Using of Prickly Pear (*Opuntia Spp.*) Fruit Juice and Peels in Cookies Production

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ABSTRACT

Cactus pear pulp and peel are rich sources of important nutrients and bioactive compounds, which are degraded during dehydration. This work aims to determine the chemical characteristics of fresh juice and peel of *Opuntia ficus-indica* (yellow cultivar) and *Opuntia littoralis* (red cultivar), using them in cookies production and evaluating the quality of cookies. Results showed higher TSS, polyphenols, flavonoids and betalains for the red cultivar (either juice or peels), while the yellow cultivar possessed higher pH and carotenoids. The major phenolic acids of all samples are gallic followed by chlorogenic. While the predominant flavonoids are catechins followed by naringenin. Yellow and red juice cookies possessed higher moisture. Yellow or red peel cookies owned higher crude fiber. Yellow and red peel cookies recorded the best microbiological quality. Peel cookies had higher weight and hardness compared to juice cookies which had higher diameters and spread ratio. All produced cookies, are organoleptically accepted. The results suggested that, fresh prickly pear juices and peels could be used in the production of delicious and healthy cookies.

Keywords: chemical characteristics, cookies quality, fresh juice and peel, prickly pear.

INTRODUCTION

Prickly pear (*Opuntia ficus-indica*) (PP) belongs to the *Cactaceae* family. It is produced in large amounts in Latin America, South Africa and the Mediterranean Sea zone, including Egypt (Hassan, 2011). Prickly pear trees could grow in sandy areas because these areas are characterized by their water shortage. The fruit pulp is soft and contains hard seeds, which highly differ in shape, size, structure and color. These seeds are sometimes eaten as part of the fresh fruit (Feugang *et al.,* 2006). Prickly pear fruits are sold in various attractive colors (green, yellow, white-orange, purple and red) either peeled or unpeeled. The color difference is a result of pigments content (chlorophylls, carotenoids and betalains), which is used as a natural food colorant (Stintzing and Carle, 2005). Prickly pear fruit is widely consumed because of its distinct flavor (either fresh or after manufactured). Where, there are many food products produced from prickly pear as candy, jelly, barbecue sauces, juices, alcoholic beverages, jams and natural liquid sweeteners (Saenz and Sepulveda, 2001).

Phenolic compounds are among the most important bioactive compounds in prickly pear fruit (Kuti, 2004), all the betaxanthin and betacyanin pigments as well as ascorbic acid, possessed powerful antioxidant activities (Gentile *et al.,* 2004). Prickly pear fruits are rich in glycosylated flavonols, flavonols, dihydroflavonols, and flavanones (Kuti, 2000). Prickly pear fruits characterize by their contents of pigments, vitamins, gum, pectin and carbohydrates (Stintzing and Carle, 2005).

Mexicans have been used *Opuntia ficus-indica* stem for treating varied health-disorders such as high cholesterol levels, cancer, ulcers and hypoglycemia (Chauhan *et al.*, 2010). In addition, recent findings report that some compounds (i.e., ascorbic acid, flavonoids, and betalains) that are presented in prickly pear pulp and peel have biological activity (Hameed-Abdel *et al.*, 2014 and Bisson *et al.*, 2010).

Cactus pear flowers and fruits are characterized by their yellow and red color, as a result of their betalain content, which replaces anthocyanins in most plant families of the Caryophyllales (Albano *et al.*, 2015). Betalains have other important effects in addition to color, such as anti-inflammatory, antioxidant and vascular-protective effects (Stintzing *et al.*, 2005 and Tesoriere *et al.*, 2005). Phenolic compounds are secondary metabolites produced via the shikimate and phenylpropanoid pathways (Cartea *et al.*, 2010). Many phenolic compounds have been detected in prickly pear peel and pulp (Yeddes *et al.*, 2013). It was stated that, cactus pear antioxidant activity is mainly attributed to some flavonoids (e.g. isorhamnetin, kaempferol and quercetin), in the fruit (Kuti, 1992).

This work aims to determine the chemical characteristics of fresh juice and peel of both *Opuntia*

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ficus-indica (yellow cultivar) and *Opuntia littoralis* (red cultivar), use all of them in cookies production and evaluate the quality of the cookies.

MATERIALS AND METHODS

Materials:

Mature fresh cactus pear fruits of *Opuntia ficus-indica* (yellow cultivar) and *Opuntia littoralis* (red cultivar) free from defects was harvested from the farm of Applicable Research Center, Desert Research Center, Matrouh governorate, Egypt, in the summer season (June, 2021) and transported to the laboratory in the cages in a car.

Wheat flour (72% extraction), sugar, butter, salt, egg and baking powder were purchased from a local market, in Cairo, Egypt.

Methods:

Raw Material Preparation:

Prickly pear fruits (5 kg) of each cultivar were brushed for three minutes under tap water with a nail brush to remove prickles and dirty particles, then peels were manually removed by sharp knife. The pulp was blended and the seeds were separated by sieving, then the obtained juice was kept at -18°C until use. Also, the cactus pear peel was collected blended and stored directly at -18ºC until use.

Cookies formula and preparation:

The used formulas in the cookie's preparation are shown in Table 1. Cookies preparing was achieved according the method of Eneche (1999), with slight modifications. The flour, sugar, butter, egg yolk and salt were hand mixed for 5 minutes to get a creamy dough. The baking powder was then added. The measured amounts of prickly pear juice or peels or their mixture were added with continuous blending until the good texture was obtained. The dough was kneaded on a clean flat surface for four minutes. It was hand spread to sheets and shaped by stamp cutting method, then dough pieces were baked in an oven (Domenica UNOX: XF043, Italy) at 180°C for 20 min, cooled and packaged for further analysis.

Chemical composition:

Moisture, ash, crude fat, crude protein and crude fiber contents were determined according to the method described by AOAC (2000).

- Carbohydrate content (g/100 g DW) was calculated by subtracting the sum of moisture, ash, crude fat, crude protein and crude fiber contents from 100.
- Caloric value: Caloric value was estimated using the modified Atwater factor as follows:

Total energy (Kcal/100g) = [(lipid"g"×9) + (protein"g"×4) + (carbohydrates "g" × 1.1 × 3.75)] as described by Falch *et al.*, 2010.

Total soluble solids (TSS)

The total soluble solids content (TSS) as the Brix value of all studied juices and peels was read using a digital refractometer (DR 6000, A. Kruss Optronic GmbH, Hamburg, Germany).

Acidity

The titratable acidity (expressed as citric acid %) was determined as follows: 10ml of juice sample was taken in a 250 ml beaker and 50 ml of distilled water was added. The content was titrated with 0.1 N sodium hydroxide, using phenolphthalein as an indicator to an end-point (AOAC, 2000).

pH value:

The pH value was measured by using a Systronic 324- combination glass electrode pH meter at 25°C.

Total polyphenols

Total polyphenol contents (TPC) in prickly pear samples were measured according to Folin-Ciocalteau method at 765 nm (UV-Vis spectrophotometer, Jenway, Staffordshire, UK) (Gao *et al.*, 2000). The results were expressed as mg gallic acid equivalents/100g (mg GAE/100g).

Total flavonoid content:

The total flavonoid contents were measured spectrophotometrically (**Yoo *et al.*, 2008**). Absorbance at 510 nm. was read, and flavonoid content in triplicate was measured and expressed as mg quercetin equivalents/100g (mg QE/100g).

Betalains Content:

The prickly pear juice and peels were diluted with distilled water and measurement was carried out at a wavelength of 535 nm and the results were expressed as mg betalains/100g using the following equation (Castellar *et al.*, 2003)

Total betalains content (mg / 100 g) = A × DF × MW × 1000 / €L

Where:

A: Absorption value at 535 nm density.

DF: Dilution volume.

L: Path length of the cuvette.

MW: Molecular weight of betalain (550 g/mol).

€: The extinction coefficient for betalain (60000 L/mol).

Table 1. Cookies formula

	YJ cookies	YP cookies	YJP cookies	RJ cookies	RP cookies	RJP cookies
Wheat flour	500 g	500 g	500 g	500 g	500 g	500 g
Butter	200 g	200 g	200 g	200 g	200 g	200 g
Sugar	120 g	120 g	120 g	120 g	120 g	120 g
Baking powder	10 g	10 g	10 g	10 g	10 g	10 g
Egg yolk	30 g	30	30	30	30	30
Salt	5 g	5 g	5 g	5 g	5 g	5 g
Yellow prickly pear juice (YJ)	200	-	110	-	-	-
Yellow prickly pear peels (YP)	-	200	100	-	-	-
Red prickly pear juice (RJ)	-	-	-	200	-	100
Red prickly pear peels (RP)	-	-	-	-	200	100

YJ: Yellow Juice, YP: Yellow Peel, YJP: Yellow Juice Peel, RJ: Red Juice, RP: Red Peel and RJP: Red Juice Peel.

3. Determination of carotenoids:

Ten grams of prickly pear samples are mixed with 30 ml of 85% acetone in a dark bottle and allowed to stand for 15 hours at room temperature. The sample is then filtered through glass wool into a 100 ml volumetric flask, and made up to volume with 85% acetone solution. The absorbance was measured by spectrophotometer (model: CT2200-s/n: RE1310004-Germany), model, Pharmacia LKB, NOVA SPEC II, at 440, 644 and 662 nm.

The carotenoids pigment was assayed spectrophotometrically using the following equations: -

After measuring at wavelengths 440, 644 and 662 nm:

Chlorophyll a = (9.784 × E 662)-(0.99 × E644) = mg/liter

Chlorophyll b = (21.426 × E644)-(4.65 × E662) = mg/liter

Carotenoids = (4.695 × E440) – 0.268 (chl. a + chl. b) = mg/liter

The carotenoids content was calculated using the aforementioned equation described by Askar and Treptow (1993). Then calculated as mg/100g.

Evaluation of the physical properties of cookies

Determination of weight and diameter of cookies

The weight and diameter of the cookie were determined according to Ayo *et al.* (2007), as follows:

The baked cookies were weighted on an electronic balance. Where the cookie units were randomly selected, weighed and the average taken.

The cookie diameter was determined by measuring each cookie unit randomly picked using a calibrated ruler and the average was taken.

Determination of cookie spread ratio

Three columns of uniformed cookies were prepared and the heights were determined. After that, the cookies were arranged horizontally from edge to edge and the length of each row was determined to calculate the cookie diameter. The cookies spread ratio was calculated as diameter per height (Giami *et al.*, 2005).

Determination of thickness of cookies

The cookies thickness was determined by arranging six cookies on top of each other, then three readings were achieved by shuffling cookies. All determinations were achieved in three replicates of six cookies, then all the readings were divided by six to get the value of one cookie (McWatters *et al.*, 2003).

Hardness:

The hardness of the cookies was expressed as the needed force to destroy the cookies. The force was measured by universal testing machine (model 4301, Instron Corp., Canton, MA, USA) according to Sindhuja *et al.* (2005).

Determination of total bacterial count (TBC)

The total bacterial count was achieved according to Frazier (1976), 1g of prickly pear cookies was added to 9 ml of ringer's solution in sterile test tube, and the tube was blended thoroughly, then 10 serial dilutions were prepared. Each dilution was aseptically transferred to three sterile Petri-dishes, then thin layer of nutrient agar was added. Each Petri-dish was mixed and gentle shaking and leaved to solidify. Then, all Petri-dishes were incubated for 24 hours at 37ºC, after that, the colonies were counted. Results were expressed as cfu /g of prickly cookies.

- Mold and Yeast enumeration:

Mold and yeast counts were determined using the plate counts technique on potato dextrose agar (PDA) according to procedures by A.P.H.A (1976) and Manual (1984). The plates were kept 3 days at 28 ºC.

Determination of phenolic compounds by HPLC:

HPLC analysis was carried out using an Agilent 1260 series. The Eclipse C18 column (4.6 mm x 250 mm i.d., 5 μm) was used for the separation. The mobile phase consisted of water (A) and 0.05% trifluoroacetic acid in acetonitrile (B) at a flow rate of 0.9 ml/min. The mobile phase was programmed consecutively in a linear gradient as follows: 0 min (82% A); 0–5 min (80% A); 5-8 min (60% A); 8-12 min (60% A); 12-15 min (82% A) ; 15-16 min (82% A) and 16-20 (82%A). The multi-wavelength detector was monitored at 280 nm. The injection volume was 5 μl for each sample solution. The column temperature was maintained at 40 °C. Phenolic compounds of the sample were identified by comparing their relative retention times with those of the standard mixture chromatogram (Elbadrawy and Sello, 2011). The concentration of an individual compounds was calculated on the basis of peak area measurement, then converted to ppm.

Sensory Evaluation:

The organoleptic characteristics of prickly pear cookies including: taste, color, texture, aroma and overall acceptability, were evaluated by 15 member panelists of Agri-Industrialization Unit's staff, using the 9-point rating hedonic scale (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 Ikechukwu *et al.*, 2017.

Statistical analysis

All measurements were achieved in triplicates (except minerals and phenolic compounds) and data are reported as average. Significant differences ($p<0.05$) were calculated using Duncan's multiple range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Chemical characteristics and phytochemicals of juices and peels:

The chemical characteristics and phytochemicals of fruit juices and peels of yellow and red prickly pear were determined and the obtained results are presented in Table 2.

The presented data in table 2, showed obviously that, red prickly pear (either juice or peels) had higher TSS (12.5 and 11.1%, respectively) in comparison with those of yellow prickly pear (11.8 and 10.3%, respectively). These results agreed with those of Palmeri *et al.*, 2020, who found that the Brix values of prickly pear juices of three differently colored cultivars (white, yellow and red), were ranged from 11.75 to 13.50.

While the opposite situation was observed for the pH values where yellow prickly pear (either juice or peels) had higher pH values (5.75 and 4.90, respectively) and lower acidity compared to red prickly pear pH (5.30 and 4.80, respectively) and higher acidity.

Regarding the results of phytochemicals in the same table, it could be noticed that, carotenoid contents of yellow prickly pear (either juice or peels), were (19.75 and 13.45 mg/100g, respectively) and higher than those of red prickly pear (9.30 and 10.95 mg/100g, respectively). These findings are following those reported by Hernández-Pérez *et al.* (2005), who mentioned that carotenoid contents in the pulp of three prickly pear varieties ranged from 4 to 85 mg/100 g fresh weight. Dietary guidelines recommended increased consumption of carotenoids-rich fruits to combat the incidence of human chronic diseases (Rao and Rao, 2007).

Table 2. Chemical characteristics and phytochemicals of fruit juices and peels of yellow and red prickly pear

	Yellow prickly pear juice	Yellow prickly pear peels	Red prickly pear juice	Red prickly pear peels	LSD
TSS (%)	11.8^{b}	10.3^{d}	12.5^{a}	11.1^{c}	0.191
pH	5.75^{a}	4.90^{c}	5.30^{b}	4.80^{d}	0.095
Acidity (% as citric acid)	0.360^{c}	0.452^{ab}	0.410^{bc}	0.480^{a}	0.051
Carotenoids mg/100g	19.75^{a}	13.45^{b}	9.30^{d}	10.95^{c}	1.377
Total polyphenols (mg GAE /100g)	42.95^{d}	76.05^{b}	45.44^{c}	87.85^{a}	2.16
Flavonoids (mg QE /100g)	9.10^{d}	13.68^{b}	10.55^{c}	18.28^{a}	1.219
Betalains mg/100g	1.30^{c}	1.53^{c}	4.16^{a}	2.80^{b}	0.259

Means (+SD) in the same row with different superscripts are significantly different ($p < 0.05$).

On the other hand, red prickly pear (either juice or peels) had higher contents of total polyphenol (45.44 and 87.85 mg GAE/100g, respectively), total flavonoids (10.55 and 18.28 mg QE/100g, respectively) and betalains (4.16 and 2.80, respectively) comparing with those of yellow prickly pear.

The flavonoid results are within the range reported by Chang *et al.* (2008) and Chávez-Santoscoy *et al.* (2009) who found that total flavonoids of juice extracted from nine Mexican prickly pears ranged from 9.58 to 37.43 mg of quercetin equivalents/100g.

The results of total polyphenols demonstrated that, the polyphenol contents of peels (either yellow or red prickly pear) were higher than those of prickly pear juice. This may be due to phenolic compounds accumulating more in the prickly pear peels than in the pulp where the total phenolic content in the peels was twice as high as in the pulp (Yeddes *et al*., 2013).

Also, the results of total betalains are following those reported by Chávez-Santoscoy *et al.* (2009) and Coria-Cayupán *et al.* (2011), who found that total betalains concentration ranged from 0.39 to 48.4 mg/100 g.

Phenolic compounds profile

One of the most important plant compounds is Phenols group, as a result of their free radicals scavenging activity, due to their hydroxyl groups (Heim *et al.,* 2002). Table 3 shows the separation and identification of compounds including sixteen phenolic compounds. The predominant phenolic acids are gallic acid (ranging from 45.65 to 87.22 ppm) followed by chlorogenic acid (ranging from 21.95 to 60.91 ppm). While the predominant flavonoids are Catechin (ranged between 16.50 and 97.04 ppm) followed by naringenin (ranged between 4.75 and 20.55 ppm). The mentioned results showed also that, ellagic acid recorded a higher concentration in yellow and red juices (21.01 and 40.05 ppm, respectively) while the peels of yellow and red prickly pear possessed lower contents (9.05 and 3.57 ppm, respectively). The opposite situation could be observed for ferulic acid which recorded higher content in yellow and red peels (21.01 and 23.99 ppm, respectively) than those of yellow and red juices (3.25 and 3.52 ppm, respectively).

These results are agreed with those reported by Zenteno-Ramirez *et al.* (2018), who found that gallic acid was the predominant phenolic acid in nine prickly pear variant juices where its content was ranged from 32.6 to 81.2 ppm.

Chemical composition of prickly pear cookies

The chemical composition of all studied prickly pear cookies was determined and the obtained results are presented in Table 4.

Moisture content results showed that cookies produced with juices (either yellow or red) possessed higher moisture content compared with peels or juice peel cookies.

The presented data illustrated obviously that, protein, lipids and carbohydrates contents did not affect as a result of prickly pear additions (either juices or peels) for both yellow and red prickly pears.

Table 3. Phenolic compounds of fruit juices and peels of yellow and red prickly pear

	Yellow juice	Yellow peels	Red juice	Red peels
Gallic acid	45.65	80.24	55.75	87.22
Chlorogenic acid	21.95	60.91	45.05	56.44
Catechins	21.80	97.04	16.50	79.12
Methyl gallate	0.58	2.80	0.80	2.50
Caffeic acid	0.49	4.10	0.35	3.72
Syringic acid	1.31	0.05	3.70	0.05
Pyro-catechol	4.05	22.05	2.75	22.50
Rutin	0.95	0.80	2.95	1.30
Ellagic acid	21.01	9.05	40.05	3.57
Coumaric acid	0.95	3.01	1.05	2.75
Ferulic acid	3.25	21.01	3.52	23.99
Naringenin	4.75	15.80	10.40	20.55
Daidzein	1.20	3.35	0.15	3.05
Querectin	0.85	0.80	0.10	0.10
Cinnamic acid	0.00	0.22	0.00	0.05
Kaempferol	0.00	2.12	0.00	0.05

Table 4. Chemical composition of prickly pear cookies

	Moisture	Protein	Lipids	Ash	Crude fiber	Carbohydrates	Caloric value K.cal/100g
YJ	14.22^{a}	10.66^{a}	19.50^{a}	1.56^{c}	0.82^{e}	54.06^{a}	434.33^{b}
YP	13.55^{c}	10.54^{a}	19.45^{a}	1.72^{a}	1.10^{ab}	54.74^{a}	436.17^{ab}
YJP	13.80^{b}	10.54^{a}	19.55^{a}	1.60^{bc}	0.95^{cd}	54.51^{a}	436.15^{ab}
RJ	14.15^{a}	10.45^{a}	19.44^{a}	1.55^{c}	0.86^{de}	54.41^{a}	434.40^{ab}
RP	13.40^{c}	10.52^{a}	19.53^{a}	1.68^{ab}	1.17^{a}	54.87^{a}	437.33^{a}
RJP	13.75^{b}	10.57^{a}	19.52^{a}	1.60^{bc}	1.05^{bc}	54.56^{a}	436.20^{ab}
LSD	0.168	0.223	0.154	0.084	0.113	1.459	2.707

Means (+SD) in the same column with different superscripts are significantly different ($p < 0.05$).

Concerning crude fiber results, it could be noticed that, cookies produced with prickly pear peels owned the highest crude fiber content (either for yellow or red prickly pears), followed by the cookies produced with juice peel mixture, then the cookies produced with juice.

Regarding the caloric value of the produced cookies, it could be noticed that, the highest caloric value (437.33 K. cal/100g) was recorded for red peel cookies, while the lowest caloric value (234.33 K. cal/100g) was recorded for yellow juice cookies.

Microbial quality of cookies:

The microbial quality of the all studied prickly cookies was examined and the obtained results were tabulated in Table 5.

The mentioned data demonstrated that yellow juice cookies had the highest total bacterial count (23×10^{2}) while red juice cookies possessed the highest mold and yeast count (9×10^{2}).

From the same table, it could be noticed that either yellow or red peel cookies recorded the lowest values of total bacterial count (18×10^{2} and 16×10^{2}, respectively) compared to juice cookies and juice peel mixture cookies. The same trend was observed for mold and yeast count, where yellow peel cookies and red peel cookies had the lowest values (0×10^{2} and 1×10^{2}, respectively).

The above results could be a good indicator about of the microbiological quality of all studied prickly pear cookies. These could be attributed to the antimicrobial compound found in prickly pear juice and peels. Phenolic compounds can interact with the micro-organism membrane proteins, affect the membrane permeability and lead to cell destruction. Besides, they can penetrate bacterial cells and coagulate their contents (Doughari *et al.,* 2008 and Sengul *et al.*, 2009). One of the bioactive compounds is coumaric acid that used as an antimicrobial agent (Wang, 2003).

Physical characteristics of cookies:

The results of weight (g), diameter (cm), thickness (cm), spread ratio and hardness (g/cm^{2}) of prickly pear cookies could be seen in Table 6.

The mentioned data illustrated that prickly pear peel cookies had the highest weight either for yellow or red prickly pear (13.976 and 14.042g, respectively). While prickly pear juice cookies recorded the highest diameters followed by prickly juice peel mixture and then peel cookies either for yellow or red prickly pears. The observed shrinkage of diameter for prickly peel cookies may be due to the crude fibers content which absorbs moisture leading that to develop a gluten network and form batter elastic network which shriveled after baking (Ayo *et al.,* 2007).

Table 5. Total Bacterial Count and Mold and Yeast count of prickly pear cookies

Treatments	TBC (cfu/g)	M& Y (cfu/g)
YJ	$23 \times 10^{2\ a}$	$3 \times 10^{2\ b}$
YP	$18 \times 10^{2\ cd}$	$0 \times 10^{2\ d}$
YJP	$20 \times 10^{2\ b}$	$1 \times 10^{2\ cd}$
RJ	$20 \times 10^{2\ b}$	$9 \times 10^{2\ a}$
RP	$16 \times 10^{2\ e}$	$1 \times 10^{2\ cd}$
RJP	$17 \times 10^{2\ de}$	$2 \times 10^{2\ bc}$
LSD	1.096	1.908

Means (+SD) in the same column with different superscripts are significantly different ($p < 0.05$).

Table 6. Physical characteristics of prickly pear cookies.

Treatments	Weight (g)	Diameter (cm)	Thickness (cm)	Spread ratio	Hardness (g/cm^2)
YJ	11.788^d	3.94^b	1.80^c	2.18^a	1730^f
YP	13.976^a	3.60^d	2.15^{ab}	1.67^d	2960^b
YJP	12.594^c	3.92^b	2.10^{ab}	1.86^c	2190^d
RJ	13.528^b	4.06^a	2.00^b	2.03^b	1830^e
RP	14.042^a	3.72^c	2.25^a	1.65^d	3360^a
RJP	12.706^c	3.78^c	2.05^b	1.84^c	2430^c
LSD	0.148	0.074	0.156	0.112	85

Means (+SD) in the same column with different superscripts are significantly different ($p < 0.05$)

Table 7. Sensory evaluation of prickly pear cookies

	Taste (9)	Color (9)	Odor (9)	Texture (9)	Overall acceptability (9)
YJ	7.055^c	7.443^b	7.888^a	7.126^b	7.577^{ab}
YP	7.165^{bc}	6.944^c	7.888^a	7.277^{ab}	7.432^b
YJP	7.270^{ab}	7.721^a	7.722^{ab}	7.287^{ab}	7.610^{ab}
RJ	7.166^{bc}	6.666^d	7.221^c	6.666^c	7.433^b
RP	7.310^a	7.443^b	7.443^{bc}	7.221^{ab}	7.599^{ab}
RJP	7.388^a	7.632^{ab}	7.721^{ab}	7.311^a	7.822^a
LSD	0.128	0.217	0.393	0.148	0.261

Means (+SD) in the same column with different superscripts are significantly different ($p < 0.05$)

On the other hand, juice cookies recorded the highest spread ratio either for yellow or red prickly pear (2.18 and 2.03, respectively) followed by juice peel mixture (1.86 and 1.84, respectively), then peel cookies (1.67 and 1.65, respectively). Cookies having higher spread ratios are considered most desirable (Abou-Zaid *et al.,* 2012).

Regarding hardness results, it could be noticed that, prickly pear peel cookies had the highest hardness either for yellow or red prickly pears (2960 and 3360 g/cm^2, respectively) followed by juice peel mixture cookies (2190 and 2430 g/cm^2, respectively), then prickly juice cookies (1730 and 1830 g/cm^2, respectively).

It may be due to, fiber and carbohydrate contents are the most effective components on the hardness of cookies after baking. Dehydration of carbohydrates and fibers could establish the matrices which contribute to the structure of cookies (Hardeep *et al.,* 2003).

Sensory evaluation of cookies

Concerning sensory evaluation results presented in Table 7. It could be observed that, cookies produced with juice peels mixture recorded the highest values of taste, color, texture and overall acceptability either for yellow prickly pear (7.270, 7.721, 7.287 and 7.610, respectively) or red prickly pear (7.388, 7.632, 7.311 and 7.822, respectively). Also, the results illustrated that, red juice cookies possessed the lowest color and texture values (6.666 for both).

Concerning the odor results, it could be noticed that, the odor of all yellow prickly pear cookies was not affected significantly. While red juice peel mixture cookies owned the highest odor value (7.721) compared to the other red prickly pear cookies.

From the previous results in table 7, it could be concluded that, all produced cookies using yellow or red prickly pear, are organoleptically accepted for all studied sensory parameters, where all the scored values are more than 5.

CONCLUSION

The obtained results showed that, red prickly pear (either juice or peels) had higher contents of TSS, polyphenols, flavonoids and betalains, while yellow prickly pear possessed higher values of pH and carotenoids. The major phenolic acids of both the juice and peels of the two cultivars are Gallic acid followed by Chlorogenic acid. While the predominant flavonoids are Catechin followed by Naringenin. The cookies produced with juices (either yellow or red) possessed higher moisture contents compared with peels or juice peel cookies. While protein, lipids and carbohydrate contents did not affect as a result of prickly pear additions (either juices or peels) for both yellow and red prickly pears. cookies produced with prickly pear peels owned the highest crude fiber contents (either for yellow or red prickly pears). yellow or red peel cookies recorded the lowest values of total bacterial count and mold and yeast count compared to juice cookies and juice peel mixture cookies. Prickly pear peel cookies had the highest weight and hardness either for yellow or red prickly pear. While prickly pear juice cookies recorded the highest diameters and the highest spread ratio either for yellow or red prickly pear. All produced cookies using yellow or red prickly pear, are organoleptically accepted for all studied sensory parameters. From the mentioned results it could be concluded that fresh prickly pear juices and peels (either yellow or red) could be used in the production of delicious and healthy cookies.

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الملخص العربي

إستخدام عصير وقشور ثمرة التين الشوكى (*Opuntia Spp.*) فى إنتاج الكوكيز

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يعتبر لب وقشور التين الشوكى مصادر غنية لبعض المغذيات المهمة والمركبات النشطة حيويا، والتى يتم فقدها اثناء التجفيف. لذلك فإن هذا البحث يهدف إلى تقدير الخصائص الكيماوية للعصير والقشور الطازجة لصنفين من التين الشوكى أحدهما أصفر (*Opuntia ficus-indica*) والأخر أحمر (*Opuntia littoralis*)، واستخدام عصير وقشور كل منهما فى إنتاج الكوكيز، وتقييم جودة الكوكيز. ولقد أظهرت النتائج أن عصير وقشور الصنف الأحمر كانت أعلى فى محتواها من المواد الصلبة الذائبة الكلية والبولي فينولات والفلافونويدات والبيتالينات. بينما تلك الخاصة بالصنف الأصفر كان أعلى فى رقم الحموضة (pH) والكاروتينات. وكانت الأحماض الفينولية الرئيسية فى كل العينات هى حمض الجاليك ثم الكلوروجينيك، بينما كانت الفلافونويدات السائدة هى كاتيشين ثم النارنجينين. ولقد كان كوكيز عصائر التين الشوكى (الأصفر والأحمر) أعلى فى محتواه الرطوبى بينما كان كوكيز القشور (سواء الأصفر أوالأحمر) أعلى فى محتواها من الألياف الخام والأفضل جودة ميكروبيولوجية. من ناحية أخرى فإن كوكيز القشور كانت أعلى وزنا وصلابة بينما كان كوكيز العصائر أكبر أقطارا ونسبة الفرد (سواء الأصفر أوالأحمر). كما أظهرت نتائج التقييم الحسى أن جميع الكوكيز المنتجة كانت مقبولة حسيا. ولقد أظهرت النتائج أن عصائر وقشور التين الشوكى الطازجة يمكن أن تستخدم فى إنتاج كوكيز لذيذ وصحى.

الكلمات المفتاحية: الخصائص الكيماوية، جودة الكوكيز، عصير وقشور طازجة، التين الشوكى.