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Oil content and main constituents of cactus seed oils Opuntia Ficus Indica of different origin in Morocco

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Abstract. This paper describes the chemical composition of 17 oil samples obtained from cactus seeds collected from five different origins in Morocco, the major producer of cactus seed oil. The oil content of the samples varied in a relatively small range between 5.4 g/100 g and 9.9 g/100 g. The main fatty acids of cactus seed oil are oleic acid (20.5 g/100 g) and linoleic acid (62.3 g/100 g) representing 80–84% of the total fatty acids. The main component of the tocopherol fraction is gamma-tocopherol (83–90%). It is followed by alpha- and delta-tocopherol whereas beta-tocopherol is found in lower amount. In all samples beta-sitosterol was found as the main phytosterol (80.0% to 84.5%). This phytosterol is also typical for many other edible vegetable oil. This study, carried out on randomly selected samples, clearly demonstrates that origin does not have an effect on the chemical composition of cactus seed oil.

Keywords: Cactus seed oil, fatty acids, tocopherols, phytosterols, Morocco

1. Introduction

The cactus plant grows native in Mexico and has been used since thousands of years as source for food. In the 16th century the plant was introduced to North and South Africa and in the Mediterranean basin [1]. Until the 70 s, little attention has been given to this plant species, but with the development of a market for tropical fruits in Europe and the United States, efforts have increased to domesticate the plant to an industrial crop [2]. Cactus is experiencing a renewed interest in several countries due to its ecological and socio-economic importance: the fight against erosion and desertification, the production of fruits, the use as animal feed and the use in the food, cosmetic and medicinal industry. Today, cactus plants occupy an area of over one hundred thousand hectares in Morocco [3], with a national fruit production estimated as about 1.1 million tons, of which 24% in El Kelaa Sraghnas, 24% in Tiznit, 19% in Guelmim and 5% in Chtouka Aït Baha. The annual production of cactus fruits can reach 50 tons/hectare [4].

Cultivation of cactus plants offers an alternative to traditional crops such as cereals and could be an interesting opportunity for the development of the Southern regions of Morocco due to the advantages of the plants including

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the adaptation to harsh environmental conditions and the multiple uses of the products,. In this context it is important to mention that a program of valorization and development of cactus plants in the Southern Provinces of Morocco was established by the Agency. This program aims at improving the production and development of products in this sector in order to contribute and integrate rural development in these areas. Several cultivars of cactus plants exist and are distinguished by the shape of fruits (oblong or round), the flower color (yellow, orange, pink), fruit color (green, yellow, orange, pink), flowering time and organoleptic characteristics of the fruit. Cultivars *Aissa* (smooth and early), *Moussa* (smooth and late) and *Acherfi* (very thorny) are most widespread in the Moroccan landscape. In this context, several women's cooperatives, associations and groups with economic interest have been mobilized to extract oil from the seeds of altered fruits and from seeds as byproducts of the production of cactus juice. Oil from cactus seeds was studied during fruit ripening [5]. The cactus seed oil is rich in polyunsaturated fatty acids [5–7]. The oil content of seeds from variety *O. ficus-indica* (prickly pears) varies from 5.0% to 14.4% according to the Turkish varieties *Ortaören* or *Eskioba* [8].

In order to identify the properties of oil from Moroccan varieties of cactus plants, we undertook a quantitative and qualitative study of the oil obtained by Soxhlet extraction from the seeds of cactus plants harvested from the five main planting sites in Morocco.

2. Materials and methods

2.1. Sample collection

Cactus seeds were collected in 2012 from five areas of cactus plantation in Morocco (Skour Rhamna (32 °35.777428′; 55′-7 °50.3976), Chtouka Aït Baha (30 °4′8.7378; 9′-9 °10.7454), Tiznit (29 °55.640441′,-9°43′37.2714), Ait Baamran(30 °4′8, 7378; 9′-9 °10.7454) and Guelmim (28 °36.871858′; 3′-10 °38.6274).

2.2. Sample preparation

Harvesting was done randomly at each site. Fruits were brushed under water, then divided into three lots and peeled by hand. The seeds were separated from the pulp with a juice sieve lower than 1 mm diameter. The two separated fractions were weighed and then the seeds were washed under water and dried in an oven at 40°C for 12 hours. Each batch of seeds was weighted and the size of the seeds ordered by decreasing sieves, type ASM200, from 3.15 mm, 2.00 mm to 1.00 mm, by vibrating the entire column of sieves. The seed weight retained by each sieve was measured.

2.3. Oil yield

Determination of oil yield was performed following method DIN EN ISO 659. Twenty grams of ground seeds were placed in a Soxhlet apparatus and extracted with hexane for 8 h. The organic phase was then concentrated under vacuum and dried for 5 min in an oven at 105°C. After determination of the extraction yield, the oil was used for the other analyses.

2.4. Analytical methods

Fatty acid composition was determined using method ISO 5508:1990 [9]. Fatty acids were converted to fatty acid methyl esters before analysis by shaking a solution of 60 mg of oil and 3 mL of hexane with 0.3 mL of 2 N methanolic potassium hydroxide. The fatty acids were analyzed by gas chromatograph (Varian CP-3800, Varian Inc.) equipped with a FID. The column used was a CP-Wax 52CB column (30 m × 0.25 mm i.d.; Varian Inc., Middelburg, The Netherlands). The carrier gas was helium, and the total gas flow rate was 1 ml/min. The initial column temperature was 170°C, the final temperature 230°C, and the temperature was increased by steps of 4°C/min. The injector and detector temperature was 230°C. Data were processed using Varian Star Workstation v 6.30 (Varian Inc., Walnut Creek, CA, USA). The results were expressed as the relative percentage of each individual fatty acid (FA) present in the sample.

Sterol composition was determined using method ISO 6799:1991 [10]. Sterol composition was determined after trimethylsilylation of the crude sterol fraction using a Varian 3800 instrument equipped with a VF-1 ms column (30 m & 0.25 mm i.d.) and using helium (flow rate 1.6 mL/min) as carrier gas. Column temperature was isothermal at 270°C, injector and detector temperature were 300°C. Injected quantity was 1 uL for each analysis. Data were processed using Varian Star Workstation v 6.30 (Varian Inc., Walnut Creek, CA, USA).

Tocopherol composition was determined using method ISO 9936:2006 [11]. Analysis of tocopherol contents was performed by high performance liquid chromatography (HPLC), using a solution of 250 mg of oil in 25 ml of n-heptane. A Shimadzu CR8A instruments (Champ sur Marne, France) equipped with a C18-Varian column (25 cm × 4 mm; Varian Inc., Middelburg, The Netherlands) was used. Detection was performed using a fluorescence detector (excitation wavelength 290 nm, detection wavelength 330 nm). Eluent used was 99:1 isooctane/isopropanol (V/V), flow rate of 1.2 ml/min.

2.5. *Statistical analysis*

Values reported in tables and figures are the means ± SE of three replications. The significance level was set at $P = 0.05$. Separation of means was performed by Tukey's test at the 0.05 significance level.

3. Results and discussion

3.1. *Influence of seed size on oil yield*

For studying the influence of the seed size on the oil yield, seed samples from only one origin (Chtouka Aït Baha) were used. Table 1 shows the amount of oil as a function of the seed size. The results reveal a significant ($P = 0.05$) influence of the seed size on the oil yield during extraction of the seeds. The amount of oil extracted from the seeds ranged 0.3 g/100 g (seed size >1.25 mm) to 9 g/100 g (seed size >2.25 mm). This is the first time that this feature is referred to our knowledge in the case of prickly pear.

3.2. *Oil content*

The economic value of oilseeds is dependent on its oil content. The oil content of 17 samples of cactus seeds from different locations in Morocco is given in Table 2. A relatively small range from 5.4 g/100 g (Skhour Rhamna-1) to 9.9 g/100 g (Chtouka Aït Baha- 6), with a mean value of 7.8% was observed. This is in good agreement with results reported by El Finti et al. [12]. In general, the oil content of the cultivars were found within the range reported for cactus seed cultivars grown in various parts of the world, such as varieties grown in Turkey (5–14.4 g/100 g) [8]. The differences between the oil content of cactus seeds from different locations can be explained by different growing, climatic, and environmental conditions and differences between different papers are also due to different analytical conditions and localities [8]. The oil yield of cactus seeds is much lower than reported for other well-known oilseeds such as argan kernels (50 g/100 g), sesame seeds (54 g/100 g), nigella seeds (34 g/100 g), sunflower (44 g/100 g), soybean seeds (19 g/100 g) and olive fruits (20 g/100 g) [13–15]. This comparison shows that the use of cactus seeds for oil production is not useful from an economical point of view for a large scale industrial processing, but against the background of a meaningful use of the seeds from juice production the oil content of the cactus seeds is interesting for a small scale processing.

Table 1
Oil content in seeds according to their diameter

Diameter of seeds	Oil content (%)
Diameter >1.25 mm	0.28 ± 0.1
Diameter >1.80 mm	0.38 ± 0.01
Diameter >2.00 mm	2.70 ± 0.2
Diameter >2.25 mm	9.16 ± 0.5

Table 2
Origin and oil content of 17 samples of cactus seed oils

	Origin names of samples	Sample	Yield (%)
Skhour Rhamna	Hadian Douar	1	5.4 ± 0.1
	Centre	2	6.4 ± 0.2
Chtouka Aït Baha	ChtoukaAït Baha (Imimkourane)	3	8.3 ± 0.2
	Chtouka Aït Baha (Chtouka ait baha)	4	8.1 ± 0.1
	Chtouka Aït Baha (Imaich)	5	8.2 ± 0.2
	Chtouka Aït Baha (Targountouchka)	6	9.9 ± 0.3
Tiznit	Tiznit (Boumzir mir left)	7	8.5 ± 0.5
	Tiznit (Ihdaren)	8	7.7 ± 0.3
	Tiznit	9	8.1 ± 0.2
	Tiznit (Boutslaft)	10	8.2 ± 0.2
	Tiznit (Izgaden)	11	9.11 ± 0.1
Ait Baamran	Ait Baamran (Mesti Amalou)	12	7.6 ± 0.2
	Ait Baamran (Mesti Begato)	13	7.3 ± 0.2
	Ait Baamran (Sbouyalhouafi)	14	6.7 ± 0.3
Guelmim	Guelmim (Rass Amlil)	15	7.9 ± 0.13
	Guelmim (Ferket)	16	5.8 ± 0.3
	Guelmim (Asrir)	17	8.7 ± 0.1
Mean Value			7.8
Standard deviation			1,2

Table 3
Fatty Acid Composition (g/100 g) of Seeds Oils from *Opuntia focus indica* from Different Origin

	Fatty acid composition (g/100 g)									
Sample	*C14:0*	*C16:0*	*C16:1*	*C18:0*	*C18:1*	*C18:2*	*C18:3*	*C20:0*	*SFA*	*UFA*
1	0.1	12.3	0.7	3.4	20.4	61.8	0.3	0.3	16.4	83.4
2	0.1	12.4	0.7	3.5	20.8	61.9	0.2	0.2	16.4	83.8
3	0.1	11.9	0.7	3.4	21.5	61.3	0.3	0.3	15.9	84
4	0.1	11.8	0.7	3.5	22.3	60.5	0.2	0.3	15.9	84
5	0.1	12.2	0.7	3.4	19.2	63.4	0.3	0.3	16.2	83.8
6	0.1	11.7	0.7	3.5	22.6	60.2	0.3	0.4	15.9	84
7	0.1	12.4	0.6	3.1	18.2	64.6	0.3	0.3	16.1	83.9
8	0.1	12	0.6	3.1	20.2	62.9	0.3	0.3	15.7	84.2
9	0.1	12.1	0.7	3	20.5	62.5	0.3	0.3	15.7	84.2
10	0.1	12	0.6	3.4	18.3	64.4	0.3	0.3	16	83.8
11	0.1	12	0.7	3.2	20.2	62.7	0.3	0.3	15.8	84.1
12	0.1	11.9	0.7	3.3	21.3	61.5	0.3	0.3	15.8	84
13	0.1	11.9	0.7	3.4	21.3	61.4	0.3	0.3	15.9	83.9
14	0.1	12	0.6	3.2	19.6	63.3	0.3	0.3	15.8	84
15	0.1	11.6	0.6	3.3	21.1	62.1	0.3	0.3	15.5	84.3
16	0.1	12	0.7	3.6	19.9	62.5	0.3	0.3	16.3	83.6
17	0.1	11.7	0.7	3.2	20.7	62.3	0.3	0.3	15.5	84.2
MV	0.1	12.0	0.7	3.3	20.5	62.3	0.3	0.3	15.9	84
SD	0	0.2	0.05	0.2	1.2	1.2	0.03	0.05	0.45	2.5

3.3. Fatty acid composition

The fatty acid (FA) composition of the oil is an essential indicator for its nutritional value [16, 17]. Table 3 shows the fatty acid composition of the 17 cactus oil samples. The main fatty acids of the cactus oil are palmitic acid (11.6–12.4 g/100 g), oleic acid (18.2–22.3 g/100 g) and linoleic acid (60.2–64.6 g/100 g). They represent 95% of all the fatty acids. The variation of the three main fatty acids of the seeds from different locations was relatively low indicating that the location has only a small influence on the composition of the fatty acids. These results differ from those reported by Ramadan and Mörsel [6], Coskuner and Tekin [5] who showed that the fatty acid composition of cactus plants grown at different locations were significantly different from each other. It is well known that the fatty acid composition of cactus seeds is strongly influenced by climatic factors, soil type in which they are grown [6]. Similarly, genetic factors may be involved.

With respect to the fatty acid composition cactus seed oil belongs to the oleic-linoleic acid group. Unsaturated fatty acids amount to about 83.0%, also with a relatively low variation. Linolenic acid is only a minor component with a concentration less than 0.3 g/100 g. The small content of linolenic acid can be used to detect adulteration of cactus oil with other oils rich in linolenic acid such as rapeseed oil and soybean oil.

Other fatty acids such as palmitoleic acid (C16:1), arachidic acid (C20:0), gadoleic acid and behenic acid (C22:0) were found only in small amounts.

3.4. Phytosterol composition

Phytosterols are structurally similar to cholesterol and they are found naturally in plant seeds. The composition and the content of these compounds are very useful parameters for detecting adulterations or to proof authenticity, since it can be considered as a fingerprint of the oil. Besides, phytosterols are of major interest due to their antioxidant activity and impact on health [16, 18]. No significant difference was observed as result of the different geographic origin of the cactus seeds (Table 4). The main phytosterol of catus seed oil is β-sitosterol representing 79.1% of the total sterol fraction. Indeed, this phytosterol can also be found in many other vegetable oils, such as soybean oil,

Table 4
Sterol composition (Weight Percentages) of cactus seed oils from different geographical origin

Samples	Cholesterol	Campesterol	Stigmasterol	ß-Sitosterol	delta-5-Avenasterol	delta-7-Stigmasterol	delta-7-Avenasterol
1	1.3	10.5	2.8	78.2	4.7	0.7	0.8
2	1.2	9.5	2.3	79.2	5.4	1.5	0.8
3	1.2	10.5	2.4	78.4	5.6	0.5	0.2
4	1	10	2.2	80.4	4.7	0.3	0.2
5	1	9.3	2.1	79.9	5.3	0.5	0.3
6	1.3	13.1	1.8	77	5.5	0.9	0.5
7	1.2	8.6	2.5	81.8	3.6	0.6	0.8
8	1.2	9	3	77.8	6.7	0.8	0.6
9	1.2	9.7	2.9	78.4	4.8	1.5	0.8
10	1.2	9	3.1	79	5.3	0.7	0.8
11	1.1	9.3	2.4	80.6	4.8	0.4	0.2
12	1	11	2.6	75.9	4.8	0.6	0.9
13	1	10	2.2	80	5.2	0.8	0.4
14	1.2	9.3	2.6	78.2	6	1.4	0.8
15	0.9	10.6	2.5	78.9	5.2	0.6	0.1
16	1	8.9	2.3	81	5	0.9	0.4
17	13	11.3	2.2	79.3	3.6	0.7	0.8
MV	1.1	10.0	2.5	79.1	5.1	0.8	0.6
SD	0.1	1.1	0.3	1.5	0.8	0.4	0.3

Table 5
Tocopherol contents (Weight Percentages) of cactus seed oils from different geographical origin

	Tocopherol (%)			
Samples	α-Tocopherol	β-Tocopherol	γ-Tocopherol	δ-Tocopherol
1	2.0	0	87.70	10.30
2	1.9	0	89.6	8.5
3	1.4	0.2	87.9	10.5
4	2.5	0	86.5	10.9
5	1.6	0	90.5	7.9
6	1.8	0.2	88.5	9.5
7	2.1	0	88.9	9
8	1.5	0	89.5	9
9	2.2	0.1	91.2	6.5
10	1.4	0	87.9	10.7
11	1.6	0	88.9	9.5
12	1.5	0.3	89.1	9.2
13	1.9	0	90.8	7.3
14	1.3	0	88.8	9.9
15	1.4	0	89.4	9.2
16	2.5	0	89.5	8
17	1.30	0	91.70	7.10
Mean value	1.8	0.0	89.2	9.0
SD	0.4	0.1	1.3	1.3

sunflower oil or olive oil [13, 19]. It is interesting to note that cactus seed oil is rich in β-sitosterol which has been shown to inhibit the absorption of dietary cholesterol [20]. Other sterols with some importance for human health [21] are campesterol (10.0% of the total sterols), delta-5-avenasterol (5.1%), and stigmasterol (2.5%). The variation of the total amount and the individual sterols is small. Minor sterols were cholesterol (1%), delta-7-stigmasterol (0.8%), and delta-7-avenasterol (0.6%).

3.5. Tocopherol composition

Tocopherols are natural occurring antioxidants with some biological activity [22, 23]. A specificity of cactus seed oil is the high content of total tocopherols [8, 13, 24]. The major tocopherol of cactus oil is gamma-tocopherol, representing an average of 90% of total tocopherols, compared with delta-tocopherol (9%) and alpha-tocopherol (1.8%). beta-tocopherol was not found (Table 5). These results are in agreement with the findings of other authors [8]. Cactus seed oil, argan oil and sesame oil are the richest source of γ-tocopherol [25, 26], while alpha-tocopherol is the major compound in olive oil [27, 28]. Tocopherol compounds are also used in food, cosmetics and pharmaceutical industries [29]. Alpha-tocopherol is recommended for human and animal consumption because it has a higher biological activity than other tocopherols, but gamma-tocopherol shows a higher antioxidant capacity as compared to alpha-tocopherol [28].

4. Conclusion

In the context of the evaluation of cactus seed oil, we conducted a comparative study of different analytical parameters of cactus seed oil according to its original production. To accomplish this work, we selected 17 samples of cactus seeds obtained from different geographical locations in Morocco.

Fruit pulp may provide low yields of oil, but it is a rich source for essential fatty acids, phytosterols, and tocopherols. These parameters showed no significant variation with reference to the different geographical origin. In fact, in this study the origin does not affect the quality of the cactus seed oil. The composition of Moroccan cactus seed oil, as well as other desirable characteristics, makes this oil a suitable ingredient in pharmaceutic, nutraceutic and cosmetic domains. Moreover, our study demonstrates the high quality of cactus seed oil and the results of this work may contribute to the development of a national or international standard for cactus seed oil.

Conflict of interest

The authors declare that there is no conflict of interest among them in this manuscript

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