ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Nutritive and Anti-Nutritive Composition of Moroccan *Opuntia ficus indica* Cladodes and Fruits.

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ABSTRACT

Opuntia ficus indica is a species of *cactaceae* family that grows in arid and semi-arid region. The fruits and cladodes are consumed by the Moroccan population. There are fewer studies on the nutritional aspect of this plant, the objective of this work was to determine the nutritional and anti-nutritional composition of cladode, seed and skin. The analysis included those for: humidity, ash and insoluble ash contents, crude protein, crude fat, total carbohydrate, fiber, phytate, saponin, steroid, oxalate, alkaloid, cyanide and mineral contents were obtained by standard methods. The results show that prickly pear seeds are nutritionally interesting and differ from other matrices (skin and cladode respectively), mainly in: fat, carbohydrate, cellulose, copper and zinc contents **(**50.90±0.10 g/kg, 772.50±1.90 g/kg, 428.90±0.60 g/kg, 48.10±0.52 mg/kg and 21.60±2.43 mg/kg dry matter respectively)**.** The anti-nutritional contents of seeds are low than that skin and cladode. All matrices showed minor anti-nutritive contents this study. The seeds have promising economic value. The challenge is to find way to incorporate them into existing food products, moreover to create new products from them.
Keywords: *Opuntia ficus indica*, fruit, cladode, nutritive, anti-nutritive

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INTRODUCTION

Opuntia ficus-indica (L.) Mill., Commonly known as prickly pear or nopal cactus belongs to the family of *Cactaceae* broadleaf angiosperms, a family which includes about 1500 species of cactus. *OFI* is a tropical and subtropical plant. It can grow in arid and semi-arid with a geographical distribution covering Mexico, Latin America, South Africa and Mediterranean countries [1-3].

Various parts of the cactus like cladodes and fruits were used for therapeutic purposes to treat ulcers [4], inflammations [5], type 2 diabetes [6] and bacterial infections [7] . We found in the literature that the cladodes and fruits contain phytochemicals [8], antioxidants, dietary fiber and minerals [9-11].

Several studies cactus fruit and cladode give nutrient contents such as betalains, amine compounds including taurine, minerals, vitamins and antioxidants; *Opuntia ficus indica* is now increasingly used as a first important natural material for the production of nutraceuticals [12, 13].

The objective of this work is to give an approximate composition of the seeds, skins and cladodes followed by the impact of nutrients and anti-nutrients on consumers.

MATERIALS AND METHODS

Sample preparation

Fruits and cladodes were collected during the month of October 2015 of Temara region (Morocco). All samples were extensively washed with distilled water. The skin and seeds were separated from the fruit pulp and washed in distilled water. After drying, the plant materials were reduced to fine powder in an electric grinder.

Chemical approximate analysis [14]

The chemical analysis was carried for seeds, skins and cladodes. This included humidity, ash and insoluble ash, crude protein, crude fat, total carbohydrate and dietary fiber. Analyses were done in triplicate according to the AOAC techniques. The evaluation of the samples was performed using specific methods for different components.

The humidity content of the resulting samples was determined by desiccation at 40°C for 24h, according to the 934.01 method as described in the AOAC techniques.

Ash and insoluble ash contents was evaluated with the 942.05 method, using 1.0 g samples, determined at 550°C for 24h in order to remove organic material. The samples were placed in shallow, broad ashing dishes that had been ignited. The samples were cooled in a desiccator, and weighed once they reached room temperature.

Protein content was calculated from the nitrogen content (%Nx6.25) analyzed by kjeldahl method 2001.11 of AOAC, using a 5g sample.

Fat was analyzed by petroleum ether extraction using a 3.0 g sample by soxhlet apparatus according to the 920.39 AOAC method.

The carbohydrate extract, was determined by calculating the differences in 100g of all the components using AOAC official method 986.25. Dietary fiber was determined according to the 991.42 and 920.39 AOAC methods.

Anti-nutrients analysis.

Phytate, oxalate and cyanide determination were done using the method described by Ogbe [15]. Spectrophotometric methods described by Obadoni [16] were used to determine the steroid and saponin contents. Alkaloid was analyzed using the method described by Davidson [17].

ISSN: 0975-8585

Mineral composition

150 mg of sample were mineralized using 2 ml of nitric acid (70%), 3 ml of hydrofluoric acid and 2 ml of hydrochloric acid. The mixture was boiled at 100-110°C for 15 hours. After cooling, 25 ml of hydrochloric acid solution were added to the mixture. After that, the mineral contents of *OFI* matrices (seeds, skins and cladodes): lead, cadmium, arsenic, mercury, copper, zinc and selenium were determined using the atomic absorption spectrophotometer, described the methods of the association of Official Analytical Chemists method 984.27 [18]. All the determinations were done in triplicates.

Statistical Analyses

Analysis of variance (ANOVA) was performed on each treatment method significance level of p <0.05, using a SPPSS 13.0 software to compare the difference between the means. The data obtained by chemical analysis of the samples were expressed as mean ± standard deviation. All analyses were carried out in triplicates.

RESULTS

The results of this study (Table1) showed that the humidity content of the seed, skin and cladode ranging between 96.00 and 155.40 g/kg. The ash was ranged from 15.70 to 238.20 g/kg and insoluble ash from 0.10 to 0.50 g/kg. The crude protein content from the various matrices ranged between 40.10 and 75.20 g/kg. Crude fat was found in the range of 2.40-50.90 g/kg. Total carbohydrate contents were found between 525.60 and 772.50 g/kg. The results (Table 1) showed significant differences (P<0.05) of all analysis.

Table 1: chemical composition of *Opuntia ficus indica* (gram/kilogram of dry matter)

	Seed	Skin	Cladode
Humidity	96.00±0.20	152.50±0.30	155.40±0.10
Ash	15.70±0.30	200.40±0.70	238.20±1.60
Insoluble Ash	0.50±0.10	0.20±0.10	0.10±0.10
Crude protein	63.50±0.50	40.10±2.90	75.20±5.80
Crude fat	50.90±0.10	2.40±0.20	5.80±0.10
Total carbohydrate	772.50±1.90	604.20±2.10	525.60±3.80

Mean±standard deviation ; n=3

In the table 2, the pectin content varied from 4.50 to 86.10 g/kg and the cellulose content ranged from 80.10 to 428.90 g/kg of dry matter. Statistically significant differences were found in the pectin (P⩽0.01) and cellulose (P< 0.05) content of the analysed.

Table 2: dietary fiber contents of *Opuntia ficus indica* (gram per kilogram of dry matter)

	Seed	Skin	Cladode
Pectin	4.50±1.90	86.10±11.40	52.20±2.60
Cellulose	428.90±0.60	80.10±0.10	217.10±0.50

Mean±standard deviation ; n=3

Table 3: anti-nutrient contents of *Opuntia ficus indica* (milligram per kilogram)

	Seed	Skin	Cladode
Phytate	9800±800	34200±2500	24900±800
Steroid	566.60±13.20	2434.20±49.30	1504.40±66.00
Saponin	20400±200	63600±100	87200±100
Oxalate	ND	ND	ND
AlKaloïd	ND	ND	ND
Cyanide	ND	ND	ND

ND : Not detected, Mean±standard deviation ; n=3

According to table 3, the levels of phytate in the samples ranged between 9800 to 34200 mg/kg. Steroid was found in the range of 566.60-2434.20 mg/kg of dry matter, saponin varied from 20400 to 87200 mg/kg in the analysis. Statistically significant differences were found in the total content ($p < 0.05$) of all tests.

The mineral contents in this study of the seeds, skins and cladodes are given in Table 4. According to the results, Pb, Cd, Cu, Zn and Se were found in the tested samples. by against As and Hg haven't been detected by the technique used. Lead content ranged from 0.02 to 0.62 µg/g. The level of Cadmium changed from 0.04 to 0.05 µg/g. While the copper content ranged between 1.11 and 48.10 µg/g, Zinc contents were found between 1.75 and 21.60 µg/g, Selenium had a content of between 8.40 and 26.30 µg/g.

Table 4: Mineral contents of *Opuntia ficus indica* (in milligram per kilogram of dry matter)

	Skin	Cladode	Seed
Pb	0.62±0.03	0.03±0.01	0.02±0.01
Cd	0.45±0.02	0.05±0.01	0.04±0.02
As	ND	ND	ND
Hg	ND	ND	ND
Cu	48.10±0.52	1.23±0.04	1.11±0 .03
Zn	21.60±2.43	3.35±0.05	1.75±0.01
Se	11.20±1.36	26.30±2.21	8.40±1.32

ND : Not detected, Mean±standard deviation ; n=3

Table 5: comparative study of mineral contents of *Opuntia ficus indica* seed, skin and cladode (in milligram per kilogram of dry matter)

Mineral	This study			Litterature					
	Seed	Skin	Cladode	Seed [24]	Seed [25]	Seed[26]	Seed [14]	Cladode[27]	Skin [14]
Cu	1.11±0.03	48.10±0.52	1.23±0.04	10.3	-	2.1±0.7	<8.3	0.49 ± 0.30	<8.5
Zn	1.75±0.01	21.60±2.43	3.35±0.05	707.7	4.30±0.99	3.2 ±0.3	41.6	2.04 ± 1.05	17
Pb	0.02±0.01	0.62±0.01	0.02±0.01	-	-	-	-	-	-
Cd	0.04±0.02	0.45±0.02	0.05±0.01	-	-	-	-	-	-
As	ND	ND	ND	-	-	-	-	-	-
Hg	ND	ND	ND	-	-	-	-	-	-
Se	8.40±1.32	11.20±1.36	26.30±2.21	-	-	-	-	-	-

-: empty space

DISCUSSION

In our samples the humidity content in the dry matter of seeds was lower than those the skin and cladode. This phenomenon can be explained by the hygroscopic property due to exposure to air before passing to the loss on drying. This observation is much felt in the cladodes with a higher content.

After matrices ignition at 550°C, the cladode gave the highest ash content than skin and seed. Comparing to other work the ash content in the seed is less than the value found by Kossori of France (5.90 ± 1.25%); by against, the ash value of skin is higher than the level achieved in the matrix of the same author (12.1 ± 1.46) [19]. The work by özcan of Turkey on seeds gave a ash content (1.27 ± 0.03%), this result is similar to our study [20] ; Hernandez-Urbiola of Mexico obtained a ash content (24.30%) in older cladodes (135 days) similar this study [21]. These results of variations may be due to the geographical location of matrix, climate and land ownership. These ash contents found in the seeds, skin and cladode were indicated that the investigated samples contain nutritional reserves in minerals.

The protein content found in the seed and skin was less than the result obtained by studying of kossori *et al*. 11.8% ± 1.17 and 8.30 ± 0.90% respectively [19] ; but similar the result of Hernandez-Urbiola *et al.* obtained in the cladode (7.07%) [21] ; against greater than the value obtained by Ozcan *et al.* in the seed (4.78 ± 0.6%) [20]. The essential function of a food protein is to meet the needs of the body nitrogen and amino acids. The quality of protein depends of its composition of essential amino acids. The vegetable protein is involved in energy intake and in supplementation of essential amino acids. The lipid content in the seed of our study was similar to that found by Kossori of France (6.77 ± 0.51%) and Ozcan of Turkey (5.0 ± 0.9%). The daily intake of lipid rich in polyunsaturated fatty acids contributes to improving our nutritional system. Essential fatty acids are essential for the maintenance of cells in the body, protects the nervous system and also help fight against bad cholesterol.

Total carbohydrates otherwise called carbohydrates are stored as starch in plants. They act as natural laxatives, facilitating digestion and are the primary source of energy used by the body. The diversity of consumed carbohydrates provides the body glucose to maintain blood levels for the function of the central and peripheral nervous system, but also dietary fiber. It is also a food source for colon health [22]. Carbohydrate in the cladodes rate was lower than the value found of the study by Hernandez-Urbiola Mexico (60.77%). This content is obtained by deduction in 100g of dry matter the proportion of moisture, protein, lipid and ash. The insoluble ash content of the study is very low. This observation can justify the lack of land in our samples.

The composition in soluble and insoluble fiber has been shown in Table 2. The pectin content was higher in the skin than in the seed and cladode. In the study conducted by Kossori on the skin and seed (7.71 ± 1.45% and 6.69 ± 0.46% respectively), there was a similarity with our results. Always in the study of Kossori, cellulose contents in the seed and skin were 83.2±0.25% and 71.4 ±1.99% respectively, these values were much higher than our results. Dietary fibers are beneficial for health and have become a phytochemical source. In recent years, the fiber is considered to be the most important nutrient, especially in the prevention of obesity, which is an epidemic disease worldwide [23]. Dietary fiber is categorized into soluble and insoluble fibers. The distinction is due to the chemical properties of sources fiber and analytical quantification; it does not necessarily reflect the physiological effects. The definition also includes lignin fibers and other related compounds that are intrinsic and intact in the wall of the plant cell. Insoluble fiber reaches the colon, largely unchanged and is not fermented by bacteria. The water retention characteristics of the insoluble fiber are high, therefore, lead to high peristaltic action, which increases the moving speed of the colon contents. This reduces the transit time through the gastrointestinal tract, and contribute to overall laxative effect [24, 25]. In the large intestine soluble fiber is urged by the bacterial flora. Multiplying the bacterial flora increases the mass and the water content of the stool. In addition, diets high in fiber promotes chewing, which slowing both the eating process and increases the flow of saliva; this contributes to satiety and maintenance of dental health. Dietary fiber moving through the small intestine and bile acid; divalent cations such as calcium, zinc and iron are bonded to the fiber surface, which can reduce their absorption. The result of anti-nutritional factors was presented in Table 3. The phytate and steroid contents in the seed are less than the results of skin and cladode. These compounds decrease the nutritional value of the matrix. Anti-nutritional factors are compounds that reduce the use of nutrients and/or food intake of plants or plant products used for human consumption such as proteins, vitamins and minerals. They play a critical role in determining the use of plants for human use. The Phytate operate over a wide pH range, and therefore its presence in the feed has a negative impact on the bioavailability of divalent and trivalent ions, such as Zn^{2+} minerals, $Fe^{2+} / ^{3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+} and Cu^{2+} [26].

The saponin content in the cladodes is greater than the value obtained in the seed and skin. High saponin content in the feed can be used in the inhibition of dental caries, platelet aggregation, treatment of hypercalcemia in humans, and as an antidote against acute lead poisoning. In epidemiological studies, saponins gave an inverse relationship to the incidence of kidney stones. The methods used for the analysis of the oxalate, alkaloid and cyanide did not reveal the presence of these elements in our samples. This phenomenon may be due to the sensitivity limit of the method used. The data on characteristics indexes are shown in Table 4. According to the Codex Alimentarius, oils are classified as non-drying oils (iodine number less than 100 and refractive index between 1.467 and 1.472), semi-drying oils (100 <iodine <130, 1,470 <refractive index <1.478) and drying oils (iodine value> 130 and 1,481 <refractive index <1.482). The standard of the acid value is less than 4 mg of potassium hydroxide / g and that of the peroxide value is less than 10 meq per kg of oil. Comparing these standards codex found in our values, we found that our oil is in good condition. This oil can be used in the food system without risk. cactus pear oil is deemed rich in omega 6 by Ghazi *et al.* [27]. A diet rich in omega-6 modifies physiological state: increased blood viscosity, vasospasm, vasoconstriction and decreased bleeding time [28].

The comparison of mineral of the seed, skin and cladode with other studies is given in Table 5. The results of this study showed that all the matrices in this study were rich in selenium whose cladode was three times richer than the seed and twice as rich as the skin. In addition, the skin was rich in copper and zinc. The presence of insignificant quantity of lead and cadmium shows the nutritional quality of our samples. Comparing our results with those of the literature, the seed gave a grade copper and zinc similar to that of Özcan and al. (2011) [20] (2.1 ± 0.7 mg / kg and 3.2 ± 0.3 mg / kg respectively). The similarity is also observed at the value obtained in copper (4.30 ± 0,99mg / kg) of the study of Al-Juhaimi and Özcan (2012) [29]. There is a difference with the values found by Ghazi *et al.* [30] (10.3 mg / kg and 707.7 mg / kg) and Kossori *et al.* [19] (<8.3 mg / kg and 41.6 mg / kg) Respectively. They have found high levels. The skin showed copper in an amount five times higher than the value (<8,5mg / kg) found by Kossori *et al* (1998); against by the similarity exists at the zinc (17 mg / kg). Copper and zinc grades obtained by Méndez *et al.* [31] (0.49 ± 0.3 mg / kg and 2.04 ± 1.05 mg / kg respectively) were similar to those of the study. The difference in content of inorganic compounds by various authors from different countries can be due to the geographical location of the plant, growing conditions, use of fertilizers, irrigation, climate and genetic affiliation [27, 32]. Zinc is an essential trace element for all living organisms [33]. He acts as a cofactor and is part of the constitution of several enzymes and proteins [27, 34].

Three trace elements whose copper and selenium may have a negative impact on mechanical skeletal tissues and could jeopardize skeletal health due to inadequate intake [35].

CONCLUSION

The chemical and mineral compositions of samples of *Opuntia ficus indica* were different according to matrix. All samples were rich in protein, carbohydrate, cellulose and selenium. Only the seed gave a high content of lipid. Due to the cellulose content, the seeds and cladodes can be used as a source of dietary fiber. Through our study and information from the literature, *Opuntia ficus indica* can be a good source of macro and micro minerals, and consumed as a food ingredient to support human nutrition.

ACKNOWLEDGMENTS

The authors are very grateful to University Mohammed V (pharmacognosy laboratory and galenic preparations laboratory for their contribution this work).

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