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Physicochemical Properties, Bioactive Compounds and Sensory Evaluation of *Opuntia dillenii* Fruits Mixtures

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Abstract Color, bioactive compounds and sensory evaluation of five *Opuntia dillenii* drinks mixed with strawberry and barley were studied during storage under cooling (4±˚C). It was found that *Opuntia dillenii* fruits had high levels of ascorbic acid (AA) (55.29 mg/100g), betacyanins (56.91), betaxanthin (45.64), total phenolic compounds (TCP) (179.30 mg/100g) and antioxidant capacity (AC) (53.32%). Mixtures with *Opuntia dillenii* had excellent red color and the ratio 3:1 (*Opuntia dillenii*: strawberry, T_2) had the highest values of a*, color index and Chroma (20.18, 1.050 and 27.21 respectively). Also, the addition of *Opuntia dillenii* significantly increased the levels of AA, TCP and AC in all mixtures. Moreover, the mixture T_2 had the highest levels of AA (18.67 mg/100m), TPC (71.12 mg/100ml) and AC (35.70 %). For sensory evaluation, all mixtures had acceptable properties and the mixtures of *Opuntia dillenii* with strawberry had better quality than those with barely. In addition, the mixture T_2 had the best quality and stability during the storage. Therefore, *Opuntia dillenii* fruits can be successfully used to produce new drinks by mixing with strawberry and barley and the mixture T_2 had the best properties and stability during the storage.

Keywords: *opuntia dillenii, color properties, ascorbic acid, phenolics, antioxidant capacity, sensory evaluation*

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1. Introduction

Beverages have been used to deliver high concentrations of functional ingredients. The functional beverages, such as sports and performance beverages, and energy beverages, not only provide taste and refreshment satisfaction, but can also provide necessary nutrients to prevent nutrition-related diseases [1]. Also, beverages contain many compounds which display antioxidant activity (such as polyphenolic compounds) and have many other positive effects in the human system and therefore if consuming them, then this can be viewed as a positive change in diet [2].

Cactus pear fruits grow in semiarid regions and are excellent sources of nutrients, pigments and functional compounds [3]. Betalain, the pigments present in cactus fruits, are responsible for the fruit colors and, therefore, they have a strong influence in the consumer acceptance. Based on the antioxidant properties of betalain, they are related to the preventive action against several diseases and some other beneficial effects to health [4]. There are many species of cactus fruits one of them is *Opuntia dillenii* which originates from southeastern parts of North America, the east coast of Mexico, and from the north of South America. The juicy flesh of fruits is purple in color and contains many rounded seeds, and betalains are the most characteristic substances of *O. dillenii* [5]. Likewise, strawberry (*Fragaria* × *ananassa* Duch.) is one of the most commonly consumed berries and is an important dietary source of fiber and bioactive compounds. In particular, strawberries are rich in vitamin C and folate. Barley has recently gained a lot of attention because of its high levels of β-glucan which is an important functional ingredient to lower plasma cholesterol, reduce glycemic response and promote weight management [6]. Moreover, barley β-glucan is capable of imparting a smooth mouth feel to beverage products and providing an excellent source of soluble dietary fiber thus it could potentially serve as an alternative to traditional beverage thickeners such as alginates, pectin, xanthan, and carboxymethylcellulose [7].

Although, *Opuntia dillenii* fruits have a high nutritional value, their consumption is hard because of their acidic taste and the presence of a large number of seeds [8]. Hence, it is preferably to incorporate them with other products as a source of natural colorants and functional ingredients. In this regard, studies on products fortified with *Opuntia dillenii* fruits are still scarce. Therefore, this study was designed to maximize the utilization of *Opuntia dillenii* fruits by incorporating them with strawberry and barley to produce new mixes. Also, physicochemical properties, color attributes and sensory evaluation of these mixes during storage were determined.

2. Materials and Methods

2.1. Raw Material

Cactus pear (*Opuntia dillenii*) fruits were harvested from the farm of Faculty of Agriculture, Suez Canal University, Ismailia (30˚ 36′ North Latitude, 32˚ 16’ East

Longitude), Egypt at full ripe stage. Strawberry fruits and sucrose were purchased from the local market. Wort extract from barely was purchased from El-Ahram Carbonated Beverage Corporate.

2.2. Plant Material

An upright or spreading, fleshy plant usually is growing to 50-100 cm tall. Its stems are much branched and consist of a series of flattened, fleshy segments which are longer than they are broad and sparsely covered in groups of 1-7 sharp spines (2-4 cm long). Its showy yellow flowers (6-8 cm across) are borne along the margins of the stem segments. Its fleshy fruit have several tufts of small barbed bristles on their surface and turn reddish-purple as they mature (Figure 1).

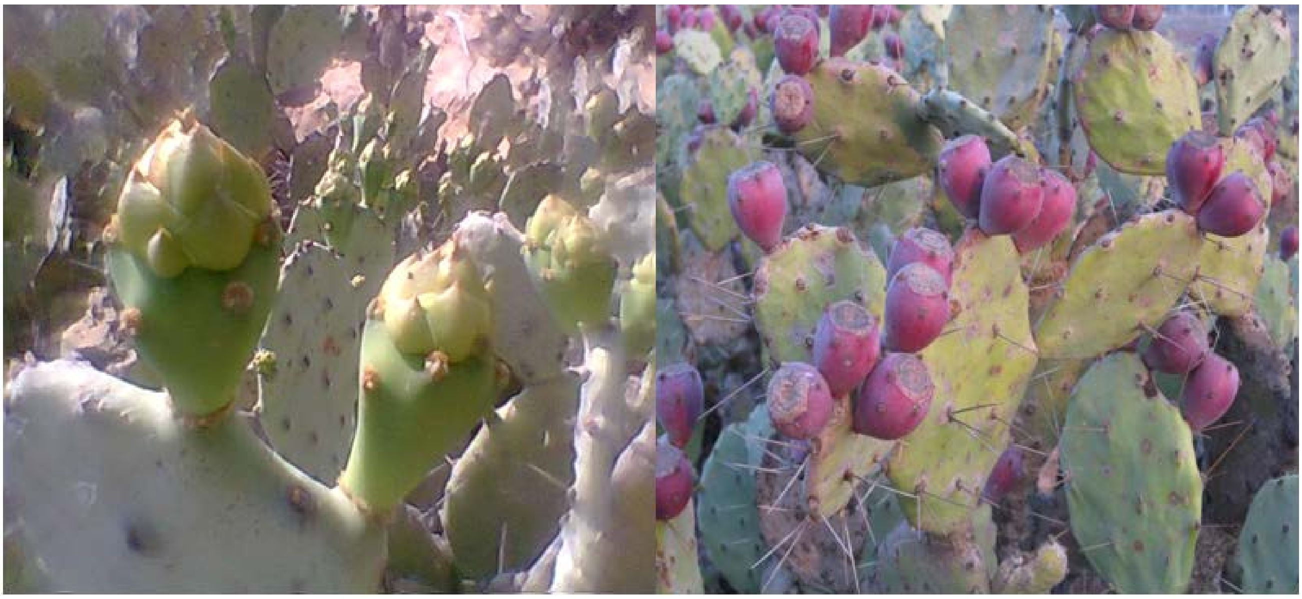

Figure 1. *Opuntia dillenii* (Ker-Gawl) Haw (family Cactaceae) is commonly known as pear bush, prickly pear, mal rachette or tuna

2.3. Stems

The stems are much branched and consist of a series of flattened fleshy (*i.e*. succulent) segments, which are sometimes confused for leaves. These segments (10-40 cm long, 5-20 cm wide and 1-2 cm thick) are green or bluish-green in color and longer than they are broad (*i.e*. elliptic or egg in shape). They are hairless (*i.e*. glabrous) and covered in small raised bumps (*i.e*. areoles) which bear tiny spiny bristles (*i.e*. glochids). Most of these small raised bumps (*i.e*. areoles) also have 1-7 larger sharp spines (2-4 cm long). The leaves are reduced to small, slightly curved, cone-shaped (*i.e*. conical) structures (up to 6 mm long) and are quickly shed (*i.e*. they are caduceus).

2.4. Flowers and Fruit

The flowers (up to 7 cm long and 6-8 cm across) are bright yellow and sometimes have greenish or pinkish colored markings on the outer 'petals'. Flowering occurs mostly during spring and summer. The immature fruit are green, but they turn reddish-purple in color as they mature. These fruit (4-9 cm long and 3-4 cm wide) are fleshy (*i.e*. succulent), pear shaped (*i.e*. pyriform) or almost rounded (*i.e*. globose), berries. They may have a shallow depression at the top, especially when they are young, and always have several tufts of small barbed bristles (*i.e*. glochids) on their surface. The reddish or purplish colored pulp in the center of the fruit contains large numbers of seeds. These seeds (4-5 mm long and 4-4.5 mm wide) are generally yellow or pale brown in color and somewhat rounded (*i.e*. subglobose) in shape (Figure 2).

2.5. Methods of Juices Process

Samples Preparation Full ripe *Opuntia dillenii (O.dilleni)* fruits were washed thoroughly under running tap water to remove the glochids (thorns). Fruits were manually peeled and the uncolored sides (top and bottom) were removed. Strawberry fruits were washed and drained on a cheese cloth and then the necks were removed. *O.dillenii* and strawberry fruits were homogenized at 6000 rpm for 5 min to produce homogeneous pulps. Different mixtures were prepared from *O.dilleni* pulp alone (T_5) and mixed with either strawberry pulp (T_{1-2}) or wort (T_{3-4}) at two ratios (2:1) and (3:1). The mixtures were mixed with sugar syrup (15 %) to reach 10% total soluble solids in the final mixtures. All blends were heated to 80° C and filled in sterilized glass bottles (200 ml). The bottles were thermally treated in water bass at 95° C for 7 min. Then the bottles were suddenly cooled with tap water, and then were placed in a refrigerator at a temperature of 4±1° C for analyses.

2.6. Chemical Analysis

Moisture content, pH, TSS, ascorbic acid and total acidity (%, as citric acid, after titration with 0.01 N NaOH to end point, pH 8.2) were determined according to the methods described in AOAC [9]. Color index was determined according to Meydov et al. [10].

Total Anthocyanin was extracted and determined according to Wrolstad et al. [11]. Total phenolic compounds Total phenolic compounds (TPC) were extracted and determined according to the method of Osorio-Esquivel et al. [12] by using Folin–Ciocalteu phenol reagent.

Figure 2. Flowers and Fruits of *Opuntia dillenii*

Betalain pigments and antioxidant compounds were extracted according to the method of Ravichandran et al. [13]. The content of betalain compounds; betaxanthins and betacyanins in the ethanol extract, was determined spectrophotometrically at 538 and 480 nm with a UV–VIS spectrometer, respectively as described by Stintzing et al. [14]. Antioxidant activity was determined according to Ravichandran et al [13].

Color attributes The colors of the samples (expressed in L^* and a^*) were measured by the Minolta colorimeter (Minolta Co. Ltd., Osaka, Japan). Measurements were replicated five times and the results were averaged.

Sensory evaluation Sensory evaluation of *O.dilleni* drinks was performed at zero time and every month for six months of storage period. It was carried out by staff members of Food Technology Department, Suez Canal University. Scoring was performed as taste (20 degree), color (20 degree), consistency (10 degree) and overall acceptability (degree 50 degrees).

2.7. Statistical Analysis

All measurements were in triplicate and analysis of variance with two factorial (treatments and storage period) were conducted by a completely randomized model using the ANOVA +Tukey's test at $p<0.05$. Using CoStat (1998) under windows software version 6.311.

3. Results and Discussion

3.1. Chemical Analyses

The results of the chemical properties of *O.dilleni*, strawberry and wort are presented in Table 1. The results show that, the pH value of wort was significantly higher (4.55) than those of strawberry (3.56) and *O.dilleni* pulp (3.36). The pH value of strawberry pulp was similar to that of ripe fruits from many strawberry cultivars, which ranged from 3.4 to 3.8 [15]. Clearly, *O.dilleni* pulp had the highest level of acidity (1.42%, as citric acid) when compared with strawberry and wort. Similar values of acidity were reported by Mazur et al. [16] for ripe strawberries. The data show that *O.dilleni* pulp contained higher content (55.29 mg/ 100g) of ascorbic acid than strawberry (38.58 mg/ 100g), but it was not detected in the wort. The results of ascorbic acid content in the present work were higher than that found by Diaz-Medina et al. [8] for *O. dillenii* fruits. However, ascorbic acid content in strawberry pulp was lower than that found by Mazur et al.

[16] in fully ripe strawberry fruits. The wort recorded the highest total soluble solid (TSS) content (13.33%) when compared with *O dillenii* pulp (8.33%) and strawberry pulp (7.41%). No significant difference was found in moisture content between *O dillenii* pulp (89.01%) and strawberry pulp (89.50%), but wort had significantly higher moisture content (91.88%).

Table 1. Chemical properties of *O.dillenii*, strawberry pulps and wort (mean ±SD)

Parameters	*O. dillenii*	Strawberry	Wort
pH value	$3.36^{c}\pm0.1$	$3.56^{b}\pm0.1$	$4.55^{a}\pm0.3$
Acidity (%, as citric acid)	$1.42^{a}\pm0.1$	$1.11^{b}\pm0.01$	$0.10^{c}\pm0.1$
Ascorbic acid (mg/ 100g)	$55.29^{a}\pm2.7$	$38.58^{b}\pm0.9$	ND
TSS (%)	8.33b±0.3	$7.41^{c}\pm0.1$	$13.33^{a}\pm0.1$
Moisture (%)	$89.01^{b}\pm0.5$	$89.50^{b}\pm0.01$	$91.88^{a}\pm1.8$
Betacyanins (mg/ 100g)	56.91±1.5	ND	ND
Betaxanthin (mg/ 100g)	45.64±1.5	ND	ND
Anthocyanin (mg/ 100g)	ND	19.13±1.0	ND
Total phenolic content (mg/ 100g)	$179.30^{b}\pm1.4$	$253.22^{a}\pm2.2$	$52.18^{c}\pm0.6$
Antioxidant activity (%)	$53.32^{a}\pm2.1$	$47.49^{b}\pm1.1$	$19.61^{c}\pm0.3$
Color attributes			
L^*	$31.48^{a}\pm1.0$	$26.50^{b}\pm1.9$	$25.70^{c}\pm0.1$
a^*	$20.16^{a}\pm1.2$	$14.30^{b}\pm0.3$	$1.63^{c}\pm0.1$
C^*	$22.94^{a}\pm1.3$	$15.\ 92^{b}\pm0.4$	$1.49^{c}\pm0.8$

ND =not-detected
Means in same row with different superscripts (a,b,c…..) are significantly different ($p<0.05$).

Color is one of the most important attributes of foods, being considered as a quality indicator for their acceptance. The results in Table 1 indicate that *O.dillenii* pulp contained betalain fractions including betacyanin (56.91 mg/ 100g) and betaxanthine (45.64 mg/ 100g), however anthocyanin was detected only in strawberry pulp (19.13 mg/ 100g). Neither betalain fractions nor anthocyanin pigments were detected in the wort. With respect to total phenolic compounds, the highest level was found in strawberry pulp (235.22 mg/ 100g) when compared with *O.dillenii* pulp (179.30 mg/ 100g) and wort (52.18 mg/ 100g). Furthermore, *O.dillenii* pulp displayed the highest antioxidant activity (53.32%) comparing with strawberry pulp (47.49%) and wort (19.61%). Qingming et al [17] reported that malt contains many phenolic compounds and significant antioxidant activities, which should be considered as a new source of natural antioxidant for pharmaceutical or dietary needs. The results of color attributes show that, *O.dillenii* pulp exhibited significantly higher L^* value (31.48) comparing with both strawberry pulp (26.50) and wort (25.70). Also, similar trends were observed in a^* and C^* (Chroma) values.

3.2. Effect of Storage at 4±1°C on Ascorbic Acid, Total Phenolic Compounds and Antioxidant Activity of *O. dillenii* Drink Mixtures

Changes in ascorbic acid contents during cold storage (at 4±1°C) are given in Table 2. The results show that, the drink mixture (T_2) contained the highest ascorbic acid content compared to the other drink mixtures. This could be due to the higher level of *O.dillenii* pulp which contained higher ascorbic acid content than the strawberry pulp as observed in Table 1. During storage period, ascorbic acid contents significantly decreased in all mixture and the mixture T_2 still had the highest level. The same trend was observed by Choi *et al.* [18] for pasteurized orange juice stored at 4.5°C. Also, the contents of ascorbic acid in different juices were decreased during storage depending on temperature, oxygen and light access [19]. In addition, this bioactive compound may follow an anaerobic pathway of degradation [20]. The results indicate that *O. dillenii* pulp with strawberry pulp by 3: 1 ratio (T_2) had the highest total phenolic compound contents (Table 2), this because of the higher level of total phenolic compounds in *O. dillenii* and strawberry pulps as shown in Table 1.

During storage period, the total phenolic contents significantly decreased which may be attributed to the decomposition of phenolic compounds during the storage. These results agree with those found by (Zheng and Lu [21] and Igual *et al.* [22] for pineapple and grapefruits juices during refrigeration storage at 4°C. However, Tavirini *et al.* [23] reported that phenols did not change in kiwifruits stored for 2 months at 0°C, but they observed a significant rise after a long storage (6 months at 0°C).

The data presented in Table 2 show that the mixture T_2 had the highest antioxidant activity (34.14%). Clearly, this was due to the higher levels of phenolic compounds and ascorbic acid in T_2 comparing with other mixtures. Also, a significant decrease of antioxidant activity was noticed during the storage period which was due to the degradation in ascorbic acid and phenolic compounds. Fruits with high antioxidant activity generally contain a great quantity of antioxidant substances, especially phenolic compounds and specifically flavonoids [23]. The acquired results are concordant with those found by Igual *et al.* [22] in antioxidant activities for grapefruit juices stored under cold storage. In contrast, Arena *et al.* [24] and Piga *et al.* [25] found an increase in the antioxidant activity after storage for 2 months of orange juices reconstituted from concentrate.

3.3. Color Attributes of *O. dillenii* Drink Mixtures

The changes in color attributes L^*, a^*, ΔE and color index values are presented in Table 3. *O. dillenii* pulp caused a decrease in L^* values for all mixtures and T_2 had the lowest ones and this was due to the dark color of both *O. dillenii* and strawberry pulps. Also, the results show that L^* values significantly increased during storage period.

These results are appropriate with those found by El-Samahy *et al.* [26] for *O. ficus indica* juices and agree with those shown for color index values. Similarly, Rodrigo *et al.* [27] found that, the L^* values raised with time for orange–carrot juice at 10 ºC. In contrast, Esteve *et al.* [28] reported a slight decrease in L^* values of different commercial orange juices stored at 4±1°C. In addition, *O. dillenii* pulp significantly increased a^* values because of its red color and T_2 displayed the highest a^* values. During storage period a^* values significantly decreased. Regarding to the color index, the T_2 had the highest values compared with the other drink mixtures and during storage period, the color index values significantly decreased. Moreover, ΔE values significantly boost during storage period and the differences among T_2, T_1 and T_4 were non-significant. This increase in the ΔE values could be referred to the degradation in both pigments betalain in *O. dillenii* pulp and anthocyanin in strawberry pulp. Some metal cations, such as iron, copper, tin and aluminum were reported to accelerate betalain degradation [29].

Table 2. Changes in ascorbic acid, total phenolic compounds and antioxidant activity of *O. dillenii* drink mixtures during storage period at 4±1°C

Parameter	Treat.	Storage time (Months)							Mean
		0	1	2	3	4	5	6	
Ascorbic acid (mg/100ml)	T1	15.31	6.35	6.31	5.31	4.69	3.38	3.29	**6.85^{B}±3.8**
	T2	18.67	6.99	6.60	5.76	4.72	4.16	3.90	**7.77^{A}±4.8**
	T3	10.02	4.44	3.78	3.20	2.72	1.96	1.52	**4.44^{D}±2.6**
	T4	13.76	5.33	4.90	4.11	2.79	1.61	1.14	**5.91^{C}±4.0**
	T5	16.40	5.77	5.59	4.34	3.44	2.48	2.15	**6.46^{BC}±4.5**
	Mean	**14.83^{a}±3.2**	**6.96^{b}±1.6**	**5.78^{c}±1.1**	**5.44^{cd}±1.3**	**4.55^{de}±1.1**	**3.68^{ef}±1.1**	**2.72^{f}±1.1**	
Total phenolic compounds (mg/100ml)	T1	71.55	59.81	53.56	51.53	49.56	42.53	35.43	**52.01^{B}±11.1**
	T2	71.12	61.24	59.35	55.17	50.19	43.18	37.21	**53.93^{A}±10.9**
	T3	63.65	58.72	50.41	45.39	43.41	36.39	28.61	**46.66^{D}±11.6**
	T4	64.64	60.57	54.65	46.18	44.21	37.18	37.62	**50.00^{C}±11.5**
	T5	69.52	61.59	58.53	46.28	44.29	37.29	36.54	**49.89^{C}±11.1**
	Mean	**68.10^{a} ±3.7**	**60.39^{b}±1.5**	**55.30^{c}±3.5**	**48.93^{d}±4.1**	**46.33^{e}±3.1**	**39.33^{f}±3.1**	**35.08^{g}±3.6**	
Antioxidant capacity (%)	T1	31.03	30.65	30.51	29.69	29.03	28.69	28.36	**29.71^{C}±1.14**
	T2	35.69	35.54	34.43	34.36	33.88	33.03	32.06	**34.14^{A}±1.37**
	T3	25.69	25.50	24.53	24.19	23.73	23.36	22.36	**24.19^{E}±1.37**
	T4	28.93	28.14	27.93	27.69	26.69	26.03	25.03	**27.24^{D}±1.42**
	T5	33.69	33.21	32.69	32.03	31.57	31.03	30.36	**32.08^{B}±1.31**
	Mean	**31.01^{a}±3.69**	**30.67^{ab}±3.72**	**30.02^{bc}±3.69**	**29.59^{bc}±3.68**	**28.98^{de}±3.72**	**28.43^{ef}±3.62**	**27.63^{f}±3.71**	

Means with different superscripts (a, b, c…) for each storage time are significantly different ($p<0.05$)
O. dillenii : strawberry 2:1 (T_1); *Odillenii*: strawberry 3:1 (T_2);O. *dillenii*: wort 2:1 (T_3); *O. dillenii*: wort 3:1 (T_4); *O.dillenii* drink (T_5).

Table 3. Changes in color attributes of the *O. dillenii* drink mixtures during storage period at 4±1°C

Parameters	Treatment	Storage time (month)							Mean
		Zero	1	2	3	4	5	6	
L^*	T_1	19.20	25.18	27.50	30.9	33.67	37.25	39.66	**30.48^{C}±6.8**
	T_2	18.69	26.23	26.85	28.98	31.07	34.81	37.21	**29.13^{D}±8.8**
	T_3	22.40	26.34	30.85	35.49	36.05	37.69	39.96	**32.69^{A}±6.1**
	T_4	23.23	24.39	28.50	35.11	37.15	38.21	38.87	**32.21^{A}±6.4**
	T_5	17.31	24.72	28.67	34.97	36.83	37.37	39.95	**31.36^{B}±7.8**
	Mean	**20.17^{g} ±2.4**	**25.37^{f}±1.1**	**28.48^{e}±1.7**	**33.04^{d}±2.7**	**34.96^{c}±2.5**	**37.07^{b}±1.3**	**39.13^{a}±1.2**	
a^*	T_1	17.54	12.54	8.55	6.25	5.40	4.40	3.70	**8.34^{D}±4.8**
	T_2	20.18	15.18	13.18	11.38	8.70	7.70	6.37	**11.81^{A}±4.6**
	T_3	12.33	9.07	5.67	4.48	3.95	3.49	3.40	**6.06^{e}±3.3**
	T_4	13.66	11.06	10	9.12	8.90	7.56	7.06	**9.62^{C}±2.2**
	T_5	16.40	14.40	12.4	9.60	8.50	7.32	6.85	**10.78^{B}±3.5**
	Mean	**16.02^{a}±3.0**	**12.45^{b}±2.4**	**9.96^{c}±2.8**	**8.16^{d}±2.6**	**7.09^{e}±2.2**	**6.10^{f}±1.9**	**5.48^{f}±1.8**	
ΔE	T_1	-	8.60	13.37	17.93	21.18	25.08	27.23	**16.20^{C}±9.2**
	T_2	-	10.77	13.17	16.07	19.52	22.89	25.33	**15.40^{D}±8.1**
	T_3	-	9.01	15.73	20.30	23.31	25.68	27.13	**17.31^{B}±9.4**
	T_4	-	8.34	12.61	23.58	20.91	20.26	20.90	**15.23^{D}±8.2**
	T_5	-	11.13	15.48	22.07	25.26	26.47	28.63	**18.43^{A}±9.7**
	Mean	**-**	**9.57^{f}±1.4**	**14.08^{e}±1.7**	**19.08^{d}±2.9**	**22.04^{c}±2.3**	**24.08^{b}±2.4**	**25.85^{a}±2.9**	
Color index	T_1	0.911	0.861	0.809	0.717	0.704	0.625	0.619	**0.751^{B}±0.01**
	T_2	1.049	0.999	0.910	0.798	0.795	0.687	0.660	**0.845^{A}±0.02**
	T_3	0.816	0.780	0.733	0.729	0.687	0.672	0.326	**0.721^{B}±0.01**
	T_4	0.893	0.830	0.754	0.733	0.667	0.664	0.637	**0.721^{B}±0.01**
	T_5	0.885	0.810	0.761	0.747	0.661	0.637	0.631	**0.737^{B}±0.01**
	Mean	**0.913^{a}±0.10**	**0.859^{ab}±0.10**	**0.795^{bc}±0.08**	**0.747^{cd}±0.05**	**0.705^{de}±0.07**	**0.659^{ef}±0.05**	**0.636^{f}±0.03**	

Means with different superscripts (a, b, c…) for each storage time are significantly different ($p<0.05$)
O. dillenii : strawberry 2:1 (T_1); *Odillenii*: strawberry 3:1 (T_2);O. *dillenii*: wort 2:1 (T_3); *O. dillenii*: wort 3:1 (T_4); *O. dillenii* drink (T_5).

Table 4. Changes in the sensory evaluation of the drink mixtures during storage period at 4±1 ºC

Para.	Treat.	Storage time (month)							Mean
		Zero	1	2	3	4	5	6	
Taste 20)	T_1	14.66	14.57	14.31	13.67	13.50	13.00	12.17	**13.70^{AB}±2.3**
	T_2	15.22	15.16	15.00	14.70	14.64	14.60	14.15	**14.79^{A}±2.6**
	T_3	13.15	13.06	12.68	12.67	12.00	11.68	11.60	**12.41^{BC}±2.0**
	T_4	12.00	11.81	11.50	11.45	10.77	11.01	9.92	**11.21^{C}±2.1**
	T_5	14.37	13.30	12.98	12.70	11.68	10.52	10.77	**12.34^{BC}±2.4**
	Mean	**13.86^{a}±3.1**	**13.56^{ab}±2.3**	**13.23^{ab}±2.7**	**13.16^{ab}±2.3**	**12.52^{ab}±2.2**	**12.17^{ab}±2.5**	**11.73^{b}±2.4**	
Color (20)	T_1	16.75	15.44	14.52	14.07	13.71	13.08	12.35	**14.28^{A}±2.9**
	T_2	17.08	16.40	15.42	14.78	13.78	12.42	11.02	**14.42^{A}±2.5**
	T_3	15.50	11.30	11.28	10.64	10.45	10.44	9.68	**11.33^{b}±2.3**
	T_4	16.07	13.60	12.62	12.60	11.51	10.74	9.90	**12.44^{B}±2.6**
	T_5	17.70	15.56	14.65	14.20	13.14	12.59	11.22	**14.16^{A}±3.0**
	Mean	**16.62^{a}±2.1**	**14.46^{b}±2.6**	**13.70^{bc}±2.4**	**13.26^{bcd}±3.2**	**12.52^{cde}±1.9**	**11.86^{de}±2.1**	**10.84^{f}±2.0**	
Consistency (10)	T_1	8.16	8.14	7.67	7.67	7.65	7.50	7.25	**7.72^{AB}±0.5**
	T_2	8.15	8.08	7.98	7.61	7.60	7.50	7.44	**7.77^{A}±0.5**
	T_3	7.81	7.80	7.67	7.37	6.87	6.81	6.25	**7.23^{C}±0.9**
	T_4	7.66	7.60	7.58	7.42	7.34	6.81	6.78	**7.32^{BC}±0.8**
	T_5	7.83	7.77	7.64	7.61	7.61	7.61	7.30	**7.63^{AB}±0.5**
	Mean	**7.91^{a}±0.5**	**7.79^{ab}±0.8**	**7.67^{ab}±0.7**	**7.55^{abc}±0.6**	**7.43^{abc}±0.6**	**7.31^{bc}±0.7**	**7.06^{e}±0.7**	
Overall acceptability (50)	T_1	35.66	35.60	34.42	34.35	34.07	34.01	33.95	**34.59^{B}±3.5**
	T_2	42.83	41.40	35.57	40.42	40.01	39.25	35.65	**39.31^{A}±5.0**
	T_3	37.78	32.06	31.88	30.00	29.64	28.81	27.41	**30.37^{C}±2.7**
	T_4	34.49	32.30	31.60	30.35	29.94	29.38	27.55	**30.81^{C}±3.4**
	T_5	35.83	32.82	31.98	31.52	30.34	29.81	29.81	**31.73^{C}±5.5**
	Mean	**36.18^{a}±7.4**	**34.78^{ab}±4.9**	**33.33^{abc}±3.7**	**33.02^{abc}±4.5**	**32.88^{bc}±5.0**	**32.46^{bc}±5.0**	**30.88^{c}±4.6**	

Means with different superscripts (a, b, c…) for each storage time are significantly different ($p<0.05$)

O.dillenii: strawberry 2:1 (T_1); *O.dillenii*: strawberry 3:1 (T_2); *O. dillenii*: wort 2:1 (T_3); *O.dillenii*: wort 3:1 (T_4); *O. dillenii* drink

3.4. Sensory Evaluation of *Opuntia dillenii* Drinks Mixtures during Storage at 4±1°C

Scores of the sensory properties of *O. dillenii* drinks are recorded in Table 4. In general all mixtures were acceptable and *O. dillenii* pulp improved the sensory attributes. Moreover, the drinks containing *O. dillenii* pulp with strawberry pulp had higher scores than those with wort and T_2 had the highest ones. The taste scores did not significantly change during the first three months of the storage period then they significantly decreased. During storage period, the color scores significantly decreased after the first month and T_2 had the highest color scores. For consistency, T_1, T_2 and T_5 had the highest consistency scores and this may be due to the higher percentage of *O. dillenii* pulp in these samples. Also, during storage period, consistency scores gradually decreased. The scores of the overall acceptability indicated that, T_1 T_2 had the highest scores compared to the other drink mixtures. During storage period the overall acceptability scores gradually decreased and these changes may be due to the degradation in color and phenolic compounds as shown in Table 2 and Table 3.

4. Conclusion

It can be concluded that *O.dillenii* fruits had high levels of ascorbic acid, total phenolic compounds, betalain pigments and antioxidant activity which are important for human health. Also, the mixtures of *O.dillenii* pulp with strawberry and barley had improved propertied such as color, antioxidant activity and sensory properties. Moreover, the addition of *O.dillenii* pulp improved the quality and the stability during the storage and the mixture T_2 (*O.dillenii*: strawperry, 3:1) had the best properties and stability during the storage. New functional drinks can be produced by mixing *O.dillenii* pulp with strawberry and barley.

Competing Interests

The authors have no competing interests.

Abbreviation

AA	Ascorbic acid
AC	Antioxidant capacity
DF	dietary fiber
DPPH	2,2-diphenyl-1-picrylhydrazyl
FDA	The United States Food and Drug Administration
HMF	5-(hydroxymethyl)-2-furfural
LDL	Low density lipoprotein
TPC	Total phenolic compounds

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