Anadolu Tarım Bilimleri Dergisi
Anadolu Journal of Agricultural Sciences
http://dergipark.ulakbim.gov.tr/omuanajas

Research /Araştırma

Anadolu Tarım Bilim. Derg./Anadolu J Agr Sci, 31 (2016)
ISSN: 1308-8750 (Print) 1308-8769 (Online)
doi: 10.7161/omuanajas.260973

Determination of fruit characteristics of cactus pear selected from Adana province

Mehmet Tütüncü[a*], Abdulkadir Sarıer[b], Burhanettin İmrak[b], Songül Çömlekçioğlu[c], Ali Küden[c], Ayzin Baykam Küden[c]

[a]*Ondokuz Mayıs University, Agriculture Faculty, Horticulture Department, Samsun,* [b]*Çukurova University Pozantı Agricultural Research and Application Center, Adana,* [c]*Çukurova University, Agriculture Faculty, Horticulture Department, Adana*
[*]Corresponding author/sorumlu yazar: *mtutuncu.tr01@gmail.com*

Geliş/Received 02/02/2016 Kabul/Accepted 21/04/2016

ABSTRACT
The study was performed on thirty one cactus pear genotypes selected from Adana province in Turkey to determine their pomological characteristics. Fruits of selected genotypes were collected from their natural sites in 2012 and 2013 and the fruit characteristics were evaluated by using ten different fruit traits. The results showed that the average fruit weight was about 80 g, the average seed number per fruit was 240 and the fruit shape of the selected genotypes was generally elliptical (64.74%). Ease of fruit peeling were classified as medium (54.83%). Total Soluble Solids (TSS) of the genotypes were determined between 7% and 15% and the pH value was between 5.17 and 7.36. Titratable acidity content (TA) was found to be significantly different in a genotype-dependent way and acidity varied between 1.94% and 9.08%. The simplified scoring method was used to evaluate the selected genotypes and the genotype of 01 OP 19 gave the highest score.

Keywords:
Opuntia
Pomology
Prickly pear Selection
Weighted ranked method

Adana bölgesinden selekte edilen dikenli incirlerin meyve özelliklerinin belirlenmesi

ÖZET
Bu çalışma Adana bölgesinden seçilen otuz bir dikenli incir genotipinin pomolojik özelliklerini belirlemek için gerçekleştirilmiştir. 2012 ve 2013 yıllarında seleksiyonu yapılan genotiplerden doğal ortamlarında meyveler toplanmış ve on farklı meyve özelliği kullanılarak değerlendirilmiştir. Genotiplerin değerlendirilmesinde tartılı derecelendirme yöntemi kullanılmıştır. Elde edilen sonuçlara göre, ortalama meyve ağırlığı 80 g, meyve başına ortalama tohum sayısı 240, seçilen genotiplerde meyve şekli genel olarak eliptik (%64.74) olarak bulunmuştur. Meyve kabuğunun soyulma zorluğu orta (%54.83) olarak sınıflandırılmıştır. Genotiplerin suda çözünebilir kuru madde miktarı %7 ile %17, pH 5.17-7.36 arasında bulunmuştur. Titre edilebilir asitlik genotipe bağlı olarak önemli farklılık göstermiş ve %1.94 ile %9.08 arasında bulunmuştur. Basit derecelendirme yöntemi sonucunda 01 OP 19 no.lu genotip en yüksek puanı almıştır.

Anahtar Sözcükler:
Opuntia
Pomoloji
Dikenli incir
Seleksiyon
Basit derecelendirme yöntemi

1. Introduction

Cactus pear (*Opuntia ficus-indica* (L.) Mill.), belongs to *Cactaceae* family, is well adapted to semi-arid and arid regions and plant can survive in prolonged drought conditions. Cactus pear has been an alternative significant agricultural food resource due to its well adaptation capability to arid lands where the many fruit species cannot presence naturally (De Wit et al., 2010).

Finding an alternative food resources for human as well as for animals in a region located in erratic rainfall is highly dependent its climatic conditions and availability of natural resources of certain region (Nefzaoui, 2009). Therefore, cactus pear is life-saving food resource for human being and animals in underdeveloped African countries where people having struggle during prolonged arid period. Additionally, cactus pear fruit is rich in minerals and vitamins (Galati et al., 2003) and it is easily accessible and affordable food for people lives in rural areas (Chipeta, 2010). It is well reported previously that fruits and other parts of the plant are used in traditional medicine (Wolfram et al., 2003), to prevent heart attack, cataract, neurological diseases as well (Shadidi, 1997; Greenway, 2001;

Lopez, 2007; Corral-Aguayo et al., 2008).

Cactus pear naturally grows in bushy areas, garden borders as an individual plant or population in costal sides of Mediterranean and Aegean regions in Turkey (Karababa et al., 2004). There is no commercial plantation and cultivars in Turkey, but fruits are sold in local bazaars and consumption is limited. In this study, we aimed to: (1) determine pomological characteristics of selected cactus pear genotypes naturally grown in Adana in Turkey; and, (2) evaluate genotypes using weighted ranked methods.

2. Materials and Methods

2.1. Material

The study was performed on thirty one genotypes selected from different locations of Adana province in Turkey in 2012 and geographic information of the selected plants were recorded (Table 1). The selected plants were indicated and given special code individually such as "XX OP YY" (XX: province traffic code, OP: *Opuntia*, YY: genotype number).

Table 1. Geographical data of selected genotypes

No	Code	Location	Altitude (m)	Latitude (N)	Longitude (E)
1	01 Op 02	Mustafalar	256	37° 05' 08''	35° 28' 38''
2	01 Op 03	Kaş Obası	282	37° 08' 54''	35° 30' 34''
3	01 Op 04	Karlık	261	37° 10' 02''	35° 30' 20''
4	01 Op 05	Karlık	305	37° 16' 55''	35° 31' 55''
5	01 Op 06	Pirili	89	37° 05' 18''	35° 11' 06''
6	01 Op 07	Pirili	110	37° 06' 27''	35° 08' 33''
7	01 Op 08	Pirili	110	37° 06' 47''	35° 08' 37''
8	01 Op 09	Pirili	110	37° 06' 47''	37° 08' 37''
9	01 Op 10	Araplar	162	37° 11' 58''	35° 02' 47''
10	01 Op 11	Karaisalı	231	37° 10' 09''	35° 07' 09''
11	01 Op 12	Kesmeburun	18	36° 45' 51''	35° 29' 30''
12	01 Op 13	Kesmeburun	18	36° 45' 08''	35° 30' 02''
13	01 Op 14	Şıhganim	7	36° 44' 26''	35° 30' 29''
14	01 Op 15	Zeynepli	17	36° 44' 12''	35° 34' 30''
15	01 Op 16	Zeynepli	17	36° 44' 17''	35° 34' 11''
16	01 Op 17	Deveci Uşağı	7	36° 45' 18''	35° 27' 19''
17	01 Op 18	Vayvaylı	20	36° 51' 21''	35° 36' 21''
18	01 Op 19	Vayvaylı	49	36° 54' 10''	35° 37' 41''
19	01 Op 21	Yeniköy	28	36° 56' 58''	35° 45' 42''
20	01 Op 22	İsalı	36	36° 55' 26''	35° 43' 11''
21	01 Op 23	İsalı	38	36° 55' 26''	35° 43' 11''
22	01 Op 24	Balcalı	58	37° 01' 49''	35° 22' 51''
23	01 Op 25	Hocalı	166	37° 07' 09''	35° 24' 26''
24	01 Op 26	Maltepe	357	37° 07' 06''	35° 24' 43''
25	01 Op 27	Bebeli	17	36° 36' 11''	35° 26' 07''
26	01 Op 28	Bebeli	17	36° 39' 28''	35° 29' 54''
27	01 Op 29	Kaldırım	14	36° 41' 04''	35° 31' 28''
28	01 Op 30	Kaldırım	14	36° 41' 05''	35° 31' 38''
29	01 Op 31	Terliksiz	4	36° 40' 59''	35° 19' 23''
30	01 Op 33	Beyköy	5	36° 44' 04''	35° 17' 59''
31	01 Op 34	Bucak	407	37° 13' 55''	34° 56' 39''

2.2. Method

2.2.1. Pomological and statistical analysis

Fruits were collected from selected genotypes in their natural habitat and analyses were done both in 2012 and in 2013 on these selected plants. Pomological analyses were performed according to Mashope (2007) in pomology laboratory of Horticultural Department in Çukurova University. Twenty one fruit samples were randomly collected from selected genotypes and following fruit characteristics were evaluated: fruit length (FL) (mm), fruit diameter (FD) (mm), total fruit weight (TFW) (g), and edible fruit weight (EFW) (g). Fruit shape (FS) was classified based on FD/FL rate in

four different category which were oblong (0.45-0.55), elliptical (0.56-0.69), ovoid (0.70-0.79) and round (0.80-0.89) (Mashope, 2007). Fruit firmness (FF) measured using hand penetrometer (Wagner Instruments, Model FT, USA) in 6 randomly selected fruits per genotype. Ease of fruit peeling (EFP) ranked from easy peeling (1) to hard peeling (5). Percentage of fruit pulp (FP) (%) estimated using ratio of edible fruit weight to total fruit weight (Mashope, 2007). Total soluble solid contents (TSS) was measured using hand refractometer (SOIF optical Instruments, VBR20T) and pH measured using digital pH meter (Mettler Toledo, S220) in fruit juice obtained from twenty one fruits per genotype. Seed number per fruit counted in five randomly selected fruits from each genotype. Titratable acidity (TA) estimated by using 5 ml fruit juice and 95 ml distilled water and titrated with 0.1N NaOH until pH value reached 8.2. Amount of NaOH spent was estimated and TA determined according to Karaçalı (2012) in terms of citric acid.

The data of pomological evaluation were statistically analyzed by using SPSS package software.

First, the distributions of the variables were checked by using Kolmogorov Smirnov normality test. Two-way variance analysis were done to observe the effect of years and genotypes and Duncan multiple comparison test were used to determine differences between the group means.

2.2.2. Evaluation of cactus pear genotypes

Evaluation of cactus pear genotypes was performed according to Balık and Beyhan (2014). Modified version of simplified scoring method was used to evaluate cactus pear genotypes and criteria were determined based on economically important fruit characteristics, simplicity of fruit harvesting and its suitability for the plantation. Genotype characteristics were determined and relative coefficient value was given for each category. Each category also divided to sub-categories and given another coefficient value. Categorical value was calculated multiplying two coefficient values for each genotype and the genotypes were compared in terms of summation of all category value. Plant characteristics and coefficient values of selected genotypes were given in Table 2.

Table 2. Plant characteristics used in weighted ranked method

Parameters	Coefficient	Categories	Category range	Point
Plant Growth Habit (PGH)	5	Upright	Plant crown ≈ Plant height	10
		Spreading	Plant crown > Plant height	7
		Decumbent		5
		Drooping		3
Cladode: number of spines per aerole (CSN)	15	Absent or very few	0 – 1	10
		Few	2 – 3	8
		Medium	4 – 5	5
		Many	6 – 7	3
		Very Many	>7	1
Fruit Shape (FSH)	10	Round	Diameter/Length = 0,80- 0,89	10
		Ovoid	Diameter/Length = 0,70- 0,79	9
		Elliptical	Diameter/Length = 0,56- 0,69	7
		Oblong	Diameter/Length = 0,45- 0,55	5
Fruit Size (FS)	15	Large	Diameter >78	10
		Medium	Diameter = 54 – 77	7
		Small	Diameter <53	4
Fruit Firmness (FF)	10	Firm	>2.80 kg.cm^{-2}	10
		Medium	2.26 – 2.79 kg.cm^{-2}	7
		Soft	1.72 – 2.25 kg.cm^{-2}	4
Fruit Skin Color (FSC)	10	Orange		10
		Yellow		7
		Purple		5
		Green		3
Fruit Flesh Color (FFC)	10	Orange		10
		Yellow		7
		Purple		5
		Green		3
Pulp (%)	15	High	>55	10
		Medium	55 – 51	7
		Low	< 50	4
Seed Number (SN)	10	Few	< 179	10
		Medium	180 - 264	7
		Many	> 265	4

3. Results and Discussion

3.1. Pomological characteristics

Considering the evaluation of fruit characteristics of selected genotypes, the lowest fruit diameters were found to be 33.08 mm and 33.29 mm in 01 OP 09 and 01 OP 12 genotypes respectively, while the highest fruit diameter was found to be 50.73 mm in 01 OP 15 genotype. Similarly, the lowest fruit length was observed in 01 OP 09 and 01 OP 12 genotypes with 59.08 and 59.65 respectively, while mean fruit length was the highest in 01 OP 33 genotype with 84.08 mm (Table 3).

Table 3. Pomological traits of selected cactus pear genotypes from Adana province - I

Code	Fruit diameter (mm)	Fruit length (mm)	Fruit firmness ($kg.cm^{-2}$)	Total fruit weight (g)	Edible fruit weight (g)
02*	47.48 ± 0.63c-f	71.7 ± 1.23e-h	2.4 ± 0.33d-l	92.35 ± 2.79a-d	47.33 ± 1.92b-h
03	44.99 ± 0.55hı	68.28 ± 1.08h-j	1.75 ± 0.18mn	75.67 ± 2.26ijk	38.17 ± 1.25kl
04	47.12 ± 0.48c-g	71.92 ± 1.02d-h	2.41 ± 0.25d-l	99.11 ± 2.18a	54.15 ± 1.51a
05	50.08 ± 0.47ab	63.63 ± 0.62k-n	2.43 ± 0.22c-l	93.54 ± 2.06abc	49.21 ± 1.35a-f
06	50.13 ± 0.66ab	62.47 ± 1.11mno	2.19 ± 0.17h-n	89.43 ± 2.09b-e	45.39 ± 1.25d-i
07	48.24 ± 0.5bcd	65.89 ± 1.04j-m	2.39 ± 0.15d-l	86.96 ± 2.08c-h	44.1 ± 1.53f-i
08	45.78 ± 0.62e-h	65.27 ± 1.06j-m	2.07 ± 0.14j-n	74.45 ± 2.22jkl	36.41 ± 1.46l
09	33.09 ± 0.6j	59.08 ± 1.34o	1.75 ± 0.07mn	29.29 ± 1.30n	17.43 ± 0.51n
10	47.68 ± 0.61cde	60.96 ± 0.97no	1.93 ± 0.13lmn	89.76 ± 2.39b-e	46.7 ± 1.34c-ı
11	44.34 ± 0.43hı	66.83 ± 1.18i-l	2.27 ± 0.24g-l	74.40 ± 1.97jkl	44.44 ± 1.51e-i
12	33.29 ± 0.6j	59.65 ± 1.29o	1.73 ± 0.06n	29.34 ± 1.30n	17.27 ± 0.51n
13	47.81 ± 0.7cde	69.97 ± 1.39g-i	2.51 ± 0.22c-k	84.39 ± 3.19d-ı	42 ± 2.19h-k
14	47.35 ± 0.59c-g	71.03 ± 1.35f-ı	2.57 ± 0.23b-j	79.70 ± 2.85gj	40.43 ± 2.27i-l
15	50.73 ± 0.58a	75.7 ± 1.35cd	2.61 ± 0.27b-h	94.00 ± 3.35abc	50.28 ± 1.86a-d
16	47.21 ± 0.53c-g	62.85 ± 1.11l-o	2.4 ± 0.15d-l	79.34 ± 2.48g-j	41.57 ± 1.83ı-l
17	45.3 ± 0.49gh	72.9 ± 1.63d-g	2.38 ± 0.13f-l	78.63 ± 2.03h-j	38 ± 1.42kl
18	45.31 ± 0.54gh	70.21 ± 1.22g-i	2.54 ± 0.34b-j	87.75 ± 2.59c-g	44.8 ± 1.5e-i
19	48.74 ± 0.57abc	68.64 ± 1.26h-j	2.24 ± 0.21g-m	92.57 ± 3.16a-d	49.63 ± 1.68a-e
21	47.37 ± 0.53c-g	69.92 ± 1.38g-i	1.75 ± 0.18mn	87.57 ± 2.53c-g	45.38 ± 1.72d-i
22	50.28 ± 0.54a	74.44 ± 2c-f	2.8 ± 0.27b-f	97.64 ± 2.88ab	52.33 ± 1.57bc
23	50.64 ± 0.48a	74.7 ± 1.41c-f	2.46 ± 0.21c-k	98.70 ± 2.58a	51.87 ± 1.58abc
24	42.18 ± 0.95ıi	65 ± 1.08j-m	2.94 ± 0.33abc	63.13 ± 2.74m	31.27 ± 1.58m
25	46.02 ± 0.89e-h	78.03 ± 1.38bc	2.63 ± 0.22b-h	88.82 ± 4.09c-f	45.31 ± 1.73d-i
26	49.1 ± 0.48ab	67.44 ± 0.96ı-k	2.49 ± 0.17c-k	86.47 ± 1.87c-h	47.06 ± 1.2b-h
27	46.4 ± 0.66d-h	75.41 ±1.06cde	2.88 ± 0.28a-f	83.83 ± 3.19e-i	43.71 ± 2.63h-j
28	47.37 ± 0.7c-g	80.07 ± 1.65b	2.92 ± 0.29a-d	67.04 ± 3.51klm	48.03 ± 2.42b-g
29	44.41 ± 0.68hı	64.86 ± 1.18jm	3.03 ± 0.21ab	68.37 ± 2.24klm	37.33 ± 1.54kl
30	47.38 ± 0.6c-g	65.86 ± 1.1j-m	2.73 ± 0.19b-g	80.41 ± 2.45f-j	41.31 ± 1.82ı-l
31	42.13 ± 1.33ıi	70.15 ± 1.33g-i	2.43 ± 0.19c-l	77.94 ± 3.96ıij	39.89 ± 2.36i-l
33	43.22 ± 0.47ıi	84.08 ± 1.14a	3.33 ± 0.31a	82.49 ± 2.27e-j	41.96 ± 1.38h-k
34	45.47 ± 0.52fgh	65.01 ± 1.14jm	2.01 ± 0.13k-n	76.35 ± 2.18ijk	38.73 ± 1.59jkl
Significant	<0.001	<0.001	<0.001	<0.001	<0.001

*Abbreviation of 01 OP 02

Fruit firmness varied between 1.7 $kg.cm^2$ and 3.3 $kg.cm^2$. Ease of fruit peeling of seventeen genotypes among thirty one were classified "Medium" (54.83%), twelve genotypes were classified "Hard" (38.70%) and only two genotypes were classified "Easy" (6.45%) (Table 3).

One of the most important quality parameters in fruit growing is fruit weight and fruit weight of economically grown cactus pear cultivars were found to be between 120 g and 200 g. In this study, fruit weight of selected genotypes was varied between 29 g and 99 g. The lowest TFW were 29.28 g in 01 OP 09 genotype and 29.24 g in 01 OP 12 genotype, while the highest was obtained from 01 OP 04 with 99.10 g. On the other hand, TFW was between 63.13 g and 99.10 g if 01 OP 09 and 01 OP 12 genotypes were excluded (Table 3). Karababa et al. (2004) previously reported in their study of cactus pear, carried out in five different locations of Adana, the mean value of TFW was found to be varied between 70.46 g and 96.71 g. Toplu et al. (2009) reported first evaluation of physico-chemical characteristics of cactus pear accessions grown in Turkey and researchers determined that TFW varied between 48.70 g and 118.07 g with an average of 77.95

g in 25 cactus pear accessions. Additionally, TFW was found to be 107.28g in another study in Adana province carried out by Bekir (2006). In present study, our findings are very similar with previous studies. However, total fruit weight of the selected cultivars were determined to be lower than its economical standard value (120 g-200 g), this situation may occur due to selected genotypes were grown naturally without any cultural applications such as fertilization and irrigation. In parallel to these results, total fruit weight and edible fruit weight (EFW) were found to be the lowest in 01 OP 09 and 01 OP 12 genotypes with 17.43 g and 17.26 g, respectively. The highest EFW was obtained in 01 OP 04 with 54.15 g.

Amount of fruit pulps were found to be average 52% similar to the results of previously reported study by Duru and Türker (2005) (Table 4). On the other hand, amount of fruit pulp was significantly lower than the results of Karababa et al. (2004). These differences may arise depending on the genotypic effect of the selected plants, different locations and number of the fruit samples analyzed.

Table 4. Pomological traits of selected cactus pear genotypes from Adana province - II

Code	Pulp (%)	Total soluble solids (ºBrix)	pH	Seed number	Titratable acidity (%)
02*	50.6 ± 0.80ef	13.5 ± 1.5ab	6.33 ± 0.73abc	239.58 ± 18.84e-ı	4.7 ± 1.44bc
03	50.31 ± 0.54ef	12.5 ± 0.5abc	6.91 ± 0.32ab	275 ± 26.46c-f	3.23 ± 0.55c
04	54.38 ± 0.61c-f	14.0 ± 0a	6.09 ± 0.8abc	234.08 ± 10.36f-i	4.38 ± 0.42bc
05	52.42 ± 0.44d-f	13.0 ± 0ab	6.63 ± 0.49ab	231.92 ± 8.88f-i	3.65 ± 0.71bc
06	50.63 ± 0.5ef	13.5 ± 0.5ab	6.98 ± 0.11ab	186.92 ± 10.86jk	2.78 ± 0.48c
07	50.22 ± 0.71ef	12.5 ± 1.5abc	6.65 ± 0.25ab	222.58 ± 11.72g-j	3.52 ± 0.19bc
08	48.25 ± 0.75f	8.0 ± 5cd	6.48 ± 0.27abc	218.08 ± 12.03h-j	5.31 ± 0.39bc
09	61.77 ± 1.51a	7.0 ± 0d	5.18 ± 0.17c	95.75 ± 6.03ı	48.7 ± 3.26a
10	51.96 ± 0.41ef	12.0 ± 0abc	5.76 ± 0.96bc	149.17 ± 19.31	3.39 ± 0.07c
11	59.31 ± 0.64a-c	15.0 ± 0a	6.34 ± 0.78abc	185.92 ± 7.55jk	5.06 ± 2.31bc
12	61.00 ± 1.42ab	7.0 ± 0d	5.18 ± 0.17c	96.75 ± 6.93ı	50.34 ± 4.9a
13	48.83 ± 0.95f	12.5 ± 0.5abc	7.37 ± 0.11a	254.67 ± 17.64d-ı	1.94 ± 1.12c
14	49.44 ± 1.05ef	9.0 ± 2bcd	7.09 ± 0.11ab	312.33 ± 14.12abc	2.77 ± 0.4c
15	58.23 ± 5.82a-d	11.0 ± 1a-d	7.32 ± 0.15a	279.75 ± 22.6cde	2.84 ± 0.8c
16	51.75 ± 0.68ef	11.5 ± 2.5a-d	7.01 ± 0.14ab	251.42 ± 16.03d-ı	2.64 ± 0.25c
17	47.81 ± 0.77f	11.0 ± 1a-d	6.4 ± 0.34abc	248.75 ± 15.1d-ı	3.04 ± 0.03c
18	50.84 ± 0.41ef	12.5 ± 0.5abc	6.67 ± 0.02ab	209.58 ± 7.47ıij	2.87 ± 0.37c
19	58.27 ± 5.71a-d	12.5 ± 1.5abc	6.59 ± 0.15ab	221 ± 11.08g-j	3.68 ± 0.61bc
21	51.39 ± 0.77ef	11.5 ± 1.5a-d	6.94 ± 0.15ab	263.42 ± 9.02d-h	3.23 ± 0.1c
22	53.58 ± 0.46c-f	12.5 ± 1.5abc	6.93 ± 0.07ab	249.25 ± 15.42d-ı	3.42 ± 0.48c
23	52.35 ± 0.49d-f	11.0 ± 3a-d	7.02 ± 0.3ab	280.33 ± 13.55cde	3.33 ± 0.9c
24	48.90 ± 0.58fef	12.0 ± 1abc	6.27 ± 0.44abc	190.42 ± 8.98jk	3.52 ± 0.64bc
25	55.70 ± 5.06 b-e	11.5 ± 0.5a-d	6.47 ± 0.42abc	274.75 ± 11.28c-f	3.68 ± 0.61bc
26	54.45 ± 0.79c-f	10.5 ± 1.5a-d	6.46 ± 0.38abc	323.08 ± 6.62ab	3.33 ± 0.64c
27	51.59 ± 1.78ef	12.0 ± 3abc	6.82 ± 0.14ab	347.67 ± 22.28a	3.17 ± 0.42c
28	50.16 ± 0.98ef	10.5 ± 0.5a-d	7.09 ± 0.32ab	259.42 ± 7.17d-h	3.2 ± 1.35c
29	54.19 ± 0.66c-f	10.25 ± 1.75a-d	7.11 ± 0.4ab	270.58 ± 15.93c-f	2.88 ± 0.45c
30	50.62 ± 1.00ef	10.5 ± 1.5a-d	7.19 ± 0.06a	277.58 ± 7.89c-f	2.24 ± 0c
31	51.76 ± 0.93ef	11.5 ± 1.5a-d	6.9 ± 0.27ab	245.25 ± 10.02d-ı	2.88 ± 0.39c
33	50.62 ± 0.58ef	10.5 ± 1.5a-d	7.23 ± 0.17a	265.08 ± 13.46dg	2.65 ± 0.61c
34	50.14 ± 0.95ef	13.25 ± 1.75ab	6.03 ± 1.28abc	289.25 ± 14.1bcd	9.09 ± 5.64b
Significant	<0.001	<0.068	<0.04	<0.001	<0.001

*Abbreviation of 01 OP 02

Total soluble solid (TSS) contents was determined between 7% and 15%. The lowest TSS content was found to be 7% both in 01 OP 09 and 01 OP 12 genotype, while the highest TSS content was 15% in 01 OP 11 genotype. Cactus pear fruit is not climacteric, therefore mainly fructose and glucose are stored as carbohydrate resource instead of starch. Level of sugar content in mature fruit remains mainly stable after harvest and this characteristic is one of the significant factors to determine fruit quality and consumers' demands. Fruits should be harvested when TSS content is higher than 12% to avoid taste problems (Berger et al., 2003). However TSS content in some Mexican cactus pear is about 17-18%, acceptable TSS content is minimum 13% (Inglese, 2009). In our study, TSS contents of the fruits of 16 genotypes were changed between 11-13%, it was higher than 13% in 6 genotypes and lower than 11% in 9 genotypes. These differences

may occur depending on the ecological conditions, ripening period, natural habitat grown in and the genotypic characteristics of the genotypes (Karaçalı, 2009).

Lowest and highest seed number per fruit of the selected genotypes were between 95 (01 OP 09) and 347 (01 OP 27) (Table 4). Seed number of a cactus pear fruit is a very important parameter in breeding program. Cactus pear fruit is botanically classified in berry fruits and each seed is placed in fruit flesh (Weiss and Mizrahi, 1993; Mondragon-Jacoba and Bardelon, 1996; Mejia and Cantwell, 2003). However, seedless fruits are preferred for marketing, but limited studies and unsuccessful results were reported on this issue. Weiss and Mizrahi (1993) reported that fruits' of BS1 cactus pear line is a parthenocarpic fruit contains abortive seeds (100%). However marketing value of parthenocarpic fruit was decreased due to smaller fruit size.

Titratable acidity levels of fruits were changed between 1.94% and 50.33%. If the genotypes contains the highest TA values such as 01 OP 09 (TA: 48.7%) and 01 OP 12 (TA: 50.33%) were excluded, the lowest acidity content was obtained to be 1.94% and the highest acidity was 9.08%. (Table 4).

According to results of the pomological analysis, there were no significant differences between two years (data not shown).

Ovoid or elliptical fruit shape is an important selection factor in cactus pear cultivars since fruit processing of ovoid or elliptical fruit was easier and fruits were less damaged during the harvest comparing to long shaped fruits (Cantwell, 1991). Fruit shape of genotypes were mainly elliptical (67.74%) and ovoid (29.03%), except two genotypes which had round (3.22%) and oblong fruits (3.22%) (Table 5).

Table 5. Fruit shape and hardness of fruit peeling of the selected genotypes

No	Code	FD/FL	Fruit shape	Ease of fruit peeling
1	01 Op 02	0.669	Elliptical	3 (Medium)
2	01 Op 03	0.664	Elliptical	3 (Medium)
3	01 Op 04	0.660	Elliptical	3 (Medium)
4	01 Op 05	0.789	Ovoid	3 (Medium)
5	01 Op 06	0.815	Round	5 (Hard)
6	01 Op 07	0.739	Ovoid	4 (Hard)
7	01 Op 08	0.707	Ovoid	3 (Medium)
8	01 Op 09	0.566	Elliptical	3 (Medium)
9	01 Op 10	0.790	Ovoid	3 (Medium)
10	01 Op 11	0.670	Elliptical	3 (Medium)
11	01 Op 12	0.564	Elliptical	3 (Medium)
12	01 Op 13	0.691	Elliptical	5 (Hard)
13	01 Op 14	0.674	Elliptical	4 (Hard)
14	01 Op 15	0.679	Elliptical	4 (Hard)
15	01 Op 16	0.759	Ovoid	3 (Medium)
16	01 Op 17	0.633	Elliptical	3 (Medium)
17	01 Op 18	0.651	Elliptical	4 (Hard)
18	01 Op 19	0.717	Ovoid	3 (Medium)
19	01 Op 21	0.685	Elliptical	3 (Medium)
20	01 Op 22	0.698	Elliptical	4 (Hard)
21	01 Op 23	0.686	Elliptical	5 (Hard)
22	01 Op 24	0.652	Elliptical	3 (Medium)
23	01 Op 25	0.591	Elliptical	4 (Hard)
24	01 Op 26	0.731	Ovoid	4 (Hard)
25	01 Op 27	0.597	Elliptical	3 (Medium)
26	01 Op 28	0.691	Elliptical	2 (Easy)
27	01 Op 29	0.725	Ovoid	2 (Easy)
28	01 Op 30	0.604	Elliptical	3 (Medium)
29	01 Op 31	0.517	Oblong	4 (Hard)
30	01 Op 33	0.708	Ovoid	4 (Hard)
31	01 Op 34	0.669	Elliptical	3 (Medium)

3.2. Evaluation of selected genotypes

Selected genotypes were evaluated by using weighted ranked method based on morphological and pomological criteria which were plant growth habit, amount of cladode spines, fruit shape, fruit size, fruit firmness, fruit skin color, fruit flesh color, fruit pulp content and seed number per fruit. According to the results, the genotypes got the highest ranking point regarding prickliness has a spine or none on its cladodes. Only three genotypes got the highest point due to the lowest seed number per fruit and two of them have purple and rather small fruits. Additionally, these two genotypes (01 OP 09 and 01 OP 12) have no marketable fruits and genotypes may belong to different species in *Opuntia* genus. As a result of weighted ranking, 01 OP 19 genotype was found to be the best genotype with 850 point and 01 OP 03 genotype was the lowest (Table 6). Additionally, except 01 OP 19, three genotypes (01 OP 05, 855; 01 OP 10, 855 and 01 OP 25, 850) were ranked as 850 point or higher. 01 OP 05 genotype got lower ranking point than 01 OP 19 due to its yellow fruit skin color and lower pulp content whereas it has less spine per areole. Similarly, 01 OP 10 genotype got lower ranking point than 01 OP 19.

Table 6. Weighted ranked method results of the selected cactus pear genotypes

Genotype	PGH*	CSN	FSH	FS	FF	FSC	FFC	PULP	SN	Total
01 OP 19	50	120	90	150	40	100	100	150	70	870
01 OP 05	50	150	90	150	70	70	100	105	70	855
01 OP 10	50	120	90	150	40	100	100	105	100	855
01 OP 25	50	150	70	150	70	70	100	150	40	850
01 OP 04	50	150	70	150	70	100	70	105	70	835
01 OP 22	50	120	70	150	100	70	100	105	70	835
01 OP 11	50	150	90	105	70	70	70	150	70	825
01 OP 16	50	120	90	150	70	70	100	105	70	825
01 OP 15	50	120	70	150	70	70	100	150	40	820
01 OP 18	50	150	70	150	70	100	100	45	70	805
01 OP 21	50	120	70	150	40	100	100	105	70	805
01 OP 23	50	120	70	150	70	100	100	105	40	805
01 OP 33	50	150	50	150	100	100	100	45	40	785
01 OP 31	50	120	90	105	70	100	100	105	40	780
01 OP 02	50	150	70	150	70	100	70	45	70	775
01 OP 13	50	120	70	150	70	100	100	45	70	775
01 OP 17	50	120	70	150	70	100	100	45	70	775
01 OP 29	35	120	70	105	100	100	100	105	40	775
01 OP 07	50	120	90	150	70	70	100	45	70	765
01 OP 30	50	120	90	150	70	100	100	45	40	765
01 OP 24	50	120	70	105	100	100	100	45	70	760
01 OP 14	50	120	70	150	70	100	100	45	40	745
01 OP 08	50	120	90	105	40	100	100	45	70	720
01 OP 26	35	45	90	150	70	70	100	105	40	705
01 OP 27	50	45	70	150	100	40	100	105	40	700
01 OP 34	50	120	90	105	40	100	100	45	40	690
01 OP 28	50	45	70	105	100	100	100	45	70	685
01 OP 09	35	120	70	60	40	50	50	150	100	675
01 OP 12	35	120	70	60	40	50	50	150	100	675
01 OP 06	50	75	100	150	40	70	70	45	70	670
01 OP 03	50	120	70	105	40	70	70	45	40	610

*PGH: Plant growth habit, CSN: Cladode: spine number per aerole, FSH: Fruit shape, FS: Fruit Size, FF: Fruit Firmness, FSC: Fruit Skin Color, FFC: Fruit Flesh Color, SN: Seed Number

because of lower fruit pulp amount whereas it has lees seed number per fruit. It may suggest that less spine and lower seed number per fruit are more significant character than fruit skin color and pulp amount when we consider the plants grown without any cultural application. Therefore, 01 OP 19 with highest ranked point and following genotypes 01 OP 05 and 01 OP 25 could be shown promising genotype for commercial plantation as well as for future breeding programs.

4. Conclucion

Spineless cladode of cactus pear plant is consumed as salad in some countries besides an edible fruit. It is known that different parts of the plant can be used for different way of consumption such as in alcoholic beverages and marmalade industries, or as an animal feed. However, consumption of edible fruits is limited in Turkey, but sometimes fruits are used to make jam or ice cream in particular areas.

Recently, some efforts have been made to increase marketing value of cactus pear fruits especially in Çukurova region in Turkey and now packed products of cactus pear fruit can be found in supermarkets (Anonymous, 2014). Nowadays, production of high quality cactus pear fruits and exportation of them are aimed as next step. However it is obvious that determination of the best genotypes in terms of fruit quality parameters and improving commercial cultivars for commercial orchards are needed. Therefore, this study on the selection of cactus pear genotypes is the first step to get an opinion about the pomological characteristics of cactus pear naturally grown in Adana-Çukurova province in Turkey.

Aknowledgements

We are thankful to financial support of the Scientific Research Projects Unit of Çukurova University (Project No: ZFYL2012).

References

Anonymous, 2014. Dikenli incirin 400 tanesi, 12 liradan satılıyor. http://www.ascihaber.com/v4/haber/devam.asp?haber_id=9221 (Access Date: 11.12.2015).

Balık, H.I., Beyhan, N., 2014. Ordu'nun Ünye ilçesinde Palaz fındık çeşidinin klon seleksiyonu. Anadolu J Agr Sci, 29(3): 179-185.

Bekir, E.A., 2006. Cactus pear (*Opuntia ficus-indica* Mill.) in Turkey: growing regions and pomological traits of cactus pear fruits. Acta Hort., 728: 51-54.

Berger, H., Rodriguez-Felix, A., Galletti, L., 2013. Field operations and utilization of cactus cladodes. Agro-Industrial Utilizations of Cactus Pear, FAO, Rome, p. 21-29.

Cantwell, M., 1986. Post-harvest aspects of prickly pear fruits and vegetable cladodes. In perishables handling, post-harvest technology of fresh horticultural crops. Cooperative extension, University of California, 59: 6-9.

Chipeta, M., 2010. Keynote address (Nefzaoui, A., Inglese, P., Belay, T., Eds). Improved utilization of cactus pear for food, feed, soil and water conservation and other products in Africa. Proceedings of International Workshop, Mekelle (Ethiopia), p. 10-11.

Corral-Aguayo, R..D., Yahia, E.M., Carillo-Lopez, A., Gonzalez-Aguilar, G., 2008. Correlation between some nutritional components and the total antioxidant capacity measured with six different assays in eight horticultural crops. J. Agric. Food. Chem., 56: 10498-10504.

De Wit, M., Nel, P., Osthoff, G., Labuschange, M.T., 2010. The effect of variety and location on cactus pear (*Opuntia ficus – indica*) fruit quality. Plant Foods Hum. Nutr., 65: 136-145.

Duru, B., Türker, N., 2005. Changes in physical properties and chemical composition of cactus pear (*Opuntia ficus-indica*) during maturation. J Prof Assoc Cactus. 22-33.

FAO, 2013. Agro-industrial utilization of cactus pear. Rome. www.fao.org/docrep/019/a0534e/a0534e.pdf (Access: 11.12.2015)

Galati, E.M., Mondello, M.R., Giuffrida, D., Dugo, G., Miceli, N., Pergolizzi, S., Taviano, M.F., 2003. Chemical characterization and biological effects of Sicilian *Opuntia ficus indica* (L.) Mill. fruit juice: antioxidant and anti-ulcerogenic activity J. Agric. Food Chem., 51: 4903-4908.

Greenway, H.T., Pratt, S.G., 2001. Fruit and vegetable micronutrients in diseases of the eye. In vegetable, fruits, and herbs in health promotion (Watson, R. R., Ed.). CRC Press: Boca Raton pp 85-98.

Inglese, P., 2009. Cactus pear: gift of the new world. Chronica Hortic., 49(1): 15.

Karaçali, I., 2012. Bahçe ürünlerinin muhafaza ve pazarlanması. Sekizinci Baskı. Ege Üniversitesi Basımevi. İzmir. p. 486.

Lopez, J.L., 2007. Use of *Opuntia cactus* as a hypoglycemic agent in managing type 2 diabetes mellitus among Mexican American patients. Nutrient Bytes, 12(1): 1-7.

Mashope, B.K., 2007. Characterization of cactus pear germplasm in Southern Africa, http//:etd.uovs.ac.za/ETD-db/theses/available/etd.../MashopeBK.pdf (Access Date: 11.12.2015).

Mejia, A., Cantwell, M., 2003. Prickly pear fruit development and quality in relation to gibberellic acid applications to intact and emasculated flower buds. J Prof Assoc Cactus, 72-85.

Mondrogon-Jacobo, C., Bordelon, B.B., 1996. Cactus pear (*Opuntia* spp. *Cactaceae*) breeding for fruit production. J Prof Assoc Cactus, pp. 19.

Shahidi, F., 1997. Natural antioxidants: An overview in natural antioxidants: chemistry, health effects, and applications. (Shahidi, F., Editor). AOCS Press: Champaign, IL, pp 1-11.

Toplu, C., Serce, S., Ercisli, S., Kamiloglu, O., Memnune, S., 2009. Phenotypic variation in physico-chemical properties among cactus pear fruits (*Opuntia ficus-indica* (L.) Miller) from Turkey. Phcog Mag., 5(20): 400-406.

Nefzaoui, A., El-Mourid, M., Salah, C., 2009. ICARDA and FAO-CACTUSNET collaborate to promote cactus (*Opuntia ficus indica*) for rangeland ımprovement and to combat desertification. Cactusnet Newsletter, 9: 28-33.

Weiss, J., Nerd, A., Mizrahi, Y., 1993. Vegetative parthenocarpy in the cactus pear *Opuntia ficus-indica* (L.) Mill. Annals of Botany, 72: 521-526.