

Prickly Pear [*Opuntia ficus-indica* (L.) Mill] Peels: Chemical Composition, Nutritional Value and Protective Effects on Liver and Kidney Functions and Cholesterol in Rats

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ABSTRACT

Extract of prickly pear peels (PPPs) were evaluated for its chemical and nutritional composition and toxicity on liver and kidney function, as well as low-density-lipoprotein (LDL)-cholesterol level on Sprague-Dawley rats. The proximate composition based on the dried weight (DW) of PPPs were: 18.50% moisture; 7% ether extract; 4.5% protein; 8% total ash; 4.9% crude fiber; 81.5% total solid, followed by both 12.8 and 288.7 mg/100 g carotenoids and ascorbic acid, respectively. Mineral analysis showed a high amount of Mg, Ca and Na: 987.2, 951.5 and 925.0 mg/100 g, respectively, followed by K (320.0 mg/100 g). Fe, Mn, Zn and Cu contents were lower 129.0, 90.8, 90.0 and 47.8, respectively. Sucrose and galacturonic acid were the main sugars. Linolenic acid (29%) was the main fatty acid followed by both palmitic (23.7%) and oleic acids (19.7%). The polyunsaturated fatty acids, linolenic acid (18:2 and 18:3) and oleic acid were also detected in higher amounts than saturated fatty acids (2: 1). In addition, kidney functions (blood urea and serum creatinine) of the treated group as well as the activity of liver enzymes *viz* aspartate tansaminase (AST) and alanine transaminase (ALT) were not significantly altered. However, the LDL-cholesterol level in the treated group was significantly decreased compared to the control. In conclusion, PPPs have no toxic effect on liver and kidney of rats and have significant nutritional value. Information provided by our work is valuable for further investigation on PPPs and its utilization as a raw material of functional foods industry.

Keywords: blood urea, carotenoids, LDL-cholesterol, liver enzymes, *Opuntia ficus-indica* peel composition, prickly pear cactus, serum creatinine

Abbreviations: ALT, serum alanine transaminas; AST, serum aspartate tansaminase; CG, control group; DW, dry weight; FW, fresh weight; IDF, insoluble dietary fiber; LDL, low-density-lipoprotein; NODCAR, National Organization for Drug Control and Research; PP, prickly pear; PPP, prickly pear peel; RDA, recommended dietary allowances; SDF, soluble dietary fibre; SFA, saturated fatty acid; TG, treated group; USFA, unsaturated fatty acid

INTRODUCTION

The processing of many fruits results in the accumulation of large quantities of by-products. Proper utilization of these by-products could reduce waste disposal problems and serve as a potential new source of fats and proteins for use in food and feed (Kamel and Kakuda 2002). The prickly pear (PP) cactus has a global distribution and is an important nutrition and food source. About 1500 species of PP cactus are in the genus *Opuntia* and many of them produce edible and highly favoured. In Egypt, the total area annually cultivated with PP fruits was about 6268.5 ha, producing about 28.431.000 Kg of the fruits which calculated about 13.420.000 Kg peels (Anonymous 2008). Fruits of PP are recognized as an important source of vitamins for local people at the natural growth sites of the plant. The vegetable stems and fruits of cactus pear are useful for a variety of purposes including food (fresh fruit, paste, jam, salads, and refreshing drinks), fodder (auxiliary feed for cattle, sheep and goats), and medicinal (antidiabetic agent) and for industrial products such as alcohol, soap, pigments, pectins, and oils (Lakshminarayana 1980). There are numerous medicinal uses of the plant. PP has a long history of traditional Mexican folk medicine use, particularly as a treatment for diabetes, PP pads have been used as a poultice for rheumatism. The fruit has been used for treating diarrhea, asthma, and gonorrhoea. The fleshy stems or cladodes have been

used to treat high cholesterol, blood pressure, gastric acidity, ulcers, fatigue, dyspnea, glaucoma, liver conditions, and wounds (Gurrieri *et al.* 2000; De Felice 2004). In South Korea the plant has been used to treat abdominal pain, bronchial asthma, burns, diabetes, and indigestion (Kim *et al.* 2006). In Sicily, a flower decoction of PP has been used as a diuretic; the cladodes were valued for their anti-inflammatory activity in treating edema, arthrosis, and whooping cough, and for preventing wound infection (De Felice 2004).

However, there is limited clinical information to support these uses. Furthermore, the health-promoting capacity of cactus pear fruit is highly attractive for the development of nutraceutical and functional foods. Dietary trends' current emphasis on safe and healthy foods extends to searches for new components with more than just nutritive value. Functional components such as dietary fiber, natural colorants, and antioxidant vitamins are some of the nutrients people want to include in their daily diet. Certain vegetables are promising sources of such components. One of them is cactus-pear fruits (Sáenz 2002). Research on the functional properties of cactus-pear fruits has also been carried out. Some constituents may be extracted and used as additives in food preparations, such as vitamin C, phenolics, taurine and betalain. In particular, possible uses of food colorants have been assessed. Cactus pear is very particular for the presence of betalain, a widely used natural colorant in the food industry (Piga 2004). In contrast to red beets, cactus pears

offer a great palette of colour hues and therefore may be used as a food colouring free from certification. These various components could all be used as natural ingredients in different foods to enhance their healthy properties. Peels and seeds are the waste products of the PP fruits processing industries. Seeds constitute about 10–15% of the edible pulp and are usually discarded as waste after extraction of the pulp. According to literature data (Sawaya and Kahn 1982; Stintzing *et al.* 2000), oil processed from the seeds constitutes 7–15% of whole seed weight and is characterized by a high degree of unsaturation wherein linoleic acid is the major fatty acid (56.1–77.0%). The sterols in seed oil are composed of β -sitosterol as the sterol marker, followed by campesterol, then stigmaterol (Ramadan and Morsel 2003a).

There are no reports in literatures about the utilization of the peels of PP fruits for preparation of dietary fiber. Dietary fiber plays an important role in human health (Anderson *et al.* 1994). High dietary fiber diets are associated with the prevention, reduction and treatment of some diseases, such as diverticular and coronary heart diseases (Anderson *et al.* 1994; Villanueva *et al.* 2003). Peels are a new desert source of dietary fiber and its content in galacturonic acid was superior to that of commercial cladode cactus racquet. Furthermore, PP fibers show a pleasant aroma and flavours (Terrazas *et al.* 2002). The fruit has many seeded berry and thick peel enclosing a delicately flavored very seedy pulp. It is known that the fruit contains vitamin C but studies on other antioxidants in peels, however, are lacking. The lipid content of peel fraction was reported to be 2.43% (on a DW basis) (El-Kossori *et al.* 1998). Besides the use of the plant in human nutrition, it is also used for cattle feed and in the production of carminic acid (Stintzing *et al.* 2001). More studies are needed for its medicinal properties, its uses as a potential food as well as dietary supplements. However, the physiological effects are related to the physicochemical and functional properties of different component of the PPPs. The purpose of this study is the evaluation of the chemical composition and the toxicity effect of PPPs as by-products from nutritional and biological points of view.

One of the major needs within the PP industry is the development of new processed PP products as well as the fruit by products. These new functional components from cactus pear peel open new possibilities for adding value to a very ancient, but not sufficiently known, crop of the arid and semiarid regions of the world. In terms of the future of biotechnological processes, countries with available raw materials are more highly favored to build strong biotechnology industries. The expansion of the PP cultivation in arid and semi-arid areas could be of interest for stimulating bioindustries in developing countries.

MATERIALS AND METHODS

Chemicals and samples

Chemicals and reagents including 2,6-dichloroindophenol, polyvinyl sulphate, polyethylene-glycol monomethyl ether and enzyme reagents were purchased from Fluka Company (Buchs, Switzerland). All other chemicals and solvents used in this study were of the analytical grade and were obtained from Merck (Darmstadt, Germany).

Prickly pear [*Opuntia ficus-indica* (L.) Mill] fruits were obtained from the field at Sinaro area, Fayoum governorate, season (2007). El Fayoum, is a large oasis in the Egyptian western desert 90–130 km southwest of Cairo. The harvested fresh fruits were taken to the laboratory, washed, and hand peeled carefully by using stainless steel knife.

Preparation of the dried powder of PPPs

After peeling, the fruits were pulped and passed through a 1.0 mm mesh sieve. The peels were washed and blanched in boiled water containing 1% NaOH for 2 min at 90°C, then washed thoroughly

with tap water and dried in an oven at 55°C for 12 h. The dried peels were ground in a blender (Moulinex 276) for 3 min and packed in polyethylene bags until analysis (Siham *et al.* 2004).

Proximate composition of PPPs

1. Determination of moisture content and ether extract

A known weight of PPPs (2 g) was dried in an oven at 105°C until a constant weight was reached (AOAC 2000). Ether extract was determined according to AOAC methods (1995).

2. Determination of total soluble solids and pH values

Total soluble solids content of 2 g dry PPPs reconstituted in 1 mL water were measured with a Bausch and Lomb, Abbe model-32, refractometer and expressed as percentage of total soluble solids. The measurements were measured at environmental temperature and corrected to 20°C according to the method described by the AOAC (1995). pH values were measured at 25°C using a Beckman pH meter.

3. Determination of total titratable acidity

For estimating titratable acidity, 10 g of PPPs dry sample was thoroughly mixed with 50 mL of de-ionized-distilled water. The mixture was then titrated by adding 0.1 N NaOH until a pH of 8.1 was attained. The volume of the sodium hydroxide, added to the solution, was multiplied by a correction factor of 0.064 to estimate titratable acidity as percentage of citric acid (AOAC 1995).

4. Determination of crude protein

The crude protein was determined using micro Kjeldahl method as describe in AOAC (2000). 2 g of PPPs sample material was taken in a Kjeldahl flask and 30 mL concentrated sulfuric acid (H₂SO₄) was added followed by the addition of 10 g potassium sulphate and 1 g copper sulphate. The mixture was heated first gently and then strongly. When the solution became colorless or clear, it was heated for another one hour, allowed to cool, diluted with distilled water (washing the digestion flask) and transferred to 800 mL Kjeldahl flask. Three or four pieces of granulated zinc and 100 mL of 40% caustic soda were added and the flask was connected with the splash heads of the distillation apparatus. Next 25 mL of 0.1 N sulphuric acid was placed in the receiving flask and distilled. When two-thirds of the liquid had been distilled, it was tested for completion of reaction. The flask was removed and titrated against 0.1 N caustic soda solution using methyl red indicator for determination of Kjeldahl nitrogen. The crude protein was then calculated by multiplying the total nitrogen by a factor of 6.25.

5. Determination of total sugars

The sugar content of the PPPs sample was determined according to the method described by Somogyi (1952). Determination of reducing sugar using the Somogyi-Nelson method is based on the absorbance at 500 nm of a colored complex formed between a copper-oxidized sugar and arsenomolybdate. The amount of sugar present is determined by comparison with a calibration curve using a spectrophotometer (Beckman DU68 spectrophotometer).

6. Determination of ash content

For determination of ash content, method of AOAC (2000) was followed. According to the method, 2 g of PPPs sample was weighed in a silica crucible. The crucible was heated in a muffle furnace for about 3–5 h at 550°C. It was cooled in a desiccator and weighed. To ensure completion of ashing, it was heated again for half an hour more, cooled and weighed. This was repeated consequently till the weight became constant (ash became white or grayish white). Then ash content was calculated by the following formula:

$$\text{Ash\%} = \text{weight of ashed sample} / \text{weight of sample taken} \times 100.$$

7. Determination of crude fiber

A known weight of dry PPPs sample (2 g) was digested with sulfuric acid (200 mL, 1.25%) then with sodium hydroxide (200 mL, 1.25%) and washed several times with diethyl ether. The resultant product was dried at 100°C then ashed at 550°C (AOAC 2000).

8. Determination of total carotenoids

Total carotenoids are an indication of β -carotene content which is a precursor of vitamin A. The carotenoids were determined using a slight modification of the procedure of Reddy and Sistrunk (1980). Exactly 2 g of dry PPPs sample was extracted until colorless with 10 mL hexane using a Thomas E-40 tissue grinder. Samples were filtered through Whatman 1 paper and the absorbency read at 440 nm and compared to a β -carotene standard curve. Total carotenoids were expressed on a fresh weight basis (mg/100 g).

9. Determination of ascorbic acid content

For ascorbic acid determination the AOAC's official titrimetric method (AOAC 1995) was used. Two g of dry sample of PPPs was mixed with 2.5 mL of the extractant solution (3% metaphosphoric (MPA) and 8% acetic acid). The mixture was homogenized for 1 min and then centrifuged at $9000 \times g$ (refrigerated at 4°C) for 20 min. This procedure was repeated twice and the two resulting supernatants were mixed together. All extractions were carried out in quintuplicate. Several precautions were taken in order to perform all the operations under reduced light and at 4°C. To summarize, 2 mL of the 3% MPA - 8% acetic acid extracts were titrated with standard indophenol dye solution (25% 2,6-dichloro-indophenol (DCIP) and 21% sodium bicarbonate in water) until a light but distinct rose pink colour appears and persists for more than 5 seconds. The indophenol solution was standardized daily with ascorbic acid solution. The titration reading was calculated by the following formula

$$\text{Ascorbic acid (mg/100 g)} = (\text{titer} \times \text{dye factor} \times \text{dilution/volume of supernatant} \times \text{weight of sample}) \times X 100$$

Dye standardization: Diluted 5 mL of standard ascorbic acid solution with 5 mL of extractant solution. Titrate with dye solution till pink color persists for 5 sec. dye factor was calculated (mg of ascorbic acid per mL of dye) as follows:

$$\text{Dye factor} = 0.5/\text{titration}$$

10. Determination of fatty acids and mineral contents

Minerals contents were determined in ash according to the method described by Farag *et al.* (1980). To identify the fatty acids content of the dried peels the method described by Cossignani *et al.* (2005) was used.

Experimental studies on rats

1. Preparation of water extract of PPPs (tea of PP)

The extract was prepared by simmering 2 g of dried PPPs in 150 mL of boiling water for at least 3 min.

2. Experimental design

Animals: Forty Sprague-Dawley adult male rats, 150-180 g body weight were obtained from the animal house of the National Organization for Drug Control and Research (NODCAR), Egypt. The standard guidelines of NODCAR were used in handling the experimental animals. All rats were fed standard rat chow water *ad libitum*. The animals were exposed to 12 h light-dark cycle throughout the experimental period.

3. Toxicity study of PPPs on liver, kidney function and low-density-lipoprotein (LDL) level

Rats were administered a water extract of PPPs by a daily oral dose equivalent to 18 mg/kg for 21 days to study the sub acute toxicity of PPPs. These doses were chosen according to Paget's table for conversion of doses (Pagets and Barnes 1964). Blood samples were obtained by fine capillary tubes through the retro orbital vein plexus of rats, under ether anesthesia at the 1st and 21st day of the experiment. Control group in this experiment was considered the rats at 1st day and treated group was the rats after receiving PPPs for 21 days.

4. Biochemical assessment

Serum was separated from whole blood of rats by using a high speed centrifuge at 4000 rpm for 10 min. Blood urea was determined by quantitative enzymatic colorimetric method (Berthelot's reaction) according to Patton and Crouch (1977) in which 0.01 mL of rat serum was mixed with the enzyme reagent and absorbance of the blue coloured chromophore was read at 560 nm by a spectrophotometer. To convert blood urea nitrogen (BUN) to urea we multiply by 60/28. Determination of serum creatinine was done by the method of Husdan *et al.* (1968), in which 0.05 mL of rat serum was mixed with 1 mL of working reagent, to form a colored complex. Two readings were obtained from spectrophotometer at 520 nm, after 20 and 60 seconds and values of serum creatinine were equal to absorbance changes of unknown standard and multiplied by 5. Aspartate transaminase (AST) (EC 2.6.1.1) and alanine transaminase (ALT) (EC 2.6.1.2) activities in serum were determined by colorimetric method of Reitman and Frankel (1957) in which 0.1 mL of rat serum was added to each of reagents (0.5 mL ALT and 0.5 mL AST buffer substrates) and incubated for 60 and 30 min respectively, followed by addition of color reagent and stand for 20 min at room temperature before mixing with sodium hydroxide. After 5 min the absorbance was measured at 505 nm. Calculation of the number of units/mL of ALT and AST of samples was done by using the standard curve. Serum low-density-lipoprotein (LDL) was determined as the differences between total cholesterol and the cholesterol content of the supernatant after precipitation of the LDL fraction by Polyvinyl sulphate in the presence of polyethylene-glycol monomethyl ether, 0.2 mL of rat serum was mixed well and centrifuged at 2000 rpm for 15 min. The cholesterol content was determined in the supernatant and calculated by this equation Bergmenyer (1985):

$$\text{LDL-cholesterol (mg/dl)} = \text{total cholesterol mg/dl} - 1.5 \times \text{supernatant cholesterol (mg/dl)}$$

Statistical analysis of data

Data management and analysis were performed using Statistical Analysis Systems. Numeric Data were summarized using means and standard deviations. Categorical data were summarized as percentages according to Statistically American System (SAS 1996). To study the differences between control and treated group, a two-way analysis of variance was performed. Comparisons between categorical variables were done by the chi-square test (Dawson and Trapp 2001), $P > 0.05$ was considered non significant.

RESULTS AND DISCUSSION

Since the peels of cactus pear fruits are normally not eaten and are difficult to separate from the pulp low interest in cactus pear fruit peel processing is understandable. However, in recent years two products containing ground peels were elaborated (Cerezal and Duarte 2005). Whereas for the first, a mixture of ground cactus pear skins, pulp, and sucrose were used to obtain a concentrated sweet product, the second consisted of ground peels, sucrose, and pectin and was addressed as marmalade. While different concentrations of preservatives and acids were tested for the first product, for the latter a formulation exhibiting 63% TSS (total soluble solids), a pH of 4.0 with potassium sorbate preservation was suggested. The optimum composition for

Table 1 Gross composition of prickly pear (means \pm SD).

Juice %	Peel %	Seeds %
48.4 \pm 0.31	47.2 \pm 2.0	3.4 \pm 0.5

Table 2 Chemical composition of prickly pear peels (means \pm SD).

Chemical analysis	Prickly pear peels	
	Fresh ^a	Dried ^b
Moisture ^c	80.17 \pm 0.93	18.50 \pm 1.47
Total soluble solids ^c	15.00 \pm 0.50	14.80 \pm 0.46
Total solids ^c	19.83 \pm 0.15	81.50 \pm 0.28
pH	4.5 \pm 0.1	4.4 \pm 0.1
Acidity as citric acid ^c	0.12 \pm 0.01	0.60 \pm 0.1
Protein ^c	0.90 \pm 0.03	4.50 \pm 0.05
Ash ^c	1.60 \pm 0.02	8.00 \pm 0.2
Crude fiber ^c	0.96 \pm 0.06	4.88 \pm 0.1
Ether extract ^c	1.69 \pm 0.13	6.99 \pm 0.05
Carotenoids ^d	2.97 \pm 0.02	12.76 \pm 0.2
Ascorbic acid ^d	59.82 \pm 0.64	288.67 \pm 4.16

^a Based on fresh weight

^b Based on dry weight

^c %

^d mg/100 g

the first product comprised 3 parts of pulp and 1 part of peels with the addition of phosphoric acid and sodium bisulphate (Mobhammer *et al.* 2006). Therefore, a new interest in studying the composition of PPPs has arisen.

Components of PP fruits

Cactus pear fruits may be divided into three fractions that may be exploited by commercial processing, seeds, peel and pulp. The thick pericarp is covered with small barbed spines hosting a juicy pulp with 150-300 non-edible seeds. The latter account for 3-7% on weight basis, followed by the pericarp and mesocarp (36-48%) and edible pulp (39-64%) (Fleker *et al.* 2002, 2005; Mobhammer *et al.* 2006). In this study, the proximate percentage of pulp, skin and seeds of PP cactus was investigated and is reported on a FW basis (Table 1). The obtained results showed that the peels of cactus pear fruit were thick enough to form an average of 47.2% of its FW. Similar results have been reported by Hussein (1978) and El-Samahy *et al.* (2006), who found the proximate percentage of peels 46.70 and 39.23 to 44.53, respectively.

Proximate chemical composition of PPPs

The proximate general composition of fresh and dried PPPs is shown in Table 2. In general, Pulp and skin contained higher amount of water (94 and 90%, respectively) than the seeds (18%) (Salim *et al.* 2009). The moisture content of fresh and dried PPPs was 80.17 and 18.50%, respectively. However, the total soluble solids were 15.00 and 14.80%, respectively. This due to reducing sugars, mainly, galacturonic acid (2.23%). In contrast to the pulp, with pH-values ranging from 5.4 to 5.8 the peel was reported to be usually more acidic (Joubert 1993; Cerezal and Duarte 2005). In this study the pH values of PPPs was ranging from 4.4 to 4.5 and total acidity (as citric acid) was 0.12 and 0.60% for fresh and dried PPPs, respectively. The percent of ash represented the total anions as well as cations whereas betalains impart orange, red, and purple colored shades to peels, pigments of green skinned cultivars consist of chlorophylls and carotenoids. Carotenoids represented the major insoluble water pigments in the PP peels (2.97 mg/100 g). β -carotene is pro-vitamin A, which play an important role in the integrity of the cells. High content of vitamin E amounting to 21.8 g/kg oil, dominated by α -tocopherol with 17.6 g/kg, were found in the lipids extracted from cactus pear peel (Hassanien and Morsel 2003; Ramadan and Morsel 2003b). Significant amounts of ascorbic acid are generally found in fruits of different *Opuntia* spp., ranging from 10 to 410 mg/kg, the most common PP shows ascorbic acid contents

Table 3 Sugar composition of prickly pear peels.

Sugar compounds	Relative %
Sucrose	2.85
Galacturonic acid	2.23
Stachyose	1.81
Mannitol	1.48
Sorbitol	0.71
Arabinose	0.05

from 180 to 300 mg/kg (Piga 2004). However, our results showed that PPPs contained high level of ascorbic acid, 590 mg/kg based on FW (Table 2). So the peel is considered as a very good source of such vitamin. Proteins contents in the peel were 0.90 and 4.50% based on FW and DW, respectively. The percent of proteins in the peels raised its nutritional value and might give some unfavorable reactions which could affect the color of the products, such as Maillard browning reaction and/or hydroxyl methyl furfural formation. Dietary fibre plays an important role in human health. High dietary fibre diets are associated with the prevention, reduction and treatment of some diseases (Anderson *et al.* 1994). Fiber is often classified as soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) (Gorinstein *et al.* 2001). It is generally accepted that those fibre sources suitable for use as food ingredient should have an SDF/IDF ratio close to 1:2. Fibre derived from fruits and vegetables have a considerably higher proportion of soluble dietary fibre (Herbafood 2002). The percent of fibers in the dried portion (4.88%) of the peel was higher than the wet portion (0.96%). Ether extracts were 1.69% and 6.99% respectively. These results were in agreement with data of Villarreal *et al.* (1964), Hussein (1978), and Ramadan and Morsel (2003a). The dried product had higher dietary fibre as well as other interesting physico-chemical characteristics.

Sugar composition of PP peels

In concordance with data obtained by others (Rosade and Diaz 1995; Saenz *et al.* 1998; Youssef *et al.* 2002; Habibi *et al.* 2009), Egyptian cactus pear peel were characterized by slightly higher content of sucrose (2.85%) followed by galacturonic acid (2.23%) and middle concentration of stachyose (1.81%) and mannitol (1.48%) (Table 3). Complex polysaccharides mainly composed of arabinose, galactose, rhamnose, and galacturonic acid which can influence the pleasant flavor and could serve as thickening agents and form viscous colloids (Stintzing *et al.* 2001; Piga 2004). These unique characteristics make the cactus pear peel sweeter and very suitable to be a good natural food or natural food additive with many categories of foodstuffs. However, further studies are required to completely characterize the hydrocolloid fractions of PP cactus.

Fatty acid fractions

The composition of fatty acids of PPPs is shown in Table 4. Linolenic acid (28.96%) was the acid with the greatest concentration followed by palmitic acid (23.71%) and oleic acid (19.73%). Among the saturated, palmitic acid was the dominating fatty acid, while both of stearic (18:0) and arachidonic acids (20:0) were estimated to be in relatively low amounts. Also, the polyunsaturated fatty acids linoleic acid, linolenic acid (18:2 and 18:3) and oleic acid were detected in higher amounts. Linolenic acid [α -linolenic acid (18:3)] and linoleic acid (18:2), were the major of the group of essential fatty acids, so called because they cannot be produced within the body and must be acquired through diet. These two fatty acids cannot be synthesised by humans, as humans lack the desaturase enzymes required for their production. In another studies, total lipids recovered from peel amount to be 36.8 g/kg based on DW (Ramadan and Morsel 2003a). Linoleic, palmitic, oleic acids, β -sitosterol and campesterol, the profile of lipids were found to be similar to

Table 4 Fatty acids composition (%) of prickly pear peels.

	Saturated (Sat)			Unsaturated (Unsat)			
	Palmitic (16:0)	Stearic (18:0)	Arachidonic (20:0)	Palmitoleic (16:1)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)
Total	33.71	3.93	5.52	2.46	19.73	28.96	15.68
Ratio Sat: Unsat	1			2			

that of the pulp oil (Hassanien and Mörsel 2003; Ramadan and Morsel 2003a).

Mineral composition of PP peels

Minerals are elements that originate in the soil and cannot be created by living things, such as plants and animals. Yet plants, animals and humans need minerals in order to be healthy. Minerals from plant sources may also vary from place to place, because the mineral content of the soil varies according to the location in which the plant was grown. The nutritional compositions of PPPs as mineral contents are given in **Table 5**. The mineral analysis showed a high amount of Mg, Ca and Na; being 987.2, 951.5 and 925.0 mg/100 g, respectively, followed by K was (320.0 mg/100 g). While contents were lower for Fe, Mn, Zn and Cu; being 129.0, 90.8, 90.0 and 47.8 mg/100 g respectively. Therefore, cactus pear peel can significantly contribute to cover the recommended dietary allowances (RDA) of these elements. These results were in agreement with (El-Kossori *et al.* 1998; Feugang *et al.* 2006).

Toxicity effects of administration of PPPs on rats

Renal function, in nephrology, is an indication of the state of the kidney and its role in renal physiology. Glomerular filtration rate describes the flow rate of filtered fluid through the kidney. Serum creatinine and blood urea nitrogen are often compared to evaluate renal (kidney) function. On the other hand, an initial step in detecting liver damage is a simple blood test to determine the presence of certain liver enzymes in the blood. Under normal circumstances, these enzymes reside within the cells of the liver. But when the liver is injured for any reason, these enzymes are spilled into the blood stream. Among the most sensitive and widely used of these liver enzymes are the aminotransferases. They include aspartate aminotransferase (AST) and alanine aminotransferase (ALT). To our knowledge no previous studies concerning the effects of PPPs on liver enzymes and kidney functions were reported. In this study no toxicity effect was detected either on liver or kidney function in treated rats. Furthermore, a significant decrease was observed in blood urea and serum creatinine, liver Enzymes (ALT and AST) as well as serum LDL-cholesterol level following oral administration of PPPs daily for 21 days to rats (**Table 6**).

Blood urea and serum creatinine (**Table 6**), were significantly decreased in rats which may be due to the high content of ascorbic acid in the peel. Korkmaz (2009) found that ascorbic acid in male rats with renal ischemia-reperfusion injury exerts renoprotective effects which may be due to radical scavenging and antioxidant activities. In another study by Galati *et al.* (2003) who investigated the diuretic effect of a 15% extract from flowers, fruits, and peeled cladodes of *O. ficus-indica* on a rat model. Peeled cladodes showed the highest diuretic effect while urea levels in blood

Table 5 Mineral contents of prickly pear peels^{*}.

Minerals							
Mg	Ca	Na	K	Fe	Mn	Zn	Cu
987.20	951.00	925.00	320.00	129.00	90.80	90.00	47.80

^{*}mg/100 g dry weight

and urine remained unchanged. This was explained by the high potassium content of *Opuntia* cladode. Furthermore, a significant decrease in liver enzymes (AST and ALT) and LDL-cholesterol as compared to control was observed (**Table 6**). This was in agreement with Ennouri *et al.* (2007), who observed an increase in high-density lipoprotein cholesterol and a reduction in LDL-cholesterol in rats treated with seed oil of *O. ficus-indica*. In humans, Shapiro and Gong (2002) demonstrated the benefit of *Opuntia* for improvement of hyperlipidemic profiles. They showed the significant decreases in total and LDL-cholesterol and reduced platelet proteins were found. Linares *et al.* (2007) indicated an advantage of using *Opuntia* in dietary supplements and functional foods because of improvement of blood lipid parameters associated with cardiovascular risks.

In this study, we found that PPPs contain essential fatty acids such as the Ω -3-polyunsaturated fatty acid α -linolenic acid and the omega 6 polyunsaturated fatty acid linoleic acid. These essential fatty acids had a role in reducing LDL (the 'bad') cholesterol (Lunn and Theobald 2006). The high level of ascorbic acid found in the dried portion of cactus pear peels, could through its antioxidant action, protects LDL-cholesterol from oxidative damage and aids in the degradation of cholesterol (Tesoriere *et al.* 2004). Also the decrease in LDL-cholesterol could be attributed to the high fiber content of the peels (Galati *et al.* 2003).

CONCLUDING REMARKS

This investigation shows the potential value of cactus pear peel as a good natural source of energy, nutritive components and antioxidants such as vitamin C and carotenoids. Based on its low acidity, high sweetness, and attractive stable colors, cactus pear peel could be very suitable as a natural additive or substituted material in the production of many foodstuffs. However, more work is required for the application of PP peels in prevention and treatment of liver and kidney diseases. The information obtained in the present investigation is useful for characterizing of PPPs and further chemical and nutritional investigations of PPPs are required. The results are also important for industrial utilization of the major by-product of the fruit.

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Table 6 Effects of prickly pear peels on blood urea, serum creatinine, Liver enzymes (ASL and ALT), LDL- Cholesterol in Rats (Means \pm SE).

Group	Urea ^a	Creatinine ^a	ASL ^b	ALT ^b	LDL ^a
Control	28.778 \pm 3.269	0.463 \pm 0.011	79.111 \pm 7.025	21.222 \pm 2.385	15.111 \pm 0.0889
Treated	24.222 \pm 0.596	0.438 \pm 0.008	65.111 \pm 2.811	18.111 \pm 20.920	13.555 \pm 0.604

^a mg/dL

^b U/ml

P-value >0.05 is considered not significant

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