

Nutritional Value of Cladodes and Fruits of Prickly Pears (*Opuntia ficus-indica*)

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ABSTRACT

Prickly pear (*Opuntia ficus-indica*), have been used for centuries as food and forage resources. The purpose of this study was to assess some of the nutritional value of their cladodes and fruit. Fruit juice contained phenolic compounds concentration of 119.66 and 123.56 mg/100 g and antioxidant activity of 40.38% and 39.18 %, respectively. Appreciable amounts of vitamin C being 15.94 and 26.76 mg/100 g, and the amount of vitamin E were 1.37 and 96.80 µg/100 g, respectively. Regard to vitamin D, it was not detected in the cladode while the fruit contained 1.40 µg/100 g. The amount of beta-carotene (β-carotene) were 57.51 and 28.01 µg/100 g for cladodes and fruit, respectively. The major fatty acids of the cladode and fruit were unsaturated fatty acids, mainly linoleic acid (omega-6), linolenic acid (omega-3) and oleic acid (omega-9). The main identified saturated fatty acids were palmitic and stearic acids. The present study demonstrated that cladodes and fruits of prickly pears can be considered as functional food due to their valuable contents of fibers, vitamins, fatty acids, phenolic compounds and antioxidants.

Key words: prickly pears, fruit, antioxidant activity, vitamins, fatty acids, phenolics.

INTRODUCTION

Environmental changes are one of the major challenges facing the world nowadays and in the future. Many countries, especially in Africa and Asia, are facing extended droughts and desertification. To overcome these circumstances, the crops have to survive water scarcity, elevated temperatures and inadequate soils. (Inglese *et al.*, 2017). *Opuntia* species are known to have an extraordinary capacity to store water and great capacity to withstand extreme environments established to be stressful for most plant species. They are widely used to prevent soil erosion and to combat desertification. Furthermore, it can deal with global environmental changes such as the elevation in atmospheric CO₂ levels. *Opuntia* species have been used for centuries as food and forage resources and in traditional folk medicine for their nutritional properties and their benefit in chronic diseases. Additionally, they have been cultivated as ornamental plants (Scalisia *et al.*, 2015, Slimen *et al.*, 2016, Díaz *et al.*, 2017).

Prickly pears belong to the dicotyledon angiosperm *Cactaceae* family. Prickly pears is a tropical and subtropical plant, it can grow in dry climates, it is geographically distributed in Mexico, South Africa and Mediterranean countries including Egypt (El-Mostafa *et al.*, 2014). Two parts of the plant are consumed as food: the fruits and the nopal pad or cladodes (Osuna-Martínez *et al.*, 2014). Prickly pears are a beneficial source of dietary fibers and bioactive phytochemical compounds, they can be consumed as an essential source of natural antioxidants therefor it is considered a functional food. Their antioxidant activity can guard against the oxidative cellular damage (Osuna-Martínez *et al.*, 2014).

Prickly pears have been traditionally used for their medicinal values, such as controlling diabetes, arteriosclerosis, asthma, burns and gastritis (López-Romero *et al.*, 2014, Hwang *et al.*, 2017). Epidemiological studies have demonstrated that regular consumption of plant-based food has the

ability to become the future of primary prevention of many chronic diseases related to oxidative stress (Feugang *et al.*, 2006, AbdEl-Razek & Hassan, 2011).

Nutritional constituents of prickly pears vary in different countries, these variations may be due to geographical location, soil, climatic conditions and maturation (Chinedu *et al.*, 2017). The purpose of the current study was to highlight the nutritional value of cladode and fruit prickly pears cultivated in Egypt.

MATERIALS AND METHODS

The experimental study was conducted at the Nutrition Laboratory, High Institute of Public Health, Alexandria University, Egypt.

Plant Materials and Preparation

Cladodes and fruits of prickly pears were purchased from a local market in Alexandria, Egypt during the summer season. Cladodes were washed, thorns were removed and crushed by a grinder then squeezed using muslin cloth to produce the extract (Galati *et al.*, 2003). The whole fresh fruits were sorted, washed with tap water, manually peeled then the juice was extracted from the whole edible pulp using a food processor and strained with no addition of water (Abd El-Razek & Hassan, 2011).

Chemical analysis

Proximate composition

Moisture, total ash, crude protein, crude fat, crude fiber and total carbohydrate (calculated by difference) contents of prickly pears cladode extract and fruit juice were determined according to the methods described by the Association of Official Analytical Chemists (AOAC., 2005).

Total phenolic content

Prickly pears cladode extract and fruit juice samples were extracted with 80% acetone using a sonication bath for 25 min. The resultant solution was centrifuged for 10 min at 6040 xg and the supernatant was used. The total phenolic content was estimated according to the Folin–Ciocalteu method according to the method described by Pakade *et al.* (2013). Gallic acid was used as the calibration standard and the results were recorded as gallic acid equivalents (mg/100 g of extract).

Total antioxidant activity

The DPPH (2,2-diphenyl-1-picryl-hydrazyl-hydrate) free radical scavenging activity assay was estimated by the method described by Pakade *et al.* (2013), the results were reported as a percentage of the DPPH concentration left in solution. Ascorbic acid was used as a positive control.

Vitamins content

The samples of prickly pears cladodes extract and fruit juice were homogenized with an extracting solution containing meta-phosphoric acid and acetic acid. The extracts were used to estimate the vitamin C content using High Performance Liquid Chromatography (HPLC) analytical assay, Hewlett Packard HPLC series 1100 with acetonitrile-water (50:50) as the mobile phases with flow rate of 1.5 ml/min, the detection was done at 254 nm according to the method described by Ismail & Fun (2003). Vitamin C content was expressed as mg/100 g.

Vitamins E, D and β -carotene contents in prickly pears cladode extract and fruit juice, extracted using *n*-hexane. The extracts were used for determining vitamins E, D and β -carotene using HPLC analytical assay according to the method described by Qian and Sheng (1998) and Kozlov *et al.* (2003). Vitamins E, D and β -carotene contents were expressed as μ g/100 g.

Fatty acid profile

Methanolic sulphuric acid and benzene were used for lipid methylation. Fatty acid profile of prickly pears cladodes extract and fruit juice were determined according to the method of Egan *et al.* (1981) using Gas Liquid Chromatography (GLC) analytical assay by Hewlett Packard (HP) 6890 GC, with Flame Ionization Detector (FID). The column phase was HP-88 (88%-Cyanopropyl-aryl-polysiloxane), 100 m, 0.25 mm ID, 0.2 μ m film thickness, Nitrogen was used as a carrier gas with flow rate of 1 ml/min. The injector temperature was 220°C. The results were expressed as fatty acids percentages. Finally, the calculated sums and ratios were; total monounsaturated fatty acids content (Σ MUFA), total polyunsaturated fatty acids content (Σ PUFA), total unsaturated fatty acids content (Σ UFA), total saturated fatty acids (Σ SFA), Σ PUFA/ Σ SFA (P/S) ratio, Σ UFA/ Σ SFA ratio and ω -6/ ω -3 ratio.

Statistical analysis

Data were fed to the computer using IBM SPSS software package version 20. Quantitative

data were described using mean and standard deviation (mean \pm SD). (Ali and Bhaskar, 2016)

RESULTS AND DISCUSSION

Proximate composition

The results in Table (1) show the proximate composition of prickly pears cladodes and fruits. The moisture content of the cladodes extract was 87.01% which is within the range reported by the Food and Agriculture Organization (FAO, 2001) as 80–95%, and agreed well with the results of Snyman (2004) and Díaz *et al.* (2017). Conversely, Méndez *et al.* (2015) and Rocchetti *et al.* (2018) reported slightly higher moisture content as 92.33% and 94.0%, respectively. The moisture content of the fruit juice was 88.6% which is within the range reported by Feugang *et al.* (2006) as 84% - 90%, this value agrees with the results reported by Bariza *et al.* (2017) as 87.07 %. A lower value of 82.2% was obtained by Medina *et al.* (2007).

The ash is an indicator of the mineral contents. Minerals play crucial roles in the body as increasing metabolic processes and enhancing growth and development (Otuna *et al.*, 2016). The ash content of the cladode extract as shown in Table (1) was 2.97%. This value is higher than that reported by El-Safy (2013) and Rocchetti *et al.* (2018) as 1.85% and 0.50%, respectively. On the other hand, this value is slightly lower than the content of 3.33% reported by Chinedu *et al.* (2017). The total ash content in the fruit juice shown in Table (1) was 0.32 %, which agrees with the previous studies (Medina *et al.*, 2007, Kamble *et al.*, 2017). In contrast, this result is lower than the values reported by Méndez *et al.* (2015) and Asma *et al.* (2017) who reported that the ash contents were 2.45 % and 1.05%, respectively.

As shown in Table (1) the crude protein content of cladodes extract was 1.39%. Different pre-

vious studies reported that the protein content of prickly pears cladodes ranged between 0.5–1% (Díaz *et al.*, 2017, Rocchetti *et al.*, 2018). On the other hand, this result is extremely higher than the value reported in previous studies being 0.14% (Abdessemed *et al.*, 2014). The obtained result is lower than that reported by El-Safy (2013) who found that the protein content was 2.64%. The data obtained in the present study show that the protein content of prickly pears fruit juice was 5.6 %. The obtained result is higher than the results obtained from previous studies (Chougui *et al.*, 2013, Méndez *et al.*, 2015, Kamble *et al.*, 2017). They reported that the protein content of the fruit juice ranged between 0.2 and 2%. The results in Table (1) generally indicated that the fruits are higher in proteins than the cladode.

Table (1) shows that the crude fat content of the prickly pears cladodes extract was 0.11%. These data agree with Rocchetti *et al.* (2018) who reported that the fat content was 0.12%. On the other hand, this result is lower than the value reported by El-Safy (2013) as 0.87%. The current data show that the fat content of the fruit was 0.22%, which is nearly similar to that reported by Chiteva and Wairagu (2013) Kamble *et al.* (2017) as 0.4% and 0.09, respectively.

The crude fiber content of the prickly pears cladodes extract was 4.14%. This value is higher than the results reported by Rocchetti *et al.* (2018) as 3.42%. Other studies reported that the crude fiber content of the cladodes was 1-2% (Feugang *et al.*, 2006, Díaz *et al.*, 2017). The crude fiber content of the fruit juice was 1.44%. This value shown in Table (1) is nearly similar to that reported by Chiteva & Wairagu (2013) as 1.37%. A slightly higher result was obtained by Méndez *et al.* (2015) as 2.5%. On the other hand, the result of the present study was extremely higher than that reported by Sawaya *et al.* (1983) as 0.02%. Also, the fibers content of

Table 1: Proximate chemical composition of cladodes and fruits of prickly pears.

Sample	Moisture content Mean \pm SD (%)	Total ash Mean \pm SD (%)	Crude protein Mean \pm SD (%)	Crude fat Mean \pm SD (%)	Crude fibers Mean \pm SD (%)	Total carbohydrates* Mean \pm SD (%)
Cladode extract	87.01 \pm 7.91	2.97 \pm 0.231	1.39 \pm 0.105	0.11 \pm 0.016	4.14 \pm 0.436	8.52 \pm 0.836
Fruit juice	88.6 \pm 8.02	0.32 \pm 0.056	5.6 \pm 0.521	0.22 \pm 0.018	1.44 \pm 0.013	5.26 \pm 0.567

Values represent the mean of three replicates \pm standard deviation (SD) on fresh weight

* calculated by difference.

the cladode is higher than that of the fruits.

Table (1) demonstrated that the total carbohydrates content of cladode extract was 8.52%. Díaz *et al.* (2017) reported that carbohydrate content was 3-7%, Rocchetti *et al.* (2018) reported lower carbohydrate content of 3.05%. Inglese *et al.* (2017) reported that the fruit juice of *O. ficus-indica* contained 4-6% of carbohydrates. According to this figure, the fruits are rich in carbohydrates being 50-75% of the dry matter. The total carbohydrate content of the fruit juice was 5.26%, Osuna-Martínez *et al.* (2014) reported that carbohydrate content was (3-7%). On the other hand, Feugang *et al.* (2006) reported it as 12-17%.

Total phenolic content

Recently, a great deal of attention has been paid for polyphenols due to their antioxidant activity, which is concerned in several health benefits such as the prevention of inflammation, cardiovascular and neurodegenerative diseases. Polyphenols have also shown anticancer activity (El-Mostafa *et al.*, 2014). The data in Table (2) show that the content of the phenolics in cladode extract of prickly pears was 119.66 mg/100g. This result is markedly lower than that reported by Ayadi *et al.* (2009) as 900 mg/100g. The phenolic content of the fruit juice was 123.56 mg/100g. Chougui *et al.* (2013) reported that total phenolics varied in different cultivars of prickly pears and ranged from 47.23 to 66.60 mg/100 g.

Antioxidant activity

Recently, much attention has been focused on the use of plant materials as natural antioxidants which can effectively replace synthetic antioxidant. It is assumed to protect humans from oxidative cell damages, resulting in the protection against several diseases (Dib *et al.*, 2013, Rocchetti *et al.*, 2018). The data in Table (2) show the total antioxidants activity of prickly pears cladodes extract and fruit juice. Antioxidants activity of cladodes extract was 40.38%. This result is extremely higher than that

obtained by Astello-Garcia *et al.* (2015) as 12.7% and that of Rocchetti *et al.* (2018) as 0.104%. On the contrary, other previous studies of Chaouch *et al.* (2016) showed higher values (54.52%-78.93%) and that of Du-Toit *et al.* (2018) as 83.77- 95.53%. Fruit juice had antioxidants activity of 39.18%. This result is within the ranges reported by Chaouch *et al.* (2016) as 46.32%- 64.08% and that of Alsaad *et al.* (2019) as 36.5-78.1%. Conversely, the result of the present study is higher than that reported by Abd El-Razek & Hassan (2011) and Mabrouki *et al.* (2015) as 28.68% and 11.54%, respectively.

Vitamins content

The data in Table (2) show that vitamin C (ascorbic acid) content in the cladodes is 15.94 mg/100 g, the obtained result is within the range that was reported by Slimen *et al.* (2016) and Kamble *et al.* (2017) as 7-22 mg/100 g, and is higher than the results reported by Inglese *et al.* (2017) as 11 mg/100 g. On the other hand, it is lower than the result of Fernández-López *et al.* (2010) as 18.5 mg/100 g. Fruit juice was found to contain vitamin C at varying levels. It is considered as a valuable source of ascorbic acid. Inglese *et al.* (2017) found that the vitamin C content of prickly pear fruit juice varied from 24.1–28.0 mg/100 g. Toplu *et al.* (2009) reported that prickly pear fruits exhibit a vitamin C content of 18.04 to 37.31 mg/100 g fresh weight, and Slimen *et al.* (2016) reported that it ranged from 1 to 48 mg/100 g. vitamin C content in the present study was 26.76 mg/100 g, which lies within the previously reported ranges, and agrees well with that reported by Tesoriere *et al.* (2004) as 29 mg/100 g.

Vitamin E, was detected in the cladodes extract as shown in (Table 2) being 1.37 µg/100 g. On the other hand, it was not detected in other previous studies according to El-Mostafa *et al.* (2014) and Kamble *et al.* (2017). Prickly pear fruit juice contained 96.8 µg/100gm vitamin E. This result is higher than that reported by Tesoriere *et al.* (2004) as 80 µg/100 g. On the other hand, Abd El-Razek

Table 2: Phenolic content, antioxidant activity, and some vitamins content of cladodes and fruits of prickly pears.

	Phenolic content (mg/100 g)	Antioxidant Activity (%)	Vitamin C (mg/100 g)	Vitamin E (µg/100 g)	Vitamin D (µg/100 g)	β-Carotene (µg/100 g)
Cladode extract	119.66	40.38	15.94	1.37	ND	57.51
Fruit juice	123.56	39.18	26.76	96.80	1.40	28.01

ND: not detected.

et al. (2012) reported higher results (125 µg/100 g). Vitamin D was not detected in cladodes extract while fruit juice contained 1.40 µg/100 g vitamin D. These results cannot be compared with previous results since none of the researchers measured vitamin D content in prickly pear cladodes or fruits in their studies. The absence of the two fat soluble vitamins; namely E and D is expected due to the very low content of fat in both of the cladodes and the fruit, as shown in Table (1).

Beta carotene is a precursor of vitamin A and is changed in the body to vitamin A which is needed for healthy eyes and skin. Epidemiological studies have shown that high intakes of carotenoid-rich fruits and vegetables and high blood levels of β-carotene are associated with decreased incidence of some cancers because of its antioxidant properties and help eliminating the free radicals from the body (Toplu *et al.*, 2009). The β-carotene content of cladode extract as shown in Table (2) was 57.51 µg/100 g, which lies within the previous reported range of Slimen *et al.* (2016) as 47-77 µg/100 g, and was higher than that reported by Shedbalkar *et al.* (2010) as 11.3–53.5 µg/100 g. On the other hand, Feugang *et al.* (2006) stated that β-carotene is not detected in cladodes in their study. As regards prickly pears fruits, the β-carotene content was 28.01 µg/100 g, which agreed with the result of Shedbalkar *et al.* (2010) as 29.9 µg/100 g and is nearly similar to Abd El-Razek *et al.* (2012) as 17.54 µg/100 g, which are extremely higher than the previous studies in which β-carotene ranged from 1.2-3 µg/100 g. (Fernández-López *et al.*, 2010, Slimen *et al.* 2016, Kamble *et al.*, 2017).

Fatty acid profile

The data in Table (3) demonstrated that fatty acids of crude fat extracted from the cladodes were found to be rich source of the unsaturated fatty acids, representing 69.24% of the total fatty acids content (monounsaturated 24.24%, and polyunsaturated 45.00%). While, the saturated fatty acids constituted 30.76%. The main unsaturated fatty acids were linoleic acid (omega-6), linolenic acid (omega-3) and oleic acid (omega-9) with 24.81, 20.19 and 10.39%, respectively. The main saturated fatty acids include palmitic and stearic acids

with levels of 7.53 and 6.96%, respectively. These results are in accordance with those of El-Mostafa *et al.* (2014) who mentioned that the results of linoleic acid, linolenic acid and oleic acid were 34.87, 33.23 and 11.16%, respectively, while palmitic acid was 13.87%. The fatty acid profile of prickly pear fruit juice showed that the unsaturated fatty acids were more predominant (59.91%), while saturated fatty acids were 40.09%. Of the unsaturated fatty acids, linoleic acid was the dominating fatty acid, followed by linolenic acid, and oleic acid as 19.46%, 16.75%, and 16.36%, respectively. While, saturated fatty acids were, palmitic acid (15.36%) followed by stearic acid (5.33%). Previous studies on prickly pear showed a similar pattern (Ramadan & Mörsel, 2003, El-Mostafa *et al.*, 2014).

The presence of high amount of the essential

Table 3: The Fatty acids profile of cladodes and fruits of prickly pears

Fatty acids profile	Cladode (%)	Fruit (%)
Poly unsaturated fatty acids		
Linolenic acid (C18:3 α / ω -3)	20.19	16.75
Linoleic acid (C18:2c/ ω -6)	24.81	19.46
Mono unsaturated fatty acids		
Oleic acid (C18:1c/ ω -9)	10.39	16.36
Myristoleic acid (C14:1)	2.41	5.32
Cis-10-Pentadecenoic acid (C15:1)	3.21	0.15
Palmitoleic acid (C16:1)	1.86	1.14
Cis-11-Ecosenoic acid (C20:1)	6.36	0.73
Saturated fatty acids		
Palmitic acid (C16:0)	7.53	15.36
Stearic acid (C18:0)	6.96	5.33
Undecanoic acid (C11:0)	ND	0.83
Lauric acid (C12:0)	ND	2.15
Tridecanoic acid (C13:0)	4.96	5.38
Myristic acid (C14:0)	2.24	4.94
Pentadecanoic acid (C15:0)	5.47	3.30
Heptadecanoic acid (C17:0)	2.71	2.80
Arachidic acid (C20:0)	0.90	ND
Total monounsaturated fatty acids (Σ MUFA)	24.23	23.70
Total polyunsaturated fatty acids (Σ PUFA)	45.00	36.21
Total unsaturated fatty acids (Σ UFA)	69.23	59.91
Total saturated fatty acids (Σ SFA)	30.77	40.09
Σ PUFA/ Σ SFA (P/S) ratio	1.46	0.90
Σ UFA/ Σ SFA ratio	2.25	1.49
ω -6/ ω -3 ratio	1.23	1.16

ND: not detected. ω : omega, P/S ratio: polyunsaturated/saturated ratio

fatty acids suggested that this prickly pears cladodes extract and fruit juice are highly nutritious due to the ability of unsaturated oils to reduce serum cholesterol. Linoleic acid is an essential fatty acid that cannot be synthesized by the body and is a precursor of arachidonic acid biosynthesis, it is one of the most important polyunsaturated fatty acids in human food due to its hypocholesterolemic effects and its role in preventing distinct heart vascular diseases. It was also described to be very essential for brain development (Otuna *et al.*, 2016).

The ratio of unsaturated to saturated fatty acids of the cladodes extract was 2.25; this result is quite close to other previous studies of López-Cervantes *et al.* (2011) and El-Safy (2013). While that of the fruit juice was 1.49, that agrees well with the result of Ramadan & Mörsel, (2003).

These recorded differential levels of the nutritional content of prickly pears could be attributed to climatic variations, geographical location, coupled with soil condition and the level of fertilization. (Food and Agriculture Organization of the United Nations, 2001, Chinedu *et al.*, 2017)

CONCLUSION

The current study revealed that prickly pears cladodes and fruits can be considered as functional food due to their valuable contents of fibers, vitamin C, fatty acids, phenolic compounds and antioxidants activity.

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القيمة الغذائية لأوراق وثمار التين الشوكي

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تم استخدام التين الشوكي لعدة قرون في الغذاء والأعلاف. الغرض من هذه الدراسة هو تسليط الضوء على القيمة التغذوية للسيقان الورقية وثمار التين الشوكي. في هذه الدراسة، احتوت السيقان الورقية وثمار التين الشوكي على ١١٩,٦٦ و ١٢٣,٥٦ ملجم / ١٠٠ جم على الترتيب من المركبات الفينولية. كان نشاط مضادات الأكسدة ٤٠,٣٨٪ و ٣٩,١٨٪ على الترتيب. كان محتوى فيتامين (ج) بنسبة ١٥,٩٤ و ٢٦,٧٦ ملجم / ١٠٠ جم، وكانت كمية فيتامين (هـ) ١,٣٧ و ٩٦,٨٠ ميكروجرام / ١٠٠ جم. فيما يتعلق بفيتامين (د)، لم يوجد في السيقان الورقية التين الشوكي بينما تحتوي الثمار على ١,٤٠ ميكروجرام / ١٠٠ جم. وكانت كمية البيتا كاروتين ٥٧,٥١ و ٢٨,٠١ ميكروجرام / ١٠٠ جم على الترتيب. تبين أن الأحماض الدهنية الموجودة في السيقان الورقية وثمار التين الشوكي كانت الأحماض الدهنية غير المشبعة وخاصة حمض اللينوليك (أوميغا ٦) وحمض اللينولينيك (أوميغا ٣) وحمض الأوليك (أوميغا ٩)، بينما الأحماض الدهنية المشبعة اشتملت على حمض البالمتيك وحمض الاستياريك. أوضحت الدراسة الحالية أنه يمكن اعتبار السيقان الورقية وثمار التين الشوكي غذاءً وظيفياً بسبب محتواها المرتفع من الألياف وفيتامين (ج) والأحماض الدهنية والمركبات الفينولية ومضادات الأكسدة.

