World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Assessment of jelly candy manufactured from prickly pear fruits *(Opuntia Spp.)*

Hind Saad Abu-shama [1,*], Fatma Aly Ahmed [2] and Hossam El-Din Abd El- magied Badr [1]

[1] *Department of Plant Production, Agri-Industrialization Unit, Desert Research Center, Cairo, Egypt.*
[2] *Department of Medicinal and Aromatic Plants, Desert Research Center, Cairo, Egypt.*

World Journal of Advanced Research and Reviews, 2022, 16(01), 767–783

Publication history: Received on 20 September 2022; revised on 24 October 2022; accepted on 27 October 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.16.1.1100

Abstract

The purpose of the present study was to assess fresh juice and peels of cactus pear *Opuntia ficus-indica* (yellow cultivar) and *Opuntia littoralis* (red cultivar),local origin for their Physicochemical properties and bioactive compounds as well as jelly candies prepared by using six formulas of prickly pear juice and peels were studied .The obtained results showed that, prickly pear juices (red and yellow cultivars) were the highest T.S.S (12.3 and 11.9%, respectively) and PH values (5.2 and 5.7, respectively), while the lowest values were recorded for the peels. On the contrary, the peels possessed the highest total phenolic contents (87.72 and 76.15 mg Gallic acid/100 g FW) and flavonoids (18.182 and 13.55 mg Querectin/100 g FW) for red and yellow, respectively. Whereas, red prickly pear showed lower content of carotenoids and higher content of betalains than yellow prickly pear (either for juice or peels). On the other hand, results showed that jelly candies produced from prickly pear are found to be important source of total polyphenols, flavonoids, carotenoids, and betalains and have low microbial load during cold storage for 4weeks. Sensorial evaluation showed that red peels, red juice and yellow juice jelly candies were the most accepted by panelists with the same values which considered “Like very Much ” .Therefore, prickly pear fruits can be used for food manufacturing especially children's foods which are considered to be healthy, attractive colors, have no side effects and are appropriate in sensorial properties which leads to an increase in the add value.

Keywords: Prickly pear; Jelly candies; Physicochemical properties; Bioactive components; Microbiological and sensorial properties

1. Introduction

Both children and adults are widely consumed confectionery products. whereas, in the age group under 17 years jellies and gummies are particularly popular due to their organic and chewy nature [1]. For the manufacturing of jellies, consideration has been given to the use of natural juices or purees of orange, strawberry, and other red fruits or fruit by-products [2,3]. These can produce healthier formulations with antioxidant properties and improve the organoleptic properties (color, flavor, and texture) of gummies and jellies [4].

Gelling agents, sucrose, glucose syrup, acids, flavorings, and colorants are used in confectionery hydrogel products manufacturing [5]. The high sugar content and low nutritional value of confectionery products are questionable for their association with cardiovascular diseases, hypertension, diabetes and obesity [6]. For that, consumers demand healthier confectionery hydrogels foods with the most higher natural antioxidants and lower sugar content than current commercial products [7]. Replacement with natural pigments, such as betalains, anthocyanin and carotenoids in food industry because consumers have been avoiding foods that contain synthetic colorants [8].

* Corresponding author: Hind S. Abu-shama
Department of Plant Production, Agri-Industrialization Unit, Desert Research Center, Cairo, Egypt.

The Opuntia cactus is a xerophyte of of about 200 to 300 species that grows mainly in arid and semiarid regions. Due to their remarkable genetic diversity, Opuntia plants exhibit high capacity to environmental adaptation, and therefore can be encountered in places of almost all climates [9].The fruit is sweet and delicious due to its characteristics such as good amount of sugar content and low acidity [10]. Cactus fruits can be eaten fresh or in the form of different food products such as juices, jams, ice creams, and extruded food products [11].

Prickly pears are also rich in phenols, flavonoids, betaxanthins and betacyanins , which favor a healthy status through hypoglycemic and hypolipidemic actions, and antioxidant properties [12,13,14] . Multifunctional characteristics and potentially active nutrients features of the cactus pear *Opuntia Spp*. fruit and vegetative cladodes make it suitable for the production of health-promoting food and dietary supplements and to be excellent candidates for improved healthy food. Thus, leading to use as food and medicine[15].

Recently, prickly pear cultivation has expanded in desert areas of Egypt as a result of its tolerance to difficult environmental conditions and its ability to grow in sandy soil with giving productivity. Prickly pear is considered one of commonly used plants due to its nutritional value, health benefits, and bioactive components. Therefore, the objective of this study was to analyze physicochemical properties and bioactive compounds of prickly pear fresh juice and peels from yellow and red cultivars and determine physical, chemical, phytochemical and microbiological of jelly candy during cold storage for 4weeks and evaluate sensorial properties.

2. Material and methods

2.1. Materials

2.1.1. Prickly pear fruits

- Mature fresh cactus pear fruits of *Opuntia ficus indica* (yellow cultivar) and *Opuntia littoralis* (red cultivar) were harvested from the farm of Applicable Research Center, Desert Research Center, Matrouh governorate, Egypt, in the summer season (June, 2021).
- Sugar and gelatin were obtained from a local market (Cairo, Egypt).
- Solvents and all chemicals: were obtained from El-Gomhoria Co. Cairo, Egypt.

2.2. Methods

2.2.1. Preparation of prickly pear juice and peels

Prickly pear fruits (5 kg) of each cultivar were brushed under tap water with a nail brush to remove prickles and dirty particles, then peels were manually removed by sharp knife. Both the peels and the pulp of prickly pear fruits were pulped by using a blender and strained through stainless steel strainer to separate the seeds and any other residues, subsequently the strained juice and peels were kept in polyethylene bags at -18°C for further use.

2.2.2. Formulas of prickly pear jelly candies and preparation

Six formulas of prickly pear juice, peels and other ingredients were used to prepare jelly candies as shown in Table 1.

Table 1 Prickly pear jelly candies formulas (%)

Ingredient (%)	RJ	RJP	RP	YJ	YJP	YP
Red prickly pear juice	60.3	30.15	-	-	-	-
Red prickly pear peels	-	30.15	60.31	-	-	-
Yellow prickly pear juice	-	-	-	60.31	30.15	-
Yellow prickly pear peels	-	-	-	-	30.15	60.31
Sucrose	30.3	30.3	30.3	30.3	30.3	30.3
Gelatin	9.1	9.1	9.1	9.1	9.1	9.1
Citric acid	0.3	0.3	0.3	0.3	0.3	0.3

The preparation of prickly pear jelly candies was conducted as following:

Half amount of prickly pear source (juice, peels and mixture juice + peels) was mixed with sugar and the mixture was heated at 70-80 °C for 5 min, then add the gelatin solution which was prepared by dissolving in the other half amount of prickly pear (juice, peels and mixture juice + peels).The mixture was cooked until the concentration of total soluble solids (TSS) reached 65°Brix (which measured using a digital refractometer) and cooled to 55-60 °C. After that, citric acid was added then, formed into a silicone molds.The mold was placed at room temperature for 30 min and kept in refrigerator at 8±2 °C for 4h.The prickly pear jelly candies samples were removed from the molds and packed in polypropylene pouches and stored cold refrigerated for 4weeks.

2.2.3. Physicochemical determination

All studied prickly pear juices, peels and the jelly candies produced form the previous formulations were evaluated in relation to:

- The total soluble solids (TSS) as the Brix value was read using a digital refractometer (DR 6000, A. Kruss Optronic GmbH, Hamburg, Germany).
- The titratable acidity (expressed as citric acid %) was determined as follows: 10ml of 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 and the data was computed and reported as the percentage of citric acid content [16].
- The pH value was measured by using a Systronic324- combination glass electrode pH meter at 25 °C.
- The moisture content in a vacuum oven according to [16].
- The hardness parameter of prickly pear jelly candies samples was measured by using a Texture Analyzer (model 4301, Instron Corp., Canton, MA, USA), with a cylindrical aluminum [17].The samples were compressed twice which allowed the sample to be deformed without penetration (expressed as g /cm^2).

2.2.4. Analytical methods

Polyphenols content was determined as total polyphenols and all values were expressed as average (mg of Gallic Acid Equivalents/g on fresh base) [18] .

The total flavonoid contents were measured spectrophotometrically, absorbance at 510 nm. was read and flavonoids content was measured and expressed as mg Quercetin equivalents/100g (mg QE/100g) [19].

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 and for 15 hours at room temperature. Then, the sample is filtered through glass wool into a 100 ml volumetric flask, and made up to volume with 85% acetone solution. The absorbance was measured byspectrophotometer (UV-VIS spectrophotometer Shimadzu Model, 1240 , 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.Then calculated as mg/100g [20] .

Betalains Content

The prickly pear juice, peels and jelly candies product 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 [21] using the following equation:

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).

Determination of Phenolic compounds by HPLC

HPLC analysis was carried out using an Agilent1260 series. The Eclipse C18 column (4.6 mm x 250 mm i.d.,5µm) 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 multiwavelength 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 [22].The concentration of an individual compounds was calculated on the basis of peak area measurement, then converted to ppm.

2.2.5. Microbiological assay

Total plate bacterial count

Total plate bacterial counts of all samples were estimated by using the plate count technique on nutrient agar medium according to the procedure of American Public Health Association and Difco [23,24]. The plates were incubated at 37 °C for 48 hr and results were expressed as (cfu /gm.).

Yeasts and molds count

The procedure of Difco was followed to assay yeasts and molds occurrence by using potato dextrose agar medium. The plates were incubated at 20 – 25 °C for 5 days. If excessive growth develops, colonies counted first after 3 days and then again after 5 days and reported as yeasts and molds counts per ml or gram. Results were expressed as (cfu /gm.).

2.2.6. Sensory evaluation

Sensory characteristics evaluation of the produced prickly pear jelly candies subjected to organoleptic evaluation. The prickly pear candy samples were evaluated by 18 panelists from the staff of the Agriculture Industrialization Unit, Desert Research Center. Panelists were asked to evaluate prickly pear jelly candies for appearance, color, texture, odor, taste and overall acceptability, 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 [25].

2.2.7. Statistical analysis

A completely randomized experimental design was selected and all determinations were carried out in triplicates (except fractionation of phenolic compounds) and data were reported as mean. Significant differences ($p< 0.05$) were calculated using Duncan multiple range tests [26].

3. Results and discussion

3.1. Physicochemical properties and bioactive compounds of cactus pear fruits from yellow and red cultivars

Fruit juices and peels of red and yellow prickly pear were analyzed for their total soluble solids (T.S.S%), pH value, titratable acidity (as citric acid %) and bioactive compounds (total polyphenols, flavonoids, carotenoids and betalains) and the obtained results are shown in Table (2).

From these results it could be noticed that, there was significant differences for total soluble solids between all cactus samples, which varied from 10.2 % to 12.3 %. TSS was significantly higher ($P \leq 0.05$) in the red variety than in the yellow, TSS is a variable parameter depending on maturity stage and fruit metabolism. On the other hand, the highest pH was noticed for yellow prickly pear juice (5.70) and the lowest pH was noted for red prickly pear peels (4.68). A significant ($P<0.05$) difference was observed in pH among all prickly pear samples. This was lower than that stated by El-Gharras et al., [27] who found that pH of green, half ripe and ripe cactus fruits was, ranged from 5.95 to 6.07, 6.01 to 6.19 and 6.15 to 6.34, respectively. Also, Albano et al. [28] reported that pH of orange and purple varieties of cactus fruit were 6.02 and 5.8, respectively.

Concerning titratable acidity, it was ranged from 0.37 to 0.48 (% as citric acid). The highest acidity was noted for red prickly pear peels which was significantly (P<0.05) higher as compared to other samples. This is similar to those reported by Chalak et al.[29], who found that, a wide range of titratable acidity (from 0.08% to 0.43%) and lower than titratable acidity (0.942 ± 0.019 g/100ml) reported by Chauhan et al. [30]. The total acid content of the different varieties of juicy pulp prickly pear was 0.46 % to 0.98% [31].

Table 2 Physicochemical properties and bioactive compounds of fruit juices and peels of red and yellow prickly pear (fresh weight basis)

Sample	Physicochemical properties			Bioactive compounds (mg/100g)			
	Total soluble solids (T.S.S)%	PH value	Titratable acidity (as citric acid) %	Total polyphenols (mg GAE /100g)	Flavonoids (mg QE /100g)	Carotenoids (mg/100g)	Betalains (mg/100g)
Red prickly pear juice	12.3^{a}	5.2^{b}	0.413^{c}	45.24^{c}	10.40^{c}	9.20^{d}	4.363^{a}
Red prickly pear peels	10.9^{c}	4.68^{d}	0.484^{a}	87.72^{a}	18.182^{a}	10.90^{c}	2.988^{b}
Yellow prickly pear juice	11.9^{b}	5.70^{a}	0.367^{d}	42.75^{d}	9.231^{d}	19.9^{a}	1.320^{d}
Yellow prickly pear peels	10.2^{d}	4.95^{c}	0.448^{b}	76.15^{b}	13.548^{b}	13.4^{b}	1.613^{c}
L.S.D	0.099	0.176	0.007	1.225	0.458	1.074	0.257

Values bearing the same superscript within the same column are not significantly different (P >0.05); GAE /100g = mg gallic acid equivalents /100g
QE /100g = Querectin equivalents /100g

Regarding the bioactive compounds of fruit juices and peels of red and yellow prickly pear, it could be noticed that, both prickly pear red and yellow fruits contained a good amount of bioactive compounds. Total polyphenols and flavonoids compounds reached the highest amounts in the peels of red and yellow prickly pear which recorded (87.72 mg GAE /100g and 18.18 mg QE/100g, 76.15 mg GAE /100g, 13.55mgQE/100g (respectively) comparing to the juices (45.24 mg/100g GAE, 10.40 mg QE /100g and 42.75 mg/100g GAE, 9.231 mg QE /100g) for red and yellow prickly pear, respectively. Flowers and peels could exhibit higher phenolic contents than fruit and cladodes, with about 45.7g/100g FW. It is therefore recommended to exploit these materials to obtain bio-compounds with antioxidant characteristics [32]. In cactus pear fruits, there was a much higher phenolic content, but it referred to a whole (skin and pulp) red-skinned fruit [33]. Prickly pear *Opuntia ficus indica* is known for its high content in polyphenols exhibiting antioxidant and anti-inflammatory properties [34,35] **.**

From the same Table, it could be noticed that yellow juices and peels had higher values in carotenoids content (19.9 and 13.4 mg/100g, respectively) than red juices and peels (9.20 and 10.90 mg/100g, respectively). On the contrary, there was significant increase ($p < 0.05$) in betalains content for the red variety compared with the yellow one, whereas, red prickly pear juice and peels contained the highest contents of betalains which recorded (4.36 and 2.99 mg/100g, respectively) comparing with those of yellow prickly pear juices and peels (1.32 and 1.61 mg/100g, respectively). Total color yield depends on the respective species and clone investigated and may range from 5 to 110 mg/100g [21,36]. Therefore, cactus pear juice preparations are expected to be a suitable coloring foodstuff for low acid products such as ice-cream or yogurt [9] **.**

3.2. Phenolic compounds fractionation of fruit juices and peels of red and yellow prickly pear by HPLC

One of the most important plant compounds is phenols group, as a result of their free radicals scavenging activity, due to their hydroxyl groups [37] **.**

Table (3), shows the separation and identification of compounds including sixteen phenolic compounds. The predominant phenolic acids are gallic acid (ranging from 43.36 to 87.42 ppm) followed by chlorogenic acid (ranging from 21.85 to 61.21ppm).While the predominant flavonoids are catechin (ranged between 16.66 and 96.74 ppm) followed by naringenin (ranged between 4.62 and 20.41 ppm). The mentioned results showed also that, ellagic acid

recorded a higher concentration in yellow and red juices (20.90 and 40.24 ppm, respectively) while the peels of yellow and red prickly pear possessed lower contents (8.89and 3.17 ppm, respectively).The opposite situation could be observed for ferulic acid which recorded higher content in yellow and red peels (21.81 and 24.09 ppm, respectively) than those of yellow and red juices (3.22 and 3.42 ppm, respectively). These results are agreed with those reported by Zenteno-Ramirez et al.,[38] who found that the predominant phenolic acid was gallic acid where its content ranged from 32.6 to 81.2 ppm in nine prickly pear variant juices.

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

	Red juice	**Red peels**	**Yellow juice**	**Yellow peels**
Gallic acid	55.79	87.42	43.36	80.42
Chlorogenic acid	44.99	56.22	21.85	61.21
Catechin	16.66	79.34	21.64	96.74
Methyl gallate	0.76	2.44	0.56	2.74
Caffeic acid	0.30	3.69	0.47	4.06
Syringic acid	3.67	0.00	1.29	0.00
Pyro catechol	2.72	22.42	3.95	21.89
Rutin	2.91	1.24	0.00	0.82
Ellagic acid	40.24	3.17	20.90	8.89
Coumaric acid	1.00	2.63	0.92	2.79
Ferulic acid	3.42	24.09	3.22	21.81
Naringenin	10.24	20.41	4.62	15.77
Daidzein	0.00	3.01	1.09	3.20
Querectin	0.00	0.00	0.79	0.70
Cinnamic acid	0.00	0.00	0.00	0.17
Kaempferol	0.00	0.00	0.00	2.08

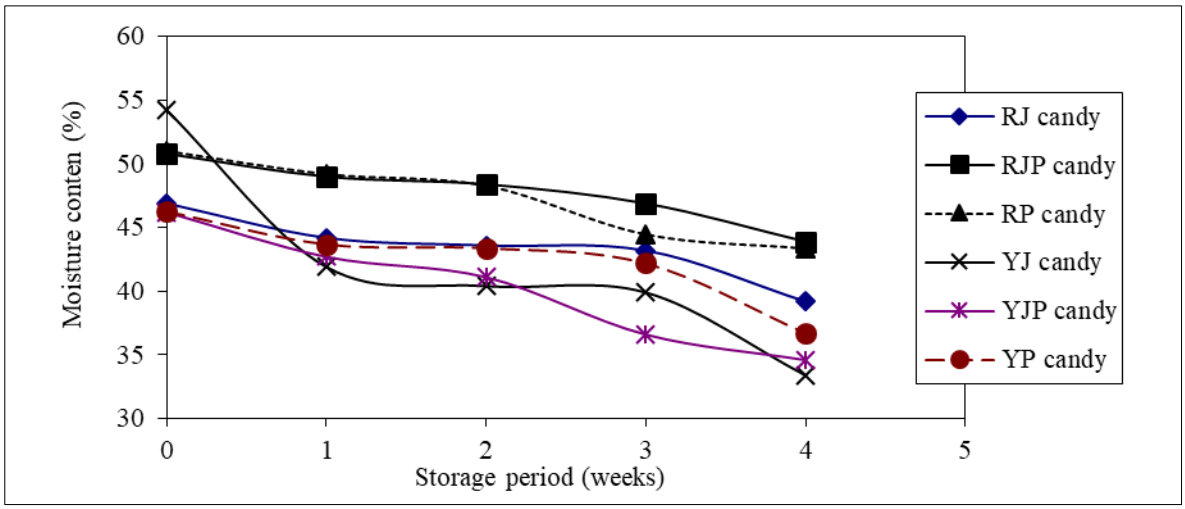
3.3. Physicochemical properties and bioactive compounds of red and yellow prickly pear jelly candies

Jelly candies prepared from juices, peels and juices peels mixture of red and yellow prickly pear fruits were assessed for their moisture content and total soluble solids (T.S.S%) during cold storage (8 ±2 ^{0}C) for 4 weeks and the obtained results are shown in figures (1) and (2).

3.3.1. Moisture content of jelly candies

Water is one of the most important components of confections, and of most foods. The nature of water bonding with food components and its interaction with the surrounding atmosphere affects the physical or textural characteristics of the food product as well as the food's shelf stability [39].

Moisture content of prickly pear jelly candies are shown in Fig.(1), it could be noticed that yellow juice, red peels and (red juice and peels) jelly candies had the highest values (54.2, 51.0 and 50.8%). While, red juice, yellow peels and (yellow juice and peels) jelly candies had the lowest values of moisture content (46.9, 46.3 and 46.2%, respectively).The statistical analysis results showed that, the cold storage period at 8 ±2^{o}C for 1, 2, 3 and 4weeks significantly ($p < 0.05$) affect the moisture content of the jelly candy samples.

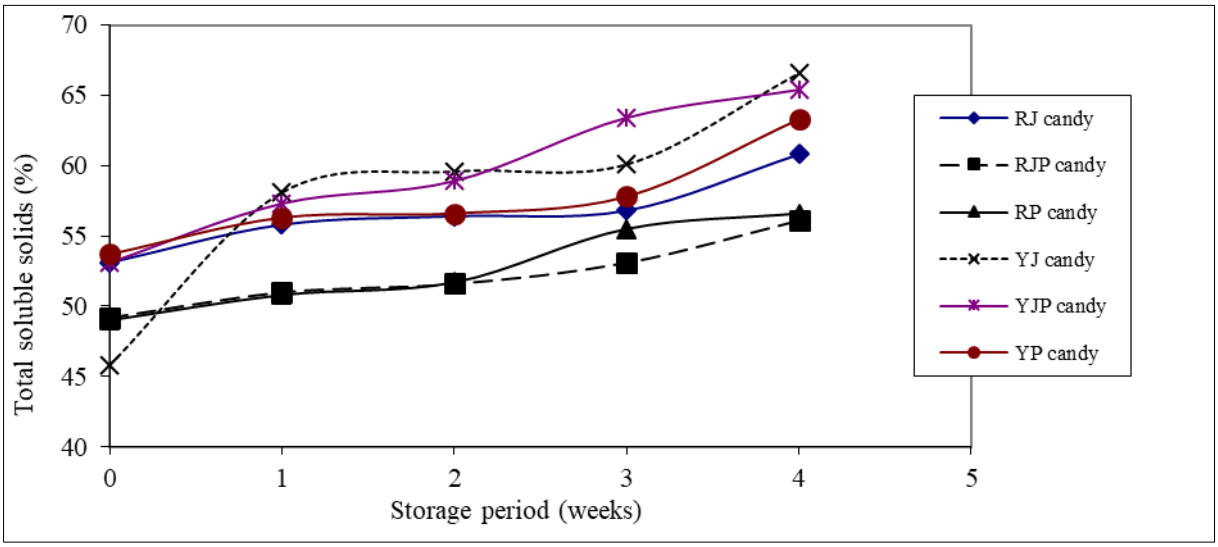


RJ :Red juice jelly candy, RJP: Red juice and peels jelly candy, RP :Red peels jelly candy; YJ: Yellow juice jelly candy ,YJP: Yellow juice and peels jelly candy, YP: Yellow peels jelly candy

Figure 1 Moisture content of prickly pear jelly candies during cold storage for four weeks

3.3.2. Total soluble solids (T.S.S%) content

Total soluble solids (◦ Brix), in addition to firmness, are measures of internal quality attributes in determining fruit maturity [40] **.** The TSS is reported to increase with ripeness and is used as an indicator of soluble simple sugars or acids, reported to predominantly include sugars; glucose, fructose and sucrose; or acids; citric, ascorbic and mallic acids [41]**.**



RJ : Red juice jelly candy, **RJP:** Red juice and peels jelly candy, **RP :**Red peels jelly candy**; YJ**: Yellow juice jelly candy **,YJP**: Yellow juice and peels jelly candy, **YP:** Yellow peels jelly candy

Figure 2 Total soluble solids of prickly pear jelly candies during cold storage for four weeks

Fig. (2), shows the changes in total soluble solids content (T.S.S) of studied prickly pear jelly candies at zero time and within storage period for 4weeks. At zero time, the highest T.S.S was recorded in yellow peels candy 53.7% and the lowest value were recorded in yellow juice candy with 45.8%.From the presented data it can be summarized that, there was a gradual increase in T.S.S values during cold storage of jelly candy. At the end of storage, the T.S.S values ranged from 56.1% to 66.6% and the increment was more pronounced in yellow juice jelly candy sample compared with others.

3.3.3. PH values and titratable acidity (% as citric acid)

The changes in pH values and titratable acidity (% as citric acid) of prickly pear jelly candies at zero time and during cold storage for 4 weeks were determined and the results are presented in Table (4).

Table 4 PH values and titratable acidity (% as citric acid) of jelly candies during cold storage (8 ±2ºC) for 4weeks

Sample	PH					
	Storage period at 8±2 °C (weeks)					
	Zero time	1st week	2nd week	3rd week	4th week	L.S.D
Red juice jelly candy	3.95^{bA}	3.55^{bB}	3.40^{bC}	3.23^{bD}	3.18^{aD}	0.052
Red juice and peels jelly candy	3.70^{cA}	3.25^{dB}	3.16^{cC}	3.01^{cD}	2.88^{bE}	0.037
Red peels jelly candy	3.59^{dA}	3.26^{dB}	3.11^{cC}	3.00^{cD}	2.84^{bE}	0.080
Yellow juice jelly candy	4.18^{aA}	4.06^{aB}	3.95^{aC}	3.68^{aD}	3.18^{aE}	0.026
Yellow juice and peels jelly candy	3.48^{eA}	3.32^{cB}	3.14^{cC}	3.02^{cD}	2.88^{bE}	0.046
Yellow peels jelly candy	3.43^{fA}	3.20^{eB}	3.02^{dC}	2.84^{dD}	2.59^{cE}	0.015
L.S.D	0.042	0.046	0.063	0.051	0.043	
	Titratable acidity (% as citric acid)					
Red juice jelly candy	0.520^{cD}	0.544^{eC}	0.598^{eB}	0.671^{eA}	0.684^{eA}	0.014
Red juice and peels jelly candy	0.583^{bE}	0.638^{dD}	0.719^{dC}	0.771^{dB}	0.866^{dA}	0.008
Red peels jelly candy	0.592^{abE}	0.713^{bD}	0.847^{bC}	1.015^{bB}	1.052^{bA}	0.004
Yellow juice jelly candy	0.500^{cC}	0.496^{fC}	0.563^{fB}	0.564^{fB}	0.605^{fA}	0.038
Yellow juice and peels jelly candy	0.605^{abE}	0.667^{cD}	0.821^{cC}	0.896^{cB}	0.964^{cA}	0.004
Yellow peels jelly candy	0.620^{aE}	0.763^{aD}	1.012^{aC}	1.055^{aB}	1.290^{aA}	0.011
L.S.D	0.031	0.007	0.007	0.009	0.005	

Values bearing the same small letter within the same column (Samples are not significantly different (P > 0.05);

Values bearing the same capital letter within the same row (effect of storage period) are not significantly different (P > 0.05).

Titratable acidity (%) is an indicator of total acid content and reported a better predictor of acid contents impact on flavor, than alternate measures including pH [42].

Table (4), illustrates pH values for studied prickly pear jelly candies, the results indicated that, there were significant differences (P≤0.05) between pH values of all treatments at zero time and during storage period. At zero time of storage, yellow juice candy sample had the highest value of pH (4.18) followed by red juice candy sample (3.95).

Meanwhile, yellow peels candy was the lowest value (3.43). During storage time, there were significant decrease in pH values comparing with zero time, for all studied candy treatments, separately. Where, yellow peels candy had the highest reduction which reached 2.59 at the end of storage . On the other hand, yellow juice candy sample possessed the highest pH values during storage period compared with the other studied candy treatments. This finding is in agreement with the report of Jiamjariyatam,[43]**.** There is a possibility that gelatin derived from collagen, which is a protein and the subunit of gelatin is amino acid causing the high pH value. The same results obtained by Sogi and Singh, [44] who found that pH range of watermelon rind jams showed a movement towards acidity over the storage period. The general decrease in pH (more acidic) might be due to ascorbic acid degradation, hydrolysis of pectin and other acidic compounds [45] **.**

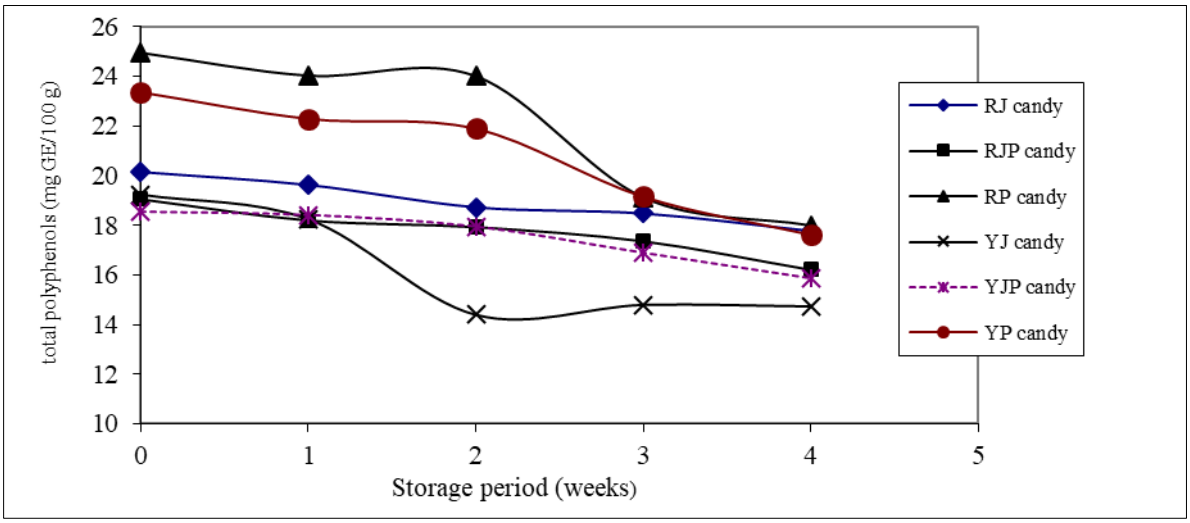
Data in Table (4), indicated that titratable acidity (% as citric acid) of studied prickly pear candy samples were significantly (P ≤ 0.05) increased with increasing storage period. The titratable acidity of all samples ranged from 0.500 to 0.620 at zero time and from 0.605 to 1.290 (% as citric acid) after cold storage at 8±2 ^{0}C for 4weeks. The lowest percentage were obtained in yellow juice candy and the highest percentage with yellow peels candy at all storage period compared to other candy samples. This agrees with Durrani et al., [46] who reported that, there was a gradual increase in Titratable acidity ratio during storage in carrot candy. The total acidity of apple candy varied non-significantly in response to the methods of candy preparation, storage conditions, and different packaging material [47]. The pH and

soluble solids content can increase, decrease or remain stable during storage; these variations are related to the processing conditions [48] .

3.4. Bioactive compounds of red and yellow prickly pear jelly candies

Jelly candies prepared from juice, peels and juice peels mixture of red and yellow prickly pear fruits were estimated for bioactive compounds (total polyphenols, flavonoids, carotenoids and betalains) during cold storage (8±2 ^{0}C) for 1,2,3 and 4weeks and the obtained results are shown in Figures (3),(4),(5) and (6).

3.4.1. Total polyphenols content



RJ :Red juice jelly candy, RJP: Red juice and peels jelly candy, RP :Red peels jelly candy; YJ: Yellow juice jelly candy ,YJP: Yellow juice and peels jelly candy, YP: Yellow peels jelly candy

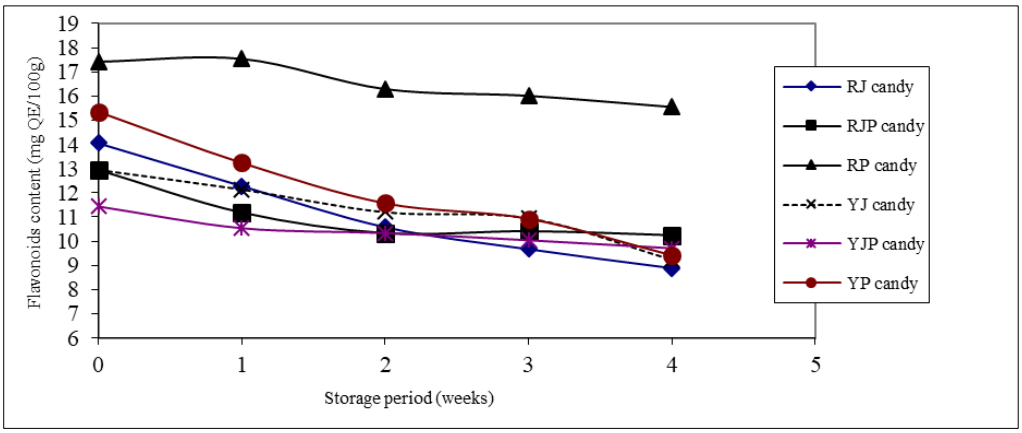
Figure 3 Total polyphenols content (mg GE/100g) of prickly pear candies during cold storage for four weeks

Regarding to the effect of storage on total polyphenols content of prickly pear candy samples, the results presented in Fig.3, showed obviously that, all studied treatment led to decrease the content of total polyphenols by extending storage period till the 4th week. The highest decrease was observed for yellow juice candy sample (14.73 mg/100 g), but no significant difference ($p > 0.05$) was found between red peels (17.99 mg/100 g) and red juice (17.77 mg/100 g) candy samples after the 4th week of cold storage. The decrease in total phenolics could mainly be resulted from oxidation, degradation of phenolic compounds, and the polymerization of phenolic compounds with proteins [49] . Kim and Padilla-Zakour,[50] showed that the decrease in total phenolics could be due to disruption in cell structure during processing. Interestingly, alkaloids, indicaxanthin, neobetanin, and various flavonoids have been isolated from the cactus [51].

3.4.2. Flavonoids content

Flavonoids are secondary metabolites and are categorized indifferent classes such as alkaloids, terpenoids, and phenolics. Its antioxidant properties are ascribed to their ability to reduce free radical formation and to scavenge free radicals [52]**.**

Data in Fig (4), indicate that, there were significant differences ($P \leq 0.05$) between flavonoids content of all prickly pear candy samples. At zero time of storage, red peels jelly candy was the highest content of flavonoids (17.42 mg/100 g FW) followed by yellow peels jelly candy which was recorded 15.35 mg/100 g (FW). While, yellow juice and peels jelly candy was the lowest value (11.44 mg/100 g FW) at zero time. On the hand, total flavonoids content exhibited a gradual decrease with increasing the storage period in all prickly pear jelly candy samples. where, flavonoids content of red peels jelly candy sample was slight decreased ($P \leq 0.05$) after storage period of 1, 2, 3 and 4weeks and recorded 17.54, 16.29, 16.01 and 15.55 mg/100g (FW), respectively. But the highest decrement at the end of the cold storage period was recorded (8.89) for red juice jelly candy compared with other studied samples at the end of storage for 4weeks. Phenolic compounds which are produced form secondary metabolites in plants contained phenolic acids and flavonoids compounds [53]. They are treated to more health encourage influence which acts as an antioxidant and thereby, it was used for more diseases, such as cancer, lowering blood glucose, and cardiovascular [54] **.**

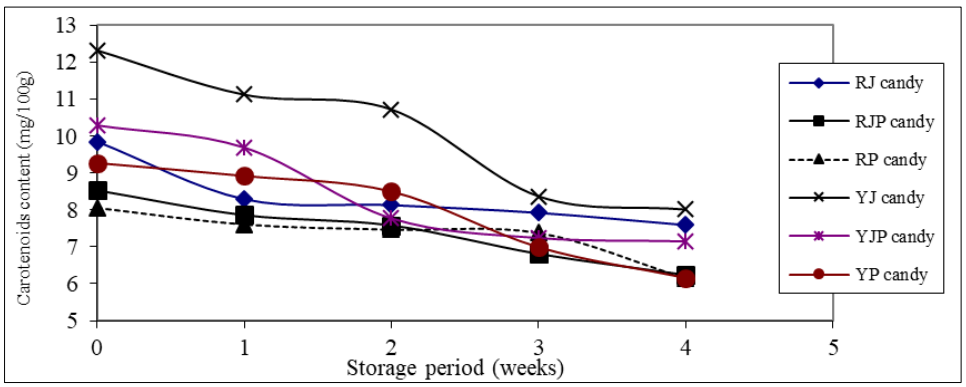


RJ : Red juice jelly candy, **RJP:** Red juice and peels jelly candy, **RP :**Red peels jelly candy**; YJ**: Yellow juice jelly candy **,YJP**: Yellow juice and peels jelly candy, **YP:** Yellow peels jelly candy

Figure 4 Flavonoids content (mg QE/100g) of prickly pear candies during cold storage for four weeks

3.4.3. Carotenoids content

The carotenoids content ranged from 8.06 to12.32 mg/100 g (FW) in all studied prickly pear jelly candy samples. Carotenoids content was significantly higher ($P \leq 0.05$) in yellow juice jelly candy and lower ($P \leq 0.05$) in red peels jelly candy at zero time (Fig.5). The loss of carotenoids content was observed during storage of prickly pear jelly candy in all samples. There was gradually decrease with increasing the storage period and the highest decrease was observed at the end of the storage period (4weeks). This degradation can lead to a loss of color of the food and to a reduction in the biological activity of the carotenoids [55]**.**



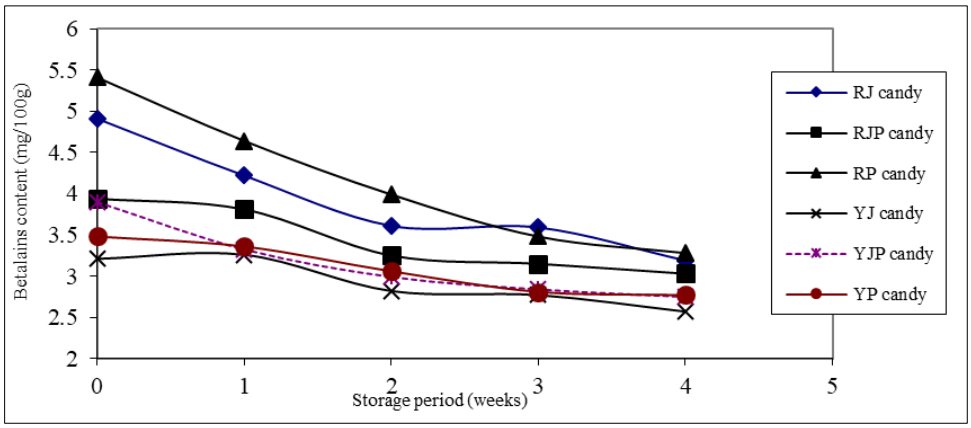
RJ : Red juice jelly candy, **RJP:** Red juice and peels jelly candy, **RP :**Red peels jelly candy**; YJ**: Yellow juice jelly candy **,YJP**: Yellow juice and peels jelly candy, **YP:** Yellow peels jelly candy

Figure 5 Carotenoids content (mg/100g) of prickly pear candies during cold storage for four weeks

3.4.4. Betalains content

Betalains content of red and yellow prickly pear jelly candies during 4weeks of cold storage at 8±2°C was determined as mg/100g samples and the results are shown in Fig.(6).

Betalains have been associated with several beneficial effects on human health, such as protection against oxidative stress-related and cardiovascular diseases [56] **.** The stability of betalains is an important aspect to consider for using these bioactive compounds in foods, since they are affected by pH, concentration of buffer, water activity, light, oxygen, temperature and enzymatic activities [57]**.** Betalains are natural pigments present at high amount in prickly pear and represent a good natural alternative to meet the growing demand of the food industry. The antioxidant properties of these betalain pigments represent an additional argument in favor of the development of their use in nutrition and health [58,59] **.**



RJ :Red juice jelly candy, RJP: Red juice and peels jelly candy, RP :Red peels jelly candy; YJ: Yellow juice jelly candy ,YJP: Yellow juice and peels jelly candy, YP: Yellow peels jelly candy

Figure 6 Betalains conten (mg/100g) of prickly pear candies during cold storage for four weeks

From the results in Fig (6), it could be noticed that, betalains content was significantly higher ($P \leq 0.05$) in red peels and red juice jelly candies and lower ($P \leq 0.05$) in yellow juice jelly candy. As the storage period increased, the betalains content in all candy samples was significantly decreased, red juice jelly candy sample showed the lowest decrease betalains content. While, the highest decrease was observed for the yellow juice jelly candy sample .Whereas, the highest value was noticed for red juice jelly candy (3.19 mg/100g) and the lowest was noted for yellow juice jelly candy (2.57mg /100 g) at the end of the storage period for 4weeks.

The purple cactus pear is an interesting alternative as a source of betalains, where betanin is the main colorant compound, and indicaxanthin and isobetanin have been detected at a low level [60]**.** During heat processing, betanin may be degraded by isomerisation, decarboxylation or cleavage by heats or acids, resulting in a gradual reduction of red color, and eventually the appearance of a light brown color [61,62]. Dehydrogenation of betanin leads to neobetanin formation, bringing about a yellow shift. Cleavage of betanin and isobetanin, which can also be induced by bases [63]**.** Betalains of prickly pear fruits are considerably interesting bioactive compounds, water soluble pigments and comprise red-purple betacyanins and yellow betaxanthins. the fruits have only betacyanins .Concentration of betacyanins are similar to red beet root, therefore, these fruits can be used as a source of the purpled natural food colorant E-162 production which is usually obtained from red beet root. These fruits are also interesting for the presence of other bioactive compounds such as polyphenols which improve their quality [64, 65. 66, 67. 68]**.**

3.5. Hardness of prickly pear jelly candies

Table 5 Hardness of red and yellow prickly pear jelly candies during cold storage (8 ±2 ^{0}C) for 4weeks

Sample	**Hardness g/cm^2**					
	Storage period at 8±2 ^{o}C (weeks)					
	Zero time	**1st week**	**2nd week**	**3rd week**	**4th week**	**L.S.D**
Red juice jelly candy	350^{cE}	1150^{dD}	1305^{dC}	1485^{eB}	1800^{dA}	27.767
Red juice and peels jelly candy	215^{eE}	1035^{fD}	1300^{dC}	1465^{fB}	1500^{fA}	15.753
Red peels jelly candy	325^{dE}	1085^{eD}	1395^{cC}	1595^{dB}	1710^{eA}	13.313
Yellow juice jelly candy	525^{bE}	1430^{bD}	2085^{bC}	2385^{cB}	2715^{cA}	10.733
Yellow juice and peels jelly candy	540^{aE}	1385^{cD}	2180^{aC}	2655^{bB}	2940^{bA}	14.885
Yellow peels jelly candy	550^{aE}	1495^{aD}	2190aC	2945^{aB}	3190^{aA}	40.461
L.S.D	13.389	11.506	13.694	14.854	40.532	

Values bearing the same small letter within the same column (effect of treatments) are not significantly different ($P > 0.05$); Values bearing the same capital letter within the same row(effect of storage period)are not significantly different ($P > 0.05$).

Hardness is one of the essential parameters in making jelly candy because it can determine the strength of the gel formed and affect the panelists' acceptance of the product [69].

Table (5), showed that, there were significant differences ($P \leq 0.05$) in all prickly pear jelly candies at zero time and during storage period . Hardness of the prickly pear jelly candies increased with the time of storage in all studied samples, but the samples of red juice and peels showed the lowest value at zero time (215 g/cm^2) and increased to 1500 at the end of storage (4weeks). Meanwhile, the sample of yellow peels candy was exhibited significantly ($p \leq 0.05$) higher Hardness values as compared to other samples during cold storage. Whereas, at the end of cold storage, the lowest increase of hardness had been recorded in red juice and peels jelly candy (1500 g/cm^2) followed by red peels candy (1710 g/cm^2) then red juice jelly candy (1800 g/cm^2).

Generally, a large increase in hardness with the time of storage in all studied samples, this might be due to, the moisture migration from the surface of candies. The final water content has a significant impact on texture and shelf life, with lower moisture content leading to harder confections that typically have longer shelf life, many candies are prone to hardening due to moisture loss; these include nougat, marshmallow, caramel , fudge , fondants, gummies and jelly candies [39]**.** Other investigation showed that the hardness of fresh jelly candy sample tested were found to decrease with the addition of konjac, but it progressively increased as the samples were stored for 8 weeks at 30 ^{o}C [70].

3.6. Total bacterial and Mold and yeasts counts for jelly candies of prickly pear

Total bacterial count (TBC) and mold and yeast counts (M&Y) of produced Jelly candies prepared from juice, peels and juice peels mixture of red and yellow prickly pear fruits during cold storage period at 8±2 ºC for 1, 2, 3 and 4weeks were determined and the results are presented in Table (6).

Table 6 Total bacterial and Mold and yeasts counts for jelly candies of red and yellow prickly pear during cold storage (8±2 ^{0}C) for 4weeks

Samples	**Total bacterial count (TBC cfu/g)**					
	Storage period (weeks)					
	Zero time	**1st week**	**2nd week**	**3rd week**	**4th week**	**L.S.D**
Red juice jelly candy	5 x10$^{2\ cE}$	9.5x10$^{2\ cD}$	13x10$^{2\ dE}$	20x10$^{2\ fB}$	39.5x10$^{2\ fA}$	2.207
Red juice and peels jelly candy	2 x10$^{2\ dD}$	4x10$^{2\ eD}$	21.5x10$^{2\ cC}$	35x10$^{2\ cB}$	64.5x10$^{2\ cA}$	2.040
Red peels jelly candy	2.5x10$^{2\ dE}$	7x10$^{2\ dD}$	12.5x10$^{2\ dC}$	27x10$^{2\ eB}$	52.5x10$^{2\ dA}$	2.436
Yellow juice jelly candy	7 x10$^{2\ cD}$	7.5x10$^{2\ dD}$	9.5x10$^{2\ eC}$	31.5x10$^{2\ dB}$	47x10$^{2\ eA}$	0.787
Yellow juice and peels jelly candy	24.5x10$^{2\ bE}$	48.5x10$^{2\ bD}$	91x10$^{2\ bC}$	96.5x10$^{2\ bB}$	104x10$^{2\ bA}$	1.710
Yellow peels jelly candy	50x10$^{2\ aD}$	52.5x10$^{2\ aD}$	104x10$^{2\ aC}$	166x10$^{2\ aB}$	184x10$^{2\ aA}$	2.947
L.S.D	2.301	1.819	1.943	2.698	2.423	
Samples	**Mold and yeasts (cfu/g)**					
	Storage period (weeks)					
	Zero time	**1st week**	**2nd week**	**3rd week**	**4th week**	**L.S.D**
Red juice jelly candy	1.5x10$^{2\ dD}$	3.5x10$^{2\ bcC}$	14.5x10$^{2\ aBC}$	15x10$^{2\ aB}$	32x10$^{2\ aA}$	1.417
Red juice and peels jelly candy	2.5x10$^{2\ cD}$	3 x10$^{2\ cCD}$	3.5x10$^{2\ dC}$	7.5x10$^{2\ cB}$	15.5x10$^{2\ bA}$	0.842
Red peels jelly candy	3.5x10$^{2\ abD}$	4.5x10$^{2\ aCD}$	5x10$^{2\ bcC}$	9x10$^{2\ bB}$	11.5x10$^{2\ eA}$	1.227
Yellow juice jelly candy	1.5x10$^{2\ dD}$	4x10$^{2\ abC}$	4.5x10$^{2\ cdBC}$	5x10$^{2\ eB}$	9.5x10$^{2\ fA}$	0.787
Yellow juice and peels jelly candy	4x10$^{2\ aD}$	4x10$^{2\ abD}$	5x10$^{2\ bcC}$	6x10$^{2\ dB}$	12x10$^{2\ dA}$	0.842
Yellow peels jelly candy	3x10$^{2\ bcD}$	3.5x10$^{2\ bcD}$	6x10$^{2\ bC}$	9x10$^{2\ bB}$	14x10$^{2\ cA}$	0.842
L.S.D	0.684	0.684	1.468	0.894	0.742	

Values bearing the same small letter within the same column (Samples are not significantly different (P > 0.05); Values bearing the same capital letter within the same row (effect of storage period) are not significantly different (P > 0.05).

Data in Table (6) shows the changes in total counts of bacteria, molds and yeasts of studied prickly pear jelly candies during cold storage period (8±2 ^{0}C) for 4weeks. From the Table, it could be noticed that, red juice and peels jelly candy sample had the lowest total bacterial count ($2x10^2$ cfu/g) compared with the other samples at zero time. While, increasing total bacterial counts were more pronounced in all studied samples during the storage period. At the end of storage (4weeks), the lowest increase of total counts of bacteria had been recorded in red juice jelly candy sample ($39.5x10^2$cfu/g) followed by yellow juice jelly candy which recorded $47x10^2$ (cfu/g) .

From the same Table, it can be observed that there was a gradual increase in total counts of molds and yeasts during storage, all samples had a low value at zero time, but prolonged cold storage period, total molds and yeasts counts were increased. Yellow juice jelly candy sample has been recorded the lowest increase of molds and yeasts at zero time $1.5x10^2$(cfu/g) and $9.5x10^2$(cfu/g) at the end of storage period .This refers to that the product can be saved more than 4weeks during cold storage. Sandhu, [71] reported mold growth within a week when stored in glass jars. On contrary, pumpkin candy was found to be safe for human consumption during three months of storage. Candy has a high sugar content that limits the growth of microbes by limiting water available for microbial growth.

3.7. Sensory evaluation of the red and yellow prickly pear jelly candies

Average sensory panel scores of appearance, color, texture, odor, taste and overall acceptability of jelly candies for juice, peels and juice peels mixture of red and yellow prickly pear are shown in Table (7).

Table 7 Sensory evaluation of red and yellow prickly pear jelly candies

Samples	Appearance	Color	Texture	Oder	Taste	Over all acceptability
Red juice jelly candy	8.18^a	8.45^a	8.00^c	7.36^{ab}	7.81^a	8.00^a
Red juice and peels jelly candy	7.81^c	7.90^b	8.18^b	7.27^{bc}	7.45^b	7.72^b
Red peels jelly candy	8.27^a	8.45^a	8.45^a	7.45^a	7.81^a	8.04^a
Yellow juice jelly candy	7.95^b	8.00^b	7.72^d	7.45 ^{a}	7.72^a	8.00^a
Yellow juice and peels jelly candy	7.72^c	7.72^c	7.63 ^{d}	7.36^{ab}	7.09^c	7.72^b
Yellow peels jelly candy	7.81^c	7.63^c	7.36^e	7.18^c	7.36^b	7.63^b
L.S.D	0.104	0.147	0.143	0.124	0.097	0.161

Values bearing the same small letter within the same column are not significantly different (P > 0.05).

From Table (7), it could be noticed that all of the studied attributes of prickly pear jelly candies received a mean score greater than (7.09) which ranged between “like moderately and like very Much” and indicated good acceptance. Red peels jelly candies possessed the highest values of all sensory parameters, which recoded 8.27 , 8.45 , 8.45 , 7.45 ,7.81 and 8.04 for appearance, color. texture, odor, taste and overall acceptability, respectively .This sample could be considered the best followed by red juice candy with recoded values 8.18, 8.45, 8.00,7.36,7.81 and 8.00 respectively, While, yellow peels jelly candy was the worst sample compared with other samples whereas, it recorded the lowest values in all Sensory characteristics.

Concerning the texture, the highest score (8.45) was recorded for red peels jelly candy which was considered significantly high compared with other samples while, yellow peels jelly candy recorded the lowest score in texture (7.36). Regarding to color results, it could be noticed that red juice jelly candy and red peels jelly candy were the highest with the same value (8.45) followed by yellow juice jelly candy which was recorded (8.00). At the same time, the lowest score of the taste was recorded for yellow juice and peels jelly candy sample (7.09), which was considered significantly low compared with other treatments. The statistical data resulted in significant differences to the level of acceptance of jelly candy. The least accepted jelly candy was yellow peels sample with acceptance value of 7.63. While, red peels, red juice and yellow juice jelly candies were the most accepted by panelists with the same values which equals to “Like very Much” the product.

4. Conclusion

The foregoing results are evidently leading to conclude that prickly pear was rich in bioactive compounds whereas the peels contained higher content of total phenolic and flavonoids for red and yellow comparing with the juices, while red prickly pear showed lower concentration of carotenoids and higher content of betalains than yellow prickly pear. Concerning, jelly candies the results showed that physicochemical, microbiological, and sensorial analyses of all studied samples by using six formulas of prickly pear juice and peels (yellow and red) fruits were suitable for utilizing prickly pear in the manufacture of jelly candy production which can be stored more than 4weeks during cold storage and has an acceptable quality to consumers. Therefore, prickly pear fruits can be used for food manufacturing especially children's foods which are considered to be healthy, attractive colors, have no side effects and are appropriate in sensorial properties which leads to an increase in the add value.

Compliance with ethical standards

Acknowledgments

The authors are grateful to the Academy of Scientific Research & Technology for giving sufficient financing for achieving this work through the scientific project entitled (Maximize the Utilization of Succulent Plants for Community Development in Matrouh Governorate).

Disclosure of conflict of interest

No conflicts of interest with any affiliations, persons or organizations

References

[1] Moloughney S.(2011). Functional confectionery: Finding the sweet spot. Nutraceuticals World. Available at: http: //www .nutraceuticalsworld.com /issues/201103/view _features /functional-confectionery-finding-the-sweet-spot (accessed 15 September 2017).

[2] Mutlu C, Tontul SA and Erbaş M.(2018). Production of a minimally pro-cessed jelly candy for childrenusing honey instead of sugar.LWT Food Sci Technol.93,499–505.

[3] Cano-Lamadrid M, Nowicka P, Hernández F. Carbonell-Barrachina AA and Wojdyło A.(2018). Phytochemical composition of smoothies combining pomegranate juice *(Punica granatum L)* and Mediterranean minor crop purées *(Ficus carica, Cydoniaoblonga, and Ziziphus jujube)*. J Sci Food Agric, 98, 5731–41.

[4] Moura SC, Berling CL, Garcia AO, Queiroz, MB, Alvim ID and Hubinger MD. (2019). Release of anthocyanins from the hibiscus extract encapsulated by ionic gelation and application of microparticles in jelly candy. Food Res Int.,121, 542–552.

[5] Klein M and Poverenov E.(2020).Natural biopolymer-based hydrogels for use in food and agriculture. J. Sci. Food Agric., 100, 2337–2347.

[6] Dai H, Li X, Du J, Ma L,Yu Y, Zhou H, Guo T and Zhang Y. (2020). Effect of interaction between sorbitol and gelatin on gelatin properties and its mechanism under different citric acid concentrations. Food Hydrocoll, 101, 105557.

[7] Šeremet D, Mandura A, Cebin A, Martini´c, A, Gali´c K and Komes D.(2020). Challenges in confectionery industry: Development and storage stability of innovative white tea-based candies. J. Food Sci., 85, 2060–2068.

[8] Azeredo H M C.(2009).Betalains: properties, sources, applications, and stability – a review International Journal of Food Science and Technology,44, 2365–2376.

[9] Stintzing FC and Carle R. (2004).Functional properties of anthocyanins and betalains in plants, food and in human nutrition. Trends Food Sci Technol.,15, 19–38.

[10] Piga A.(2004).Cactus pear: a fruit of nutraceutical and functional importance. J Prof Asso Cactus, 6, 9-22.

[11] Sáenz-Hernández C and Sepúlveda E.(2001). Cactus-pear juices. Journal of the Professional Association for Cactus Development, 4, 3-10.

[12] Schaffer S, Schmitt-Schillig S, Müller WE and Eckert GP.(2005).Antioxidant properties of Mediterranean food plant extracts: Geographical differences. J. Physiol. Pharmacol.,56,115–124.

[13] Valente LMM, da Paixão D, do Nascimento AC, dos Santos PFP, Scheinvar LA, Moura MRL, Tinoco LW, Gomes LNF andda Silva JFM.(2010). Antiradical activity, nutritional potential and flavonoids of the cladodes of *Opuntia monacantha (Cactaceae).* Food Chem.,123,1127–1131.

[14] Osorio-Esquivel O, Alicia-Ortiz-Moreno, Álvarez VB, Dorantes-Álvarez L and M. Mónica- Giusti.(2011). Phenolics,betacyanins and antioxidant activity in *Opuntia joconostle* fruits.Food Research International, 44,2160–2168.

[15] Feugang J M, Konarski P, Zou D, Stintzing FC and Zou C. (2006). Nutritional and medicinal use of Cactus pear *(Opuntia Spp.)* cladodes and fruits. Frontiers in Bioscience, 11, 2574-2589.

[16] AOAC. (2000). "Official Methods Analysis of AOAC,"International Published by AOAC, Wilson Boulevard Arlington, Virginia.

[17] Delgado P and Bañón, S. (2015). Determining the minimum drying time of gummy confections based on their mechanical properties. CyTA – Journal of Food ,13 (3), 329-335.

[18] Swain T and Hillis WE.(1959).The phenolic constituents of Prunes domestical- thequantitative analysis of phenolic constituents. J. Sci. Food Agric., 10,63-68.

[19] Yoo KM, Lee CH, Lee H, Moon B and Lee CY.(2008). Relative antioxidant and cyto-protective activities of common herbs. Food Chem., 106, 929-936.

[20] Askar A and Treptow, H. (1993). Quality Assurance in Tropical Fruit Processing. Springer Science & Business Media.,1st edition, 30-32.

[21] Castellar R, Obón JM, Alacid M and Fernández-López, JA. (2003). Color properties and stability of betacyanins from Opuntia fruits. J Agric Food Chem .,51, 2772–2776

[22] Elbadrawy E and Sello A. (2016). Evaluation of nutritional value and antioxidant activity of tomato peel extracts. Arab. J. Chem., 9, 1010-1018.

[23] American Public Health Association "APHA".(1976). Compendium of methods for the microbiological examination of food. Speck, M.L. (ed.). Washington, D.C., USA, pp. 542 – 543.

[24] Difco. (1984). Manual of Dehydrated Culture Media and Reagents for Microbiological and Clinical LaboratoryProcedures,9thEd.,DifcoLaboratoriesInc.,Detroit,USA.Online:http://www.maplica.com/Manual1%20difco%20D-G.pdf.

[25] Meilgaard M, Civille GV and Carr BT.(1999).Sensory evaluation techniques (3rd ed.). Boca Raton: CRC Press.

[26] Steel RGD, and Torrie JH. (1980).Principles and procedures of statistics. London: McGraw Hill.

[27] El-Gharras H, Hasib A, Jaouad A and El-Bouadili A.(2006). Chemical and physical characterization of three cultivars of Moroccan yellow prickly pears *(Opuntia ficus-indica)* at three stages of maturity. Cienc Tecnol Aliment.,5(2), 93-99.

[28] Albano C, Negro C, Tommasi N, Gerardi C, Mita G, Miceli A, De Bellis L and Blando, F. (2015). Betalains, phenols and antioxidant capacity in Cactus Pear *[Opuntia ficus-indica (L.) Mill.]* fruits from Apulia (South Italy) Genotypes. Antioxidants, 4(2), 269-280.

[29] Chalak L, Younes J, Rouphael S and Hamadeh, B. (2014). Morphological characterization of prickly pears *(opuntia ficus indica (l.) mill.)* cultivated in Lebanon. Int J Sci Res ., 3(6), 2541-2553.

[30] Chauhan S, Sheth N, Jivani N, Rathod I and Shah P. (2010). Biological actions of Opuntia species.Systematic Reviews in Pharmacy,1(2),146-151.

[31] Dehbi F, Hasib A, Ouatmane A, Elbatal H and Jaouad A. (2014). Physicochemical characteristics of Moroccan prickly pear juice *(Opuntia ficus-indica L.).* Int J Emerg Technol Adv Eng.,4, 300-306.

[32] El-Mostafa K, El Kharrassi, Y and Badreddine A.(2014). Nopal cactus *(Opuntia ficus-indica)* as a source of bioactive compounds for nutrition, health and disease. Molecules,19,14879–14901.

[33] Fernández-López JA, Castellar R, Obón JM and Almela L.(2002).Screening and mass-spectral confirmation of betalains in cactus pears. Chromatographia,56,591-595

[34] Butera D, Tesoriere L, di Gaudio F, Bongiorno A, Allegra M., Pintaudi, AM, Kohen R and Livrea MA.(2002). Antioxidant activities of sicilian prickly pear *(Opuntia ficus indica)* fruit extractsand reducing properties of its betalains: Betanin and indicaxanthin. J. Agric. Food Chem.,50,6895–6901.

[35] Kuti, J.O. 2004. Antioxidant compounds from four Opuntia cactus pear fruit varieties. Food Chem., 85, 527–533.

[36] Stintzing FC, Herbach KM, Mosshammer MR, Carle R, Yi WG, Sellappan S, Akoh C C, Bunch R, Felker P.(2005). Color, betalain pattern, and antioxidant properties of cactus pear *(Opuntia Spp.)* clones. J Agric Food Chem., 5, 442-451.

[37] Heim KE, Tagliaferro AR and Bobilya DJ. (2002). Flavonoid antioxidants: chemistry, metabolism and structure-activity relationships. Journal of Nutritional Biochemistry, 13, 572–584.

[38] Zenteno-Ramirez G, Juarez-Flores B I, Aguirre-Rivera J R Monreal-Montes M, GarciaJ M, Serratosa M P, Santos M Á, Perez M D and Rendon-Huerta J A.(2018). Juices of Prickly Pear Fruits *(Opuntia Spp.)* as Functional Foods. Ital. J. Food Sci., 30, 514-627.

[39] Ergun R, Lietha R and Hartel R. (2010). Moisture and shelf life in sugar confections. Critical Reviews In Food Science And Nutrition.,50,162–192 .

[40] Peng Y and Lu R .(2008).Analysis of spatially resolved hyperspectral scattering images for assessing apple fruit firmness and soluble solids content. Postharvest Biol. Technol., 48, 52–62.

[41] McGlone VA and Kawano S.(1998). Firmness, dry-matter and soluble-solids assessment of postharvest kiwifruit by NIR spectroscopy. Post-harvest Biol. Technol., 13,131–141.

[42] Sadler GD and Murphy PA. (2010). PH and titratable acidity. In Food Analysis; Springer: Berlin, Germany,pp, 219–238.

[43] Jiamjariyatam R.(2018).Influence of gelatin and isomaltulose on gummy jelly properties International Food Research Journal, 25(2),776-783.

[44] Sogi DS, and Singh S.(2001).Studies on bitterness development in kinnow juice ready to serve beverage squash and candy. Journal of Food Science Technology,38, 433-438.

[45] Imtiaz H and Iftikhar S. (2010). Chemical and organoleptic characteristics of jam prepared from indigenous varieties of apricot and apple. World Journal of Dairy and Food Sciences, 5(1),73-78.

[46] Durrani AM, Srivastava PK and Verma S.(2011). Development and quality evaluation of honey based carrot candy. J Food Sci Tech. J. Food Sci. Technol.,48(4), 502–505.

[47] Sharma S, Dhaliwal YS and Kalia M.(1998). Candied apples: a new perspective. Journal of Food Science and Technology, 35,79–82.

[48] Nachtigall AM, Souza EL, Malgarim MB and Zambiazi RC.(2004).Light blackberry jellies. Boletim do Centro de Pesquisa Processamento de Alimentos, 22(2),337-354.

[49] Varela-Santos E, Ochoa-Martinez A, Tabilo-Munizaga G, eyes RJE, Pérez-Won M, Briones Labarca V and Morales J.(2012). Effect of high hydrostatic pressure (HHP) processing on physicochemical properties, bioactive compounds and shelf-life of pomegranate juice. Innovative Food Science & Emerging Technologies,13,13–22.

[50] Kim D O and Padilla-Zakour O I. (2004). Jam processing effect on total phenolics and anti-oxidant activity capacity in anthocyanin rich fruits: cherry, plum, and raspberry, sensory and nutritive qualities of food. Journal of Food Science. 69, 395–400.

[51] Valente L, Scheinvar L, da Silva G, Antunes A, dos Santos F, Oliveira T, Tappin M, Aquino Neto F, Pereira A and Carvalhaes S.(2007). Evaluation of the antitumor and trypanocidal activities and alkaloid profile in species of Brazilian Cactaceae. Pharmacogn. Mag., 3,167–172.

[52] Panche AN, Diwan AD and Chandra SR.(2016). Flavonoids: an overview. J. Nutri. Sci., 5,e47.

[53] Manach C, Scalbert A, Morand C, Rémésy C and Jiménez L.(2004). Polyphenols food sources and bioavailability. The American Journal of Clinical Nutrition .,79(5),727–747.

[54] Huang DW and Shen SC. (2012). Caffeic acid and cinnamic acid ameliorate glucose metabolism via modulating glycogenesis and gluconeogenesis in insulin-resistant mouse hepatocytes. Journal of Functional Foods, 4(1), 358– 366.

[55] Zepka L Q and Mercadante A Z. (2009). Degradation compounds of carotenoids formed during heating of a simulated cashew apple juice. Food Chemistry., 117, 28-34.

[56] Esatbeyoglu, T, Wagner AE, Schini-Kerth VB and Rimbach G. (2015). Betanin. A food colorant with biological activity. Mol Nutr Food Res., 59, 36–47.

[57] Herbach KM, Stintzing FC and Carle R.(2006).Betalain stability and degradation-structural and chromatic aspects.J Food Sci.,71, R41–R50.

[58] Castellanos-Santiago E and Yahia EM.(2008). Identification and Quantification of Betalains from theFruits of 10 Mexican Prickly Pear Cultivars by High-Performance Liquid Chromatography and Electrospray Ionization Mass Spectrometry. J. Agric. Food Chem, 56, 5758–5764.

[59] Fernández-López JA, Giménez PJ, Angosto JM and Moreno JI. (2012).A process of recovery of a natural yellow colourant from opuntia fruits. Food Technol. Biotechnol., 50, 246–251.

[60] Sa´enz C,Tapia S, Cha´vez J and Robert P.(2009).Microencapsulation by spray drying of bioactive compounds from cactus pear *(Opuntia ficus-indica).* Food Chem.,114,616–622.

[61] Huang AS and von Elbe JH. (1985). Kinetics of the degradation and regeneration of betanine. Journal of Food Science, 50, 1115–1120.

[62] Drda´k M and Vallova´ M.(1990). Kinetics of the thermal degradation of betanine. Die Nahrung, 34,307–310.

[63] Schwartz SJ and von Elbe JH.(1983). Identification of betanin degradation products. European Food Research and Tecxhnology, 176,448–453.

[64] Skerget M, Kotnik P, Hras A, Simonic M and Knez Z.(2005). Phenols, pro anthocyanidins, flavones and flavonols in some plant material and their antioxidant activities.Food Chem., 89,191-198.

[65] Castellar R. Obón, JM, Alacid M.and Fernández-López JA. (2006). The isolation and properties of a concentrated red-purple betacyanin food colorant from *Opuntia stricta* fruits. J. Sci. Food Agric, 86,122-128.

[66] Stintzing FC and Carle R.(2007). Betalains an emerging prospects for food scientists Trends Food Sci.Technol., 18, 514-525.

[67] Obón JM, Castellar MR, Alacid M and Fernández-López JA. (2009). Production of a red-purpled food colorant from *Opuntia stricta* fruits by spray drying and its application in food model systems. J. Food Engin, 90,471- 479.

[68] Fernández-López JA, Almela L, Obón JM and Castellar R. (2010).Determination of antioxidant constituents in cactus pear fruits.Plant Foods Hum Nutr., 65, 253-259.

[69] Kusumaningrum A, Parnanto Nand Atmaka W.(2016).Kajian pengaruh variasi konsentrasi karaginan-konjac sebagai gelling agent terhadap karakteristik fisik, kimia dan sensoris permen jelly buah labu kuning *(Cucurbita maxima).* Jurnal Teknosains Pangan., 5(1),1–11.

[70] Habilla C, Slim SY, Nor Azizah and ChengLH.(2011).The properties of jelly candy made of acid-thinned starch supplemented with konjac glucomannan or Psyllum Husk Powder. International Food Research Journal.,18, 213-220.

[71] Sandhu GS.(1994). Development of sugar coated candied products (MSc thesis).Punjab Agricultural University, Ludhiana. C.F. Muzzaffar S, BabaW N, Nuzhat Nazir FA, Munaff Bhat MMand Rafiya Bazaz Muzzaffar. (2016). Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin *(Cucurbita moschata)* candy, Cogent Food & Agriculture, 2,1-13.