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Effect of maturity stage on morphological and chemical characteristics of *Opuntia ficus indica* from Morocco

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ABSTRACT: The objective of the present work was to evaluate the changes in morphological and physicochemical characteristics of Moroccan prickly pear cultivars at three different stages of maturity. The results of morphological study showed that the width, length, skin thickness, diameter and depth of receptacle differed significantly depending the cultivars and did not differ significantly depending the maturity. Other parameters such as the weight of the pulp, the skin and the whole fruit differed significantly depending on the cultivars and the maturity; they increased with advance in maturity, while the proportions of skin decreased.

For the physicochemical analyzes, the results showed that moisture, pH, Brix, vitamin C, total sugar and fat have a significant difference between the cultivars and maturity; they increased with advance in maturity, while the percentage of fat decreased. However, no important differences were observed in ash, reducing and non -reducing sugars between the stages of ripeness of the fruits.

KEYWORDS: Prickly pear, stages of maturity, morphological characteristics, physicochemical analyzes.

1 INTRODUCTION

Opuntia represents the largest and the most impressive member of the Cactaceae family. The genus *Opuntia* originates from Mexico and includes approximately 300 to 400 species and great number of varieties (Anaya-Perez, 2001; Benson, 1982; Odoux and Dominguez-Lopez, 1996; Stintzing and Carle, 2005). Prickly pear or cactus pear (*Opuntia spp*) is the most cultivated edible cactus crop in the world and is widely distributed in Mexico and the South American continent. It is also grown in many other regions of the world such as Africa, Australia, and the Mediterranean basin (Inglese et al., 2002; Mizrahi et al., 1997; Nobel, 1995; Piga, 2004), it was introduced into North Africa in the 16th century (Griffiths, 2004). On the other hand, *Opuntia ficus indica (L.) Miller* is the most commonly known cactus that is grown for fruits, vegetable forage, and fodder (Pimienta-Barrios and Munoz-Urias, 1995; Rodriguez-Felix, 2002; Russell and Felker, 1987). Cactus-pear plants have two edible parts. First, there is the fleshy stem also known as cladode, cactus pad, cactus stem, nopalito (young pad), vegetable cactus, or cactus leaf (Rodriguez-Felix, 2002). Second, the fruits are highly appealing and nutritious.

The fruit is a berry, varying in shape, size and color and has a consistent number of hard seeds. The fairly high sugar content and low acidity of the fruit (Joubert, 1993; Munoz de Chavez et al., 1995) make it very sweet and delicious but at the same time make it very susceptible to microbial invasion, thus limiting its storage life in the fresh state. Moreover, cactus pear fruit containing betalain pigments is a good potential for the use as a natural food colorant. This fruit contains the red-violet betacyanins in addition to the yellow betaxanthins (Merin et al., 1987; Forni et al., 1992; Turker et al., 2001).

Scientific studies have indicated that several parts of the species *Opuntia ficus indica* have diuretic and antigotous effects (Galati et al., 2002b). The fruits have antinflammatory and analgesic effects (Loro, del Rio, & Pe´rez-Santana, 1999; Park, Kahng, Lee, & Shin, 2001). Antiulcerous , antihyperglycemic and hypocholesterolemic effects have been demonstrated in the nopal (Galati et al.,2001; Galati et al ., 2002a; Lee et al., 2002 ; Frati el al., 1990).

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Opuntia ficus indica presents a variability in the form, the color, the weight and the content in sugar, in acids and in vitamins C, etc. These diverse parameters vary from a cultivar to another and are strongly influenced by the environment. In Morocco, efforts are currently under way to develop the prickly pear production and to increase its introduction into various common foods. Since scientific information on the physical and chemical characteristics of the cactus fruit are limited and focused only on the fruit at the stage of full maturity, this work aimed to establish the differences in chemical composition and quality between the four cultivars of cactus at three different stages of maturity. Therefore, the objective of the present study was to determine the physical and chemical characteristics at different stages of maturity as related to the apparent color variations in prickly pear fruits.

2 MATERIALS AND METHODS

2.1 PLANT MATERIAL

The study focused on the most important *Opuntia ficus indica* varieties in Morocco: *Aissa* and *Moussa* from Ait Baamrane (South of Morocco), *Shoul* (in the Central Region) and *Dellahia* from Elhoceima (North of Morocco).

2.2 COLLECTION AND PREPARATION OF SAMPLES

The sampling was carried in 2014; it was performed in three different sites and depending on maturity stage for each variety. The maturity was judged by the color and the Period of maturity of the fruit.

The first harvest or the green stage corresponded to the green color of fruit; for Aissa and Shoul cultivars, it was done in June. For *Dellahia* and *Moussa*, since they were late cultivars, the first harvest was done in August for the first one and in September for the second.

The second harvest or intermediate stage of maturity corresponded to fruit, which color was between yellow and green; for Aissa and Shoul cultivars it was done in August, *Dellahia* was done in September and *Moussa* was done in October.

The last harvest or advanced maturity corresponded to a red fruits; for Aissa and Shoul cultivars it was done in September, *Dellahia* was done in October and *Moussa* was done in January.

All the collected fruit samples were transported to the laboratory under refrigeration. The fruits were brushed for two minutes under distilled water with a nailbrush.

For the physicochemical analysis, all selected fruits were washed, manually peeled, and blended in a blender to get the juice. This one was kept at -20 °C until analyzed. The seeds were washed abundantly with the water to remove the pulp attached, dried at 60 °C for 24 h.

2.3 MORPHOLOGICAL STUDY

Morphological study focused on several parameters according to Innocenza et al, 1997: weight (g), length (cm), width (cm), shape and size of the fruit, presence of spines, color and consistency of the pulp, quantity of juice (ml), receptacle characteristics, skin characteristics, and number of normal and abortive seeds.

2.4 PHYSICOCHEMICAL ANALYSIS

All the analyses were performed in three replicates. The moisture was determined by desiccation at 105°C for 24 h, in accordance with the method described by the Association Official of Analytical Chemists (AOAC, 1990). Ash was determined at 550°C for 24 h.

The total soluble solid expressed as ºBrix was measured using a manual refractometer (ATAGO refractometer). The pH was determined by a pH meter previously calibrated with pH = 4 buffer and pH = 7. The total acidity was determined on 10 ml of juice by measuring the volume of 0.1 N NaOH necessary to take the sample to pH 8.1, which was monitored potentiometrically (Tateo, 1978).

Total sugars and reducing sugars were determined using the Bertrand method (Browne and Zerban, 1955). This dosage consisted in collecting the precipitate of the copper (II) oxide Cu2O formed by reduction of the cupro-alkaline liqueur, in presence of reducing sugars, and to measure it out by manganimetry. Bertrand's tables gave the correspondence directly between the volume of KMnO4 (0.1N) used and the content in glucose of the trial hold.

Non-reducing sugars were determined by differences between total sugars and reducing sugars.

Vitamin C content was determined using 2, 6-dichlorophenol indophenol titrimetric method (AOAC, 2000).

Fat was analyzed by petroleum ether extraction using a Soxhlet apparatus according to AOAC methods (2000). Ten grams of powder were mixed with solvent for 6H. The solvent was evaporated at 40 °C using rotavapor.

The oil weight was determined as follows: Oil weight (%) = [(M1 - M0)/M2] x 100, where M0 is the weight of the empty flask (g), M1 the weight of the flask after evaporation (g) and M2 the weight of the seeds powder (g). The resulting oil was kept away from light and at low temperature.

The fatty acids were analyzed by Gas Chromatography coupled to Mass Spectrometry (GC-MS) using a 5973N mass selective detector coupled to an Agilent gas chromatograph 6890N. Mass Spectrometric parameters (SM) were: ionization potential, 70 eV; ionization current, 2 A; temperature of the ion source, 200 °C, resolution, 1000. Mass units were followed from 30 to 450 m / z.

The oil components were identified, by comparing their retention times and mass spectra with mass spectra library23 NIST. Chromatographic conditions were identical to those used for GC analysis

2.5 STATISTICAL ANALYSES

All data represent the average of three tests. For results, the analysis of variance (ANOVA test at two ways of variation; cultivars and maturity) was used to test the possibility of significance of treatment effect, and the degree of meaning of data was taken to probability $p \leq 0.05$.

3 RESULTS AND DISCUSSION

3.1 MORPHOLOGICAL STUDY

3.1.1 QUALITATIVE MORPHOLOGICAL FRUIT CHARACTERISTICS

The morphological characteristics of the Prickly Pear fruits are reported in Tables 1 and 2.

The four *Opuntia ficus indica* fruits were easily distinguished by their shape, the presence of spins, fruits taste and receptacle position.

The varieties Shoul Aissa and Moussa have the same fruit shape (elliptical), the same consistency of the pulp (Medium), a good taste of fruit and the same receptacle scar position, which is sunken. While *Dellahia* has an ovoid shape, with a very good taste of fruit, a flatten Recepticular scar, and consistency of the pulp medium to hard.

Both varieties Shoul and Aissa were considered as small fruits because their weights was between 81 and 120 g, whereas *Moussa* and *Dellahia* had very small sizes because their weights was ≤ 80g. *Shoul* fruit was characterized by the presence of many spines, while *Dellahia* had few spines, *Aissa* and *Moussa* had intermediate spines.

Table 1: Qualitative morphological fruit characteristics for the four cultivars studied

	Characteristics					
Cultivars	**Fruits Shape**	**Fruit size**	**Spines density**	**Consistency of the pulp**	**Fruits taste**	**Receptacle position**
Shoul	Elliptic	Small (81-120g)	A lot	Medium	Good	Sunken
Aissa	Elliptic	Small (81-120g)	Intermediate	Medium	Good	Sunken
Moussa	Elliptic	Very small (≤ 80g)	Intermediate	Medium	Good	Sunken
Dellahia	Ovoid	Very small (≤ 80g)	A little	Medium to Hard	Very good	Flatten

3.1.2 QUANTITATIVE MORPHOLOGICAL FRUIT CHARACTERISTICS

According to the statistical analysis, the fruit properties (width, length, skin thickness, diameter and depth of receptacle) differed significantly depending on the cultivars and did not differ significantly depending on maturity with ($p \leq 0.05$).

Other parameters such as the weight of the pulp, the skin and the whole fruit differed significantly depending on the cultivars and the maturity.

White cultivars had more seeds (about 1378 total seeds) of which 56.32% was abortive, while Moussa was the variety that had fewer seeds (735 total seeds) with an abundance of normal seeds (59.18%) (Table 2). These values were higher than those found by Chalak et al., 2014 (324 seeds) and Bouzoubaâ et al ., 2014 (358 seeds).

Table 2: Quantitative morphological fruit characteristics for the four cultivars studied

	Characteristics				
Cultivars	**total number of seeds**	**Number of normal seeds**	**Number of Abortive seeds**	**% of Normal seeds**	**% of Abortive seeds**
Shoul	1020	430	590	42,15	57,85
Aissa	897	520	377	57,97	42,03
Moussa	735	435	300	59,18	40,82
Dellahia	1378	602	776	43,68	56,32

According to table 3, *Dellahia* was considered as the widest variety of varieties studied (5.01cm) and the least long (6.13cm). *Shoul* was the longest variety (7.8cm), whereas *Aissa* was the least long studied varieties (4.47cm).

The thickness of the skin didn't change depending on maturity : 1.9 mm for *Dellahia* and 2.2 mm for the other cultivars. The white variety had the thinner and lighter peels. These results were lower than those found in Lebanese fruits: from 2.25 to 6.59 mm (Chalak et al., 2014) and Moroccan fruits from Arbaâ Sahel et Asgherkis (south of Morocco) : from 3.62 to 4.92mm (Bouzoubaâ et al ., 2014).

Aissa was the juiciest variety (47.4 to 56.33 ml). For all studied varieties, half ripe fruits (Stage 2) were the juiciest. The amount of juice varied significantly according to maturity and did not change according to cultivars.

The depth of the receptacle did not change depending on maturity: 2.4 mm for Dellahia (since the receptacle is flatten) and 9.3 to 9.5 mm for the other cultivars (since the receptacle is sunken). This result was higher than those found in Lebanese fruits: 0.00 to 2.03 mm for receptacle flatten position and from 3.15 to 7.93 for receptacle sunken position (Chalak et al., 2014). In addition, receptacle diameter did not change depending on maturity: 19.7 to 20.1 mm, these values were within the ranges of those found in Lebanese fruits: from 15.10 to 25.97 mm.

For the weight of fruits *Aissa* was the biggest variety (from 110.14 to 111.51g), *Dellahia* was the smallest variety (from 74.23 to 74. 77g).

The pulp increased with maturity, it ranged from 54.42 to 66.02 % for green fruits (Stage 1), from 54.81 to 66.57 % for half ripe fruits (Stage 2), and from 55.43 to 67.24 % for ripe fruits (Stage 3). At all stages of maturity, the pulp of *Dellahia* represented an important part in the composition of the fruit. These results were higher than those reported for Moroccan fruits (Elkelâa, Skhour Rhamna and Ait Bâamrane); 51.93 to 54.73 % for green fruits, from 52.80 to 55.97 % for half ripe fruits, and from 53.99 to 56.36 % for ripe fruits El-Gharras et al., 2006), and Mexican, Chilean cultivars (45 %) (Sawaya et al., 1983; Sepulveda and Saenz, 1990; Joubert, 1993) and similar to Italian cultivars (58.1-61.4 %) (Gurrieri et al., 2000).

However with advance in maturity, the percent of weight of skin decreased, it ranged from 33.98 to 45.59 % for green fruits, from 33.43 to 45.19 % for half ripe fruits, and from 32.76 to 44.57 % for very ripe fruits. These values were similar to those reported by El-Gharras et al., 2006 (40.16 to 41.83 % for green fruits, from 39.05 to 41.43% for half ripe fruits, and from 38.81 to 40.38 % for ripe fruits), and lower than those reported for Mexican and Chilean cultivars (48 %) (Sawaya et al., 1983; Sepulveda and Saenz, 1990; Joubert, 1993).

Table 3: Quantitative morphological fruit characteristics for the four cultivars studied

	Cultivars											
	Shoul			***Aissa***			***Moussa***			***Dellahia***		
Characteristics	Stade 1	Stade 2	Stade 3	Stade 1	Stade 2	Stade 3	Stade 1	Stade 2	Stade 3	Stade 1	Stade 2	Stade 3
Length (cm)	7,8	7,73	7,73	7,3	7,2	7,1	6,95	6,9	6,93	6,2	6,13	6,16
Width (cm)	4,63	4,64	4,64	4,49	4,47	4,47	4,78	4,8	4,81	5,01	4,98	4,97
Weight of whole fruit (g)	94,18	94,94	95,24	110,14	110,48	111,51	80,48	80,58	80,92	74,23	74,66	74,77
Weight of the skin (g)	42,93	42,91	42,45	46,96	46,47	46,14	35,58	35,37	34,57	25,23	24,96	24,5
Weight of the pulp (g)	51,25	52,03	52,79	63,18	64,01	65,37	44,9	45,21	46,35	49	49,7	50,27
Percentage of the skin	45,59	45,19	44,57	42,63	42,06	41,37	44,2	43,89	42,72	33,98	33,43	32,76
Percentage of the pulp	54,42	54,81	55,43	57,37	57,94	58,93	55,8	56,11	57,28	66,02	66,57	67,24
Skin thickness (mm)	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	1,9	1,9	1,9
Quantity of juice (ml)/ Fruit	37,33	44,66	39,2	47,4	56,33	50,66	32,33	38,33	34,26	34,8	38,4	35,2
Receptacle depth (mm)	9,5	9,5	9,5	9,4	9,4	9,4	9,3	9,3	9,3	2,4	2,4	2,4
Receptacle diameter (mm)	19,8	19,9	19,9	19,7	19,7	19,7	19,8	19,9	19,8	20	20,1	20,1

3.2 PHYSICOCHEMICAL ANALYSIS

The physicochemical parameters for juices of Prickly Pear fruits were presented in Table 4.

3.2.1 PH

PH was measured on prickly pear juices for the three stages of maturity. The values obtained were reported in Table 4.

According to the statistical analysis, PH differed significantly depending on the cultivars and maturity. The pH turned out to be very high, it increased with the advance in maturity, being 6.25 for green mature, 6.35 for half-ripe and 6.44 for very ripe fruits. Cactus pears are considered as a low acid food (pH>4.5) because of the extremely low content of organic acids. These data were in agreement with literature data for Mexican and Chilean cultivars, which reported that the pH is ranging from 5.5 to 6.4 (Askar and El- Samahy, 1981; Sawaya et al., 1983; Sepulveda and Saenz, 1990; Joubert, 1993; Stintzing et al., 2001). Also with the values reported for Italian cultivars (6.4- 6.5) (Gurrieri et al., 2000), and with the values reported for Egyptian cultivars (6.16-6.2) (Fatma Hassan Abd El-Razek et al., 2011 and Gamil F. Bareh et al., 2012).

These results have provided that the prickly pear juice has a pH close to neutral and relatively high compared to that of citrus fruit (orange and lemon) (Kelebek H et al., 2008).

3.2.2 ACIDITY

The total acidity was determined on prickly pear juices for the different cultivars. The obtained results were reported in Table 4, expressed as mg of citric acid / 100 g of juice. Along with the pH value, the titrable acidity decreased slightly with the maturity (Table 4). Fruits at stage 3 were less acidic (0.05 mg / 100 g of juice), being slightly different from green mature (0.059 mg / 100 g of juice) and half-ripe fruits (0.053 mg / 100 g of juice).

On average, the total acid content in the prickly pear fruits varied from 0.054 to 0.057 (mg /100 g of juice) and it did not differ significantly among the cultivars with regard to the stage of ripeness. These data were similar to these found in Egyptian cultivars: 0.05 mg /100g of juice (Fatma Hassan Abd El-Razek et al., 2011), with Moroccan cultivars: 0.055-0.06

mg /100 g of juice (El-Gharras et al., 2006), and with these reported in the literature (0.05-0.18%) (Sarbojeet Jana, 2012), but were higher than those reported in Italian cultivars (0.02%) (Gurrieri et al, 2000).

The total acid content in Moroccan prickly pear juices was very low in comparison with the acidity of other fruit juices, expressed according to monohydrate citric acid, such as pear (0.3%), orange (0.8 %), apple (0.9%), peach (0.9 %), strawberry (0.9 %), pineapple (1.1 %), raspberry (1.8 %), plum (2.2%), and apricot (2.4%) (Tateo, 1978; Belitz and Grosch, 1999).

3.2.3 MOISTURE CONTENT

The moisture of Moroccan prickly pear juices differed significantly according to the cultivars and maturity, it ranged from 86.5 to 89.3 % for green fruits, from 85.34 to 88.05% for half ripe fruits, and from 85.02 to 87.3% for very ripe fruits. It decreased slightly with advances in maturity. On average, the moisture content varied from 85.97 to 87.34 %. These data were in agreement with literature data for Moroccan prickly pear juices which reported that the moisture ranged between 85.51 and 88.13% (El-Gharras et al., 2006) and with Chilean cultivars: 84 to 90 % (Sepulveda, 1998; Saenz, 2000), also with Egyptian cultivars : 84.55 to 89.75 % (Abd El-Razek F.H and Hassan.. , 2011 and Gamil et al., 2012).

3.2.4 ASH

The results of ash analysis were reported in Table 4. It differed significantly depending on the cultivars and did not differ significantly according to the maturity.

Ash content ranged from 0.372 to 0.501% for green fruits, from 0.314 to 0.541% for half ripe fruits, and from 0.329 to 0.495 for very ripe fruits. On average, it varied from 0.404 to 0.435 %. These values are comparable to those reported for other cultivars (0, 3–1%) (Sawaya et al., 1983; Sepulveda and Saenz, 1990).

3.2.5 BRIX

The soluble solid (Brix) differed significantly according to the cultivars and maturity. It increased with maturity, its average content was lowest (13.26%) in green mature fruits, increased to (13.64 %) in intermediate stage of maturity and reached the maximum (13.98 %) in advanced maturity. The white cultivars were the sweetest (15.33-15.44%), while Shoul cultivars were the less sweet (11.74-12.58%).

In the studied varieties, total soluble solids ranged between 11.74 and 15.44 %, these values are in agreement with those reported by Bouzoubaâ et al, 2014: (13.15 and 15.87%), El-Gharras et al, 2006: (10.16 and 16.61 %), and El-Samahy et al, Saenz-Hernandez, 1995; Sepúlveda et Sáenz , 1990: (12-17 %).

3.2.6 SUGARS

The results presented in Table 4 showed that the pears under study have a high content of total sugar, as it is generally found in the majority of other fruits. The sugars contents (total sugar, reducing and non-reducing sugars) were different during different stages of maturity and as function of cultivar. They increased with maturity and reached the higher values especially in advanced maturity of fruits.

Among the four varieties studied it was possible to conclude that Dellahia and Shoul cultivars were the ones that present the higher (14.98%) and lower content of total sugars (10.5%), respectively. These results were in agreement with those reported in literature: 10-17% (Sarbojeet Jana, 2012).

At all stages of maturity, the content of reducing and non-reducing sugars was the highest in the fruits of *Dellahia*: (11.5-12.15 %) and (2.48-2.87 %) successively, it was the lowest in the fruit of Shoul variety: (8.88-9.64%) and (1.62-1.8%).

In general, the content of reducing sugar found in the cultivars under study is also in agreement to results of Piga, 2004; Dehbi et al, 2014 and Gamil et al 2012

3.2.7 VITAMIN C

The Vitamin C differed significantly according to the cultivars and the maturity. It increased with maturity, its average content was lowest (43.2 mg/100g), in green mature fruits, increased to (51.43 mg/100g) in intermediate stage of maturity and reached the maximum (57.31 %) in advanced maturity. Aissa was the variety that contains more vitamin C (52.2 – 67.66 mg/100g), while *Dellahia* was the lowest (32.56 – 47.49 mg/100g).

In the studied varieties, vitamin C ranged between 32,56 and 67.66 mg/100g fresh weight representing 36.17 %- 43.41 % of the recommended dietary intake for adult for the first one, and 75.17- 90.21% for the second ((Food & Nutrition Board, 2004).

These values were higher than those found in Egyptian cultivars: 20.07- 22.22 mg/100g (Abd El-Razek et al, 2011) (Gamil et al, 2012), and in Kenyan cultivars: 5.17 mg/100 g (Rose Chiteva and Norman Wairagu, 2013), whereas it were in agreement with those found in Italian cultivars: 31-38 mg/100g (Gurrieri et al, 2000).

Moreover, the ascorbic acid content in prickly pear on average turned out to be higher than in most common fruits such as plum (3 mg/100 g), pear (4 mg/100 g), apple (6 mg/100 g), peach (7 mg/100 g), apricot (9 mg/100 g), banana (20 mg/g), and pineapple (25 mg/100 g) (Gurrieri et al, 2000).

One of the main functions of vitamin C in food systems is to prevent oxidation, having also a positive effect on human health (DellaPenna, 1999; Grusak, et al 1999; Bliss, 1999). In view that prickly pear fruits do not undergo significant browning at room temperature, this might be a reflection of the antioxidant capacity of their vitamin C levels.

3.2.8 OIL CONTENT

The oil yield obtained varied significantly with the maturation and cultivars. For all cultivars studied, it reached the maximum in intermediate stage of maturity. These data were in agreement with literature data for Moroccan prickly pear (Mouden et al, 2012).

The white variety has the least percentage (4.89-5.47%), while Aissa has the highest percentage (11.36- 12.86%). In the studied varieties, oil percentage ranged between 4.89 and 12.86%. These values were in agreement with those found in Algerian cultivars: 7.3 – 9.3 % (Chougui et al, 2013), Moroccan cultivars: 7.79- 11.86% (Mouden et al, 2012) and Turkian cultivars: 6.96% (Coskuner and Tekin, 2003).

Compared to other oil-seed crops, the *Opuntia Ficus Indica* studied presented lower oil content. Indeed, higher amounts were recovered from cotton seeds (15–24%), soybean (17–21%), grape seeds (6–20%), olive (20–25%) (Matthäus & Özcan, 2006).

Table 4: Physicochemical analysis

	Cultivars											
	Shoul			***Aissa***			***Moussa***			***Dellahia***		
Characteristics	Stade 1	Stade 2	Stade 3	Stade 1	Stade 2	Stade 3	Stade 1	Stade 2	Stade 3	Stade 1	Stade 2	Stade 3
PH	6,22	6,33	6,44	6,21	6,31	6,43	6,2	6,32	6,39	6,39	6,45	6,5
% Moisture content	87,02	86,65	86,08	89,3	88,05	87,3	86,5	85,34	85,02	86,54	85,88	85,49
% Ash	0,372	0,345	0,329	0,479	0,541	0,495	0,391	0,314	0,409	0,501	0,419	0,45
Acidity in mg of citric acid /100 g of juice	0,059	0,059	0,057	0,059	0,059	0,056	0,058	0,057	0,054	0,053	0,053	0,05
% Brix	11,74	12,54	12,58	13,33	13,55	13,82	12,85	13,14	14,1	15,13	15,34	15,44
% Total sugars	10,5	11,22	11,44	12,4	12,63	12,8	11,85	12,29	13,5	13,98	14,85	14,98
% Reducing sugars	8,88	9,54	9,64	11,3	10,39	10,3	9,87	10,16	11,12	11,5	12,15	12,11
% Non Reducing sugars	1,62	1,68	1,8	1,1	2,24	2,5	1,98	2,13	2,38	2,48	2,7	2,87
Vitamin C (mg/ 100g)	38,15	49,89	51,29	52,2	57,67	67,66	49,89	57,51	62,5	32,56	40,67	47,89
% Fat	6,44	7,31	7,29	12,2	12,86	11,36	7,53	8,63	8,35	4,89	5,47	5,22

According to table 5, for all samples studied, the extracted oils were composed mainly of unsaturated fatty acids (UFA) (between 80.3- 84.9%) including mono-unsaturated fatty acids (Palmitoleic and oleic acid) and the poly-unsaturated fatty acid (linoleic and α-linolenic). The saturated fatty acids (SFA; palmitic, stearic and arachidic fatty acids) were detected, but at

lower rates (14.6-20.4%). These results are in agreement with those of Ramadan and Mörsel, 2003 and Tlili, et al, 2011. The ratios of SFA acids to UFA varied from 3.93 to 5.81%. In all the samples, linoleic acid was the dominating fatty acid ranging from 54.4% (*Moussa*, locality 2, Stade 3) to 63.20% (*Moussa*, locality 2, Stade 1). The fatty acid contents obtained in this study were quite similar to those found in the *Opuntia ficus indica* oil studied by Matthäus and Özcan 2011 ; Ozcan and Al Juhaimi 2011; and Chougui 2013.

For maturity effect, saturated fatty acids (SFA) increased with maturity (16.9-20.4 %), while unsaturated fatty acids (UFA) decreased (82.7- 80.3%) and consequently the ratio UFA/ SFA decreased (4.89-3.93%). For variety effect, the percentage changed from one cultivar to another, *Moussa* had the highest percentage (17.7%) for SFA while *Dellahia* had the lowest percentage (14.6%). For *Dellahia* the UFA content was highest (84.9%) and for *Moussa*, it was the lowest (81.8%).

Table 5: Fatty acids composition (Variety effect)

Fatty acid	*Shoul Stade 2*	*Dellahia Stade 2*	*Moussa Stade 2*	*Aissa Stade 2*
Palmitic acid C16:0	**13,50%**	**11,20%**	**13,1%**	**12,8%**
Palmitoleic acid C16:1	0,90%	0,70%	0,5%	0,5%
Stearic acid C18:0	3,10%	3,10%	4,3%	4%
Oleic acid C18:1	**22%**	**24,50%**	**21,5%**	**20,9%**
Linoleic acid C18:2	**59,70%**	**58,90%**	**59,1%**	**60%**
α-Linolenic acid C 18:3	0,20%	0,30%	0,3%	0,2%
Arachidic acid C20:0	0,10%	0,30%	0,3%	0,4%
Gadoleic acid C20:1	0,10%	0,50%	0,4%	0,5%
Total SFA	16,7	14,6	17,7	17,2
Total UFA	82,9	84,9	81,8	82,7
UFA/ SFA	4,96	5,81	4,62	4,8

SFA: saturated fatty acid, UFA: unsaturated fatty acid.

Table 5: Fatty acids composition (Locality effect)

Fatty acid	*Moussa Locality 2, Stade 1*	*Moussa Locality 2, Stade 2*	*Moussa Locality 2, Stade 3*
Palmitic acid C16:0	**13%**	**13,10%**	**15,1%**
Palmitoleic acid C16:1	0,50%	0,50%	0,6%
Stearic acid C18:0	3,50%	4,30%	4,8%
Oleic acid C18:1	**18,50%**	**21,50%**	**24,9%**
Linoleic acid C18:2	**63,20%**	**59,10%**	**54,4%**
α-Linolenic acid C 18:3	0,30%	0,30%	0,2%
Arachidic acid C20:0	0,40%	0,30%	0,5%
Gadoleic acid C20:1	0,20%	0,40%	0,2%
Total SFA	16,9	17,7	20,4
Total UFA	82,7	81,8	80,3
UFA/ SFA	4,89	4,21	3,93

SFA: saturated fatty acid, UFA: unsaturated fatty acid.

Table 5: Fatty acids composition (Stage of maturity effect)

Fatty acid	*Aissa locality 1 stage 2*	*Aissa locality 2 stage 2*	*Aissa locality 3 stage 2*
Palmitic acid C16:0	**12,7%**	**12,8%**	**12,8%**
Palmitoleic acid C16:1	0,60%	0,50%	0,7%
Stearic acid C18:0	3,50%	4%	3,1%
Oleic acid C18:1	**19,1%**	**20,9%**	**19,1%**
Linoleic acid C18:2	**63,10%**	**60,6%**	**62,4%**
α-Linolenic acid C 18:3	0,30%	0,20%	0,2%
Arachidic acid C20:0	0,30%	0,4 %	0,3%
Gadoleic acid C20:1	0,40%	0,50%	0,2%
Total SFA	16,5	17,2	16,2
Total UFA	83,5	82,7	82,6
UFA/ SFA	5,06	4,8	5,09

SFA: saturated fatty acid, UFA: unsaturated fatty acid.

About locality effect, the contents for *Aissa* in Satge 2 did not change a lot; it varied from 16.2 to 17.2% for SFA, and from 82.6 to 83.5% for UFA.

The essential fatty acids raised a great interest because of the health potential of poly-unsaturated fatty acids. It was considered that the fatty acids play a natural preventive role in cardiovascular diseases and in alleviation of some other health problems (Faremi & Ekanem, 2011; Hooper et al., 2001). Moreover, poly-unsaturated fats were shown to promote the reduction of both total and LDL cholesterol and a small but significant decrease in HDL cholesterol (Ajayi & Ajayi, 2009).

4 CONCLUSION

The current study revealed a large variation in the morphological and physicochemical characteristics of Moroccan prickly pear fruits for cultivars during maturation from green mature stage to ripe fruits. With advance in maturity the weight of the whole fruit and pulp, pH, Brix, vitamin C and sugars increased, while, the proportions of skin, acidity, and moisture decreased. For morphological characteristics (width, length, skin thickness, diameter and depth of receptacle), no set pattern was observed between the stages of ripeness of the fruits.

In conclusion, this investigation showed the potential value of cactus-pear fruits as a good natural source of energy, and antioxidants such as vitamin C. Based on its low acidity and high sweetness, cactus-pear pulp could be very suitable as a natural additive or substituted material in the production of many foodstuffs.

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