5^{cd}	6.15^{d}

fortified with 2.5%, 5% and 10% cactus pear peel. Biscuits fortified with 7.5% cactus pear peel had the highest scores of appearance, colour, taste, flavour and overall acceptability being 8.1, 8.15, 8.15, 8.1 and 8.1, respectively. Biscuits fortified with 10% cactus pear peel was not acceptable. The results of sensory evaluation indicated that 7.5% cactus pear peel can be successfully used in fortification of wheat flour biscuits.

Conclusion

This investigation showed that cactus pear peel powder can be considered a natural source of dietary fiber and antioxidant activity. It can be used to enhance nutritional value of biscuits fortified with 7.5% cactus pear peel without remarkable effect on its sensory acceptability and physical characteristics.

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الخصـــائـــص الفيزوكيمـــاوية للبســـكـــويت المدعـــم بمســـحـــوق قشـــر التين الشـــوكى

محمد شحته الشحات – محمد رجب – حسن على ابراهيم صليحه – محمد عبدالحميد ربيع

قسم علوم الاغذية – كلية الزراعة – جامعة الزقازيق – مصر

تهدف الدراسة الحالية إلى الاستفادة من مسحوق قشر التين الشوكى فى تدعيم البسكويت، تضمنت هذة الدراسة تقدير الخواص الفيزوكيماوية والمركبات الفينولية لمسحوق قشر التين الشوكى وتدعيم دقيق القمح بمسحوق قشر التين الشوكى بنسبة ٢,٥% و٥% و٧,٥% و١٠% وأيضا تأثير تدعيم البسكويت بـ ٧,٥% مسحوق قشر التين الشوكى على الخواص الفيزيائية والحسية للبسكويت، أظهرت الخصائص الفيزوكيماوية أن مسحوق قشر التين الشوكى يتميز بـ الكثافة الظاهرية ١,١٤ جم/مل والقدرة على الانتفاخ ٣,٥٠ مل/جم وسعة ربط الماء ٣,٧٠ مل/ جرام وسعة ربط الزيت ٢,٤٩ مل/ جرام وكانت الرطوبة ١١,٢٠% والرماد ٩,٩٠% والبروتين ٣,٥٠% والدهون ١,٢٢% وpH ٥,٧ كما كان محتوى الألياف الغذائية فى قشر التين الشوكى ٣٨% والنشاط المضاد للأكسدة ٥٤,٣%. ويمثل البوتاسيوم أعلى تركيز من باقى المعادن حيث وصل تركيزه إلى ٢٢,٠٧ جرام/ كيلو جرام يليه الكالسيوم وتركيزة ١٦,٦٦ جرام/كيلو جرام ثم الماغنسيوم وتركيزة ٣,٧١ جرام/ كيلو جرام، وكان مجموع المركبات الفينولية فى قشر التين الشوكى هى ٢٢٤٣,٨٤ جزء فى المليون حيث كانت المركبات الفينولية الرئيسية هى البيروجالول والكاتيكول والكاتيكين وتركيزهم ١٠٨٨,٩٥ و٢٠١,٩٦ و١٤٩,٩٩ جزء في المليون، على التوالى، ولقد أوضحت نتائج التقييم الحسى أن البسكويت المدعم ب ٧,٥% مسحوق قشر التين الشوكي كان له أفضل الخواص الحسية من حيث المظهر واللون والطعم والرائحة والقابلية العامة بينما كانت نسبة إضافة ١٠% من مسحوق قشر التين الشوكى غير مقبولة من حيث الخواص الحسية، أظهرت النتائج أن البسكويت المدعم بـ ٧,٥% مسحوق قشر التين الشوكى زاد محتواه من الألياف الغذائية والنشاط المضاد للأكسدة.

المحكمون :

١- أ.د. أحمـد عبـدالعزيـــز الرفـــاعى أستاذ الصناعات الغذائية المتفرغ – كلية الزراعة – جامعة المنصورة.

٢- أ.د. عبدالرحمن محمد أحمد سليمان أستـــاذ الصنـــاعـــات الغـــذائيـــة – كلية الزراعة – جامعـة الزقازيـق.