Review Article

NUTRACEUTICAL AND FUNCTIONAL PROPERTIES OF CACTUS PEAR (OPUNTIA SPP.) AND ITS UTILIZATION FOR FOOD APPLICATIONS

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ABSTRACT

Natural products and health foods have recently received a lot of attention both by health professionals and the common population for improving overall well-being, as well as in the prevention of diseases including cancer. In this line, all types of fruits and vegetables have been reevaluated and recognized as valuable sources of nutraceuticals. The great number of potentially active nutrients and their multifunctional properties make cactus pear (*Opuntia spp.*) fruits and cladodes perfect candidates for the production of health-promoting food and food supplements. Recent data revealed the high content of some chemical constituents, which can give added value to this fruit on a nutritional and technological functionality basis. High levels of betalains, taurine, calcium, magnesium, and antioxidants are noteworthy.

KEYWORDS Cactus Pear, Nutraceutical, Cladode, Fruit, PCPS, SPCPS, MCPS.

INTRODUCTION

The cactus pear fruit derived from *Cactaceae* is one of the most morphologically distinct and impressive plant families. This fruit is abundantly found in Mexico and the United States (Piga, 2004), but is also grown in Africa, Madagascar, Australia, Sri Lanka and India (Piga, 2004). The fairly high sugar and acid content gives it a sweet acidic taste. Cactus fruits are usually consumed fresh, but are also put to different traditional and industrial uses (Saenz, 2000). Due to the tasty acidic flavor, succulent texture and long lasting permanence on the plant, the fruit is available throughout most of the year. It is regarded as a valuable food that is consumed as fresh fruit, as a vegetable in salads and sauces, as a main ingredient in desserts, an appetizer, and in alcoholic beverages (Barbera *et al*., 1992a; Joubert, 1993). It is also processed on a small scale in the food industries as a jelly and jam, as whole fruit in syrup or brine to be used to prepare ready-toserve sauces and liquors, among other food products (Sawaya, 1983). Moreover, cactus pear fruit contains betalain pigments which have good potential for use as natural food colorants (Forni *et al.*, 1992).

Constituents

Cactus pear fruits exhibit an ascorbic acid content of 20 to 40 mg/100 g fresh weight, and a titratable acidity of 0.03 to 0.12% with pH values ranging from 5.0 to 6.6. Its soluble solids content of 12- 17% is greater than that present in other fruits, such as prunes, apricots, and peaches (Sepulveda *et al.* 1990, Schmidt-Hebbel *et al.* 1990). Generally, cladodes are rich in pectin, mucilage and minerals, whereas the fruits are good sources of vitamins, amino acids and betalains. While the seed endosperm was reported to consist of arabinan rich polysaccharides (Habibi *et al.* 2005), the principal seed coat component was D-xylan (Habibi *et al.* 2002). In addition to lipids, seeds have been reported to accumulate proanthocyanidines (Bittrich *et al.* 1991). The fruit skin polysaccharide fraction has been subject to thorough investigations (Habibi *et al.*2003, 2004, 2005), whereas the pectin substances in fruit pulp remain to be characterized. The flowers predominantly accumulate betalains and colorless Phenolics (Arcoleo *et al.* 1961, Clark *et al.* 1980, Nair *et al.* 1964, Rösler *et al.* 1966, Shabir *et al.* 1968).

Table1. Main Technological Parameters: Chemical and Mineral Composition of Cactus-pear pulp

Technological Parameters	Range
Pulp (%)	43 – 57
Seeds (%)	2 – 10
Peel (%)	33 – 55
pH	5.3 – 7.1
Acidity (% of citric acid)	0.05 – 0.18
^{0}Brix	12 – 17
Total solids	10 – 16.20
Chemical Composition of the pulp	**Range**
Moisture (%)	84 – 90
Protein (%)	0.2 – 1.6
Fat (%)	0.09 – 0.7
Fibre (%)	0.02 – 3.1
Ash (%)	0.3 – 1
Total sugars (%)	10 – 17
Vitamin C (mg-100g^{-1})	1 - 41
Minerals	**Range**
Ca (mg-100g^{-1})	12.8 -59
Mg (mg-100g^{-1})	16.1 – 98.4
Fe (mg-100g^{-1})	0.4 -1.5
Na (mg-100g^{-1})	0.6 – 1.1
K (mg-100g^{-1})	90 – 217
P as PO_4 (mg-100g^{-1})	15 – 32.8
Amino acids	**Maximum Content (mg/L)**
Proline	1768.7
Glutamine	574.6
Taurine	572.1
Serine	217.5
Alanine	96.6
Glutamic acid	83.0
Methionine	76.9
Lysine	53.3

Functional Properties

Cactus pear is very particular for the presence of betalain, a widely used natural colorant in the food industry. Betalains are nitrogenous chromoalcaloids and their presence excludes that of anthocyanins. Betalains are stable in a pH range of 4 to 7, thus they are particularly indicated as colorants of low-acidic foods. Betalains found in cactus pear are both betacyanins (red-violet colour) and betaxanthins (yellow colour), in amounts comparable to the most betalain rich red beet hybrids, taking the whole fruit into consideration. Nowadays, betalains for food use are extracted from red beet (*Beta vulgaris* (L.) subsp. *vulgaris* cv. rubra), which contains up to 50mg/100g of betanin, a betacyanin. Sáenz *et al*. (1999) detected 100 mg of betanin per 100 g of fresh weight of purple-cactus-pear juice, which was added as a colorant to a yogurt with promising results.

Recently, Castellar *et al.* (2003) found up to 80 mg of betacyanin per 100 g of fresh weight in *O. stricta* fruits. Cactus-pear fruits could, therefore, be an even better source of betalains than red beet, which has some technological and sensory problems due to high levels of the earth-like flavour geosmin. Moreover, the contemporary presence of betacyanins and betaxanthins allows a more wide chromatic interval. Cactus-pear fruits do not contain geosmin or 3-sec-butyl-methoxypyrazine, which confer a heart-like flavor to betalains extracted from red beet, as well as high levels of nitrates and microbial contamination. Besides use as colorants, cactus-pear fruits may be utilised for other applications in food. Forni *et al*. (1994) extracted pectins from *O. ficus-indica* (L.) Mill fruits and their characterisation revealed enough galacturonic acid content for use as a food or cosmetic additive, and a very low degree of methoxylation (10%), suggesting a possible use as a low methoxyl pectin (LMP), and thus as a gelling agent for low caloric foods. Cactus-pear mucilages, in fact, have a high water-holding capacity, so they could serve as thickening or emulsifying agents and form viscous or gelatinous colloids. Recently, Teixeira *et al*. (2000) and Pintado *et al.* (2001) extracted and characterised enzymes from unripe fruits of *O. ficus-indica* (L.) Mill fruits and concluded that these extracts could be a good source of milk-clot enzymes for the dairy industry owing to their pleasant smell and structural properties and because they do not appreciably delay clotting times, unlike other plant rennets. In fact, caseinolitic activity on α_s- and β-caseins in sodium caseinate obtained from bovine, caprine and ovine milk was very similar to that of animal rennet. Lamghari *et al*. (2000) showed that cactus-pear fruit pulp fibres reduced the digestibility of a casein-based diet at the higher extent, compared to arabic gum, carragenan alginic acid, locust bean, and citrus pectin fibres. Hassan *et al*. (1995) obtained a cocoa butter equivalent as a metabolic product of *Cryptococcus curvatus* growth on cactus-pear juice, while Flores *et al*. (1994) were able to obtain economically feasible production of citric acid by solid-state fermentation of cactus-pear peel by *Aspergillus niger*.

Nutraceutical Properties

Amino acids, vitamins and carotenes

Cladodes:

The fresh young stems are a source of proteins including amino acids, and vitamins (tables 2 and 3) (Stintzing *et al.*2002, Teles *et al.*1997, Lee *et al.*2005, Majdoub *et al.*2001).

Fruits:

Various numbers of amino are also found in cactus fruits (table 2). Vitamins are nutritionally important cactus pear fruit constituents (table 3). The fat soluble vitamin E or tocopherols, and beta-carotene are found in the lipid fraction of both the cactus fruit seed and pulp (Ramadan *et al.*2003, Breithaupt *et al.*2001). The vitamin E homologues isoforms gamma- and delta-tocopherol are the main components in seed and pulp oils, respectively, amounting to about 80% of the total vitamin E content (table 4). Similar to beta-carotene, it is predominant in pulp lipids (Ramadan *et al.*2003). Carotenes and vitamin E improve the stability of the fatty oil through their antioxidative properties (Psomiadou *et al.*2001). Ascorbic acid, often erroneously addressed as vitamin C, is the third major vitamin in cactus pears. It is important to note that the total vitamin C content of cactus fruits might have been underestimated due to the presence of dehydroascorbic acid that has not been considered so far. Finally, only trace amounts of vitamin B1, vitamin B6, niacin, riboflavin, and pantothenic acid have been reported (Stintzing *et al.*2000, 2001). Phytochemical investigation of *Opuntia* revealed a great number of amino acids, eight of which are essential (table 2). Cactus fruits contain high levels of amino acids, especially proline, taurine and serine (Stintzing *et al.*2001, Askar *et al.*1981, Tesoriere *et al.*2005), while the seeds are rich in protein (Uchoa *et al.*1998).

Table2. Free amino acids contents in both cladodes (L-amino acids) and fruit pulps from Opuntia *ficus-indica*[1]

Amino acids	Fresh weight basis	
	Cladodes (g/100g)	Fruit juice (mg/L)[2]
Alanine	0.6	87.2
Arginine[3]	2.4	30.5
Asparagine	1.5	41.6
Asparaginic acid	2.1	Not valid
Glutamin acid	2.6	66.1
Glutamine [3]	17.3	346.2
Glycine	0.5	11.33
Histidine[3]	2.0	45.2
Isoleucine	1.9	31.2
Leucine	1.3	20.6
Lysine	2.5	17.4
Methionine	1.4	55.2
Phenylalanine	1.7	23.3
Serine	3.2	174.5
Threonine	2.0	13.3
Tyrosine	0.7	12.3
Tryptophane	0.5	12.6
Valine	3.7	39.4
Alpha-Aminobutyric acid[3]	Not Available	1.1
Carnosine	Not Available	5.9
Citrulline	Not Available	16.3
Ornithine	Not Available	Not detectable
Proline[3]	Not Available	1265.2
Taurine[3,4]	Not Available	434.3

[1]According to (Stintzing *et al.*2001) and (Tesoriere *et al.*2005); [2]Mean values for the pulp from three cultivars. Some amino acids present variations of 1.5 to 3 depending on the respective cultivar (Stintzing *et al.*2001); the total content of free amino acids (257.24 mg/100g) is above average for most fruits except citrus and grape; [3]Amino acids with higher contents in comparison with other fruits (Askar *et al.*1981); [4]8-12 mg/100 g fruit reported (Tesoriere *et al.*2005).

Table3. Vitamin and antioxidant contents of both *Opuntia* spp. cladodes and fruit pulp[1]

Compounds	Fresh weight in cactus pear (per 100g)	
	Cladodes	Fruit pulps
Ascorbic acid	7-22 mg	12-81 mg[2]
Niacin	0.46 mg	Trace amounts
Riboflavin	0.60 mg	Trace amounts
Thiamine	0.14 mg	Trace amounts
Total carotene	11.3 – 53.5 µg	0.29-2.37 g
Beta-carotene	Not available	1.2-3.0 µg
Total Vitamin E	Not available	111-115 µg
Vitamin K_1	Not available	53 µg
Flavonols		
Kaempferol derivatives	Not available	0.11-0.38 g
Quercetin derivatives	Not available	0.98-9 g
Isorhamnetin derivatives	Not available	0.19-2.41g

[1]According to (Stintzing *et al.*2005), (Stintzing *et al.*2001), (Stintzing *et al.*2005), (Tesoriere *et al.*2005) and (Piga. A 2004); [2]Indicates concentrations higher than that of apple, pear, grape and banana (JC Cheftel *et al.*1983) and (Sáenz C. 1985).

Table4. Levels of sterols and fat-soluble vitamin E derivatives in cactus pear (Opuntia *ficus-indica L.*) seed and pulp oils[1]

Components	Seed oil[2] (g/100g)	Fruit pulp oil[2] (g/100g)
Cholesterol	Not detectable	Not detectable
Campesterol	1.66	8.74
Beta- Sitosterol	67.5	11.2
Vitamin E:		
Alpha-T ocopherol	0.56	8.49
Beta-Tocopherol	0.12	1.26
Gamma-Tocopherol	3.3	0.79
Delta-Tocopherol	0.05	42.2

[1]From (Ben *et al.*2005); [2]Data are expressed as g/100g of seed or pulp dry weight.

Minerals, sugars and organic acids

Cladodes:

The cladodes are characterized by high malic acid contents oscillating due to a CAM-based diurnal rhythm (Stintzing *et al.* 2005, Kader A. 2002, Ben *et al.*2005). The mineral and organic acid contents of cactus pads have been reviewed recently (Stintzing *et al.*2005).

Fruits:

Based on various studies on *Opuntia* composition, fruit pulp is considered a good source of minerals (table 5), especially calcium, potassium and magnesium (Stintzing *et al.*2001, Piga a. 2004, Lee *et al.*2005, Gurrieri *et al.*2000). The seeds are rich in minerals and sulphur amino acids (Sawaya *et al.*1983). The fairly high sugar content and low acidity (Sepulveda *et al.*1990, *Joubert et al.1993*) render the fruits a delicious, sweet but sometimes a bland taste. The sugar pattern in the fruit pulp is very simple and consists of glucose and fructose in virtually equal amounts (Russel *et al.*1987, Sepulveda *et al.*1990, Sawaya *et al.*1983, Kuti *et al.*1994), while the organic acid pattern is dominated by citric acid (Stintzing *et al.*2001, Barbagallo *et al.*1998). Due to the high water content of the fruit, a total caloric value of 50 kcal/100 g is attained, which is comparable to that of other fruits such as pears, apricots and oranges (Schmidt *et al.*1990, Sawaya *et al.*1983). Directly absorbed, high glucose concentrations in cactus fruits represent an energy source instantly available for brain and nerve cells, while fructose being sweeter may enhance the fruit's flavor (Cheftel *et al.*1983).

Table5. Mineral contents of *Opuntia* spp. spineless cladode[1] and fruit pulp[2]

Components	Dry weight in cladode (g/100g DW)	Fresh weight in fruit pulp (mg/100g)
Calcium (Ca)	5.64 (5.6)	12.8-59
Magnesium (Mg)	0.19 (0.2)	16.1-98.4
Potassium (K)	2.35(2.3)	90-220
Phosphorus (P as PO_4)	0.15(0.1)	15-32.4
Natrium (Na)	0.4	0.6-1.1
Ferrous (Fe)	0.14µg (trace)	0.4-1.5

[1]Adapted from (Ben *et al.*2005). The numbers in parenthesis represent the percentage of dry weight (DW); [2]From (Piga A.2004) and (Kader A.A.2002).

Lipids

Several authors have suggested cactus pear as a new source of fruit oils (Ramadan *et al.*2003, Barbagallo *et al.*1998, Coskuner *et al.*2003, Ennouri *et al.*2005, Salvo *et al.*2002, Sawaya *et al.*1982). Fruit pulp provides lower yields of oil (0.1-1.0%), representing about 8.70 g total lipid/kg pulp dry weight compared to 98.8 g total lipids/kg for seeds (Ramadan *et al.*2003). Furthermore, it has been shown that the seed oil contains a significant amount of neutral lipid (87.0% of total lipids), while the polar lipids are at higher levels in pulp oil (52.9% of total lipid). Both oils are a rich source of essential fatty acids and sterols. Linoleic acid, as well as beta-sitosterol and campesterol (90% of the total sterols), are the major constituents of the fatty acid and sterol fractions, respectively. Finally, the peel fraction contains 36.8 g lipids per kg (Ramadan *et al.* 2003). It is important to remember that fat soluble vitamins such as alpha-, beta-, delta-, and gamma-tocopherols, vitamin K1 and beta-carotene are associated with the cactus fruit seed and pulp oils, and will prevent the lipid fractions from oxidative damage (table 3). This fact corroborates the understanding that whole fruit consumption is more reasonable than the ingestion of fruit isolates.

The fatty acid composition of prickly pear seed oil is similar to sunflower and grape seed oils as reported by (Tan *et al.*2000). Notwithstanding, the levels of total lipids, sterols and fat soluble vitamins may depend on the fruit cultivar, degree of ripeness and fruit processing, and/or storage conditions.

Phenolic Compounds

Phenolics comprise a wide variety of compounds, divided into several classes such as hydroxybenzoic acids, hydroxycinnamic acids, anthocyanins, proanthocyanidins, flavonols, flavones, flavanols, flavanones, isoflavones, stilbenes and lignans, that occur in a great number of fruits (grapefruits, oranges, berries, dark grapes, apples, etc.) and vegetables (onions, broccoli, cauliflower, Brussels sprouts, tomatoes, peppers, etc.), wine, tea, chocolate and other cocoa products in varying quantitative and qualitative amounts (Pelegrinin *et al.*2000, Manach *et al.*2004, Ross *et al.*2002, Cieslik *et al.*2006).

Cladodes:

The phenolic composition and their specific effects on human metabolism have been recently reviewed (Stintzing et al.2005).

Fruits:

The presence of phenolics has been detected in cactus pulp fruit (Tesoriere *et al.*2005, Butera *et al.*2002, Kuti *et al.*1992). Kuti *et al.* 1992 has reported an antioxidative effect due to the major flavonoids encountered in cactus fruits (quercetin, kaempferol and isorhamnetin; table 3). There is clear evidence that these compounds are more efficient antioxidants than vitamins, since phenolic compounds are able to delay prooxidative effects on proteins, DNA and lipids by the generation of stable radicals (Shahidi *et al.*1992). Furthermore, O. *ficus indica* polyphenolic compounds have been shown to induce a hyperpolarization of the plasma membrane and to raise the intracellular pool of calcium in human Jurkat T-cell lines (Aires *et al.*2004). Flavonol derivatives detected in *Opuntia ssp.* Have been recently compiled (Stintzing *et al.*2005, Iwashina *et al.*2001). When fruits are investigated, it must be taken into account that higher phenolic contents are expected in the peel, rather than the pulp. Consequently, from a nutritional point of view processing both peel and pulp appears to be advantageous.

Betalains

The most obvious feature of cactus pear fruits and flowers are the yellow (betaxanthins) and red (betacyanins) betalains, nitrogen-containing vacuolar pigments that replace anthocyanins in most plant families of the Caryophyllales including the Cactaceae (JP Zryd *et al.*2004). While their characterization in cactus flowers has been scarce (Alard et al.1985), their identification in cactus pear fruit has been of renewed interest recently (Stintzing *et al.*2005, Castellar *et al.*2003, Stintzing *et al.*2002). In addition to color, the same pigments have shown antioxidant properties being higher than for ascorbic acid (Stintzing *et al.*2005, Tesoriere *et al.*2005).

In conclusion, the specific particularities of cactus pear make it useful in several arenas: nutrition, traditional medicine and further industrial applications (Gurbachan et al.1998, Sáenz et al.).

Food Applications

Opuntia pulp has been utilized in processing indigenous products such as *Queso de tuna* and *Melcocha* (Sáenz- Hernandez, 1995; Ortiz-Laurel and Mendez- Gallegos*,* 2000); fruit sheets (Sepúlveda *et al.*, 2000); alcoholic beverage such as *Colonche* (Sáenz, 2000); minimum processed products (Piga *et al.*, 2000, 2003; Corbo *et al.*, 2004); canned and frozen products (Cerezal and Duarte, 2005; Sáenz-Hernandez, 1995; Sáenz and Sepúlveda, 2001); jams (Sawaya *et al.*, 1983); syrups (Joubert, 1993); juice products (Sáenz and Sepúlveda, 2001); dehydrated products (Lahsasni *et al.*, 2004; Rodríguez-Hernández *et al.*, 2005) and alcoholic beverages (Lee *et al.*, 2000).The fairly high sugar and acid content gives it a sweet acidic taste. Cactus fruits are usually consumed fresh, but are also put to different traditional and industrial uses (Saenz, 2000). Due to the tasty acidic flavor, succulent texture and long lasting permanence on the plant, the fruit is available throughout most of the year. It is regarded as a valuable food that is consumed as fresh fruit, as a vegetable in salads and sauces, as a main ingredient in desserts, an appetizer, and in alcoholic beverages (Barbera *et al.*, 1992a; Joubert, 1993). It is also processed on a small scale in the food industries as a jelly and jam, as whole fruit in syrup or brine to be used to prepare ready-toserve sauces and liquors, among other food products (Sawaya, 1983). Moreover, cactus pear fruit contains betalain pigments which have good potential for use as natural food colorants (Forni *et al.*, 1992). In Laikipia, the Twala Women's Group has developed syrup from the sweet fruit of *Opuntia* cactus for marketable products. The syrup is currently used to prepare "tea" (beverages with hot water and sugar) and specialized alcoholic cocktails (Drunken Monkey and Twala Twister) in the tourist lodges. The fruit is also usually eaten raw after peeling because of the sweet and juicy flesh though enclosing many small seeds. The syrup as processed by the women is, however, highly perishable and has to be stored frozen under refrigeration to retain wholesomeness and organoleptic properties.

Table6. Potential products and by-products from cactus pear fruit and cladode[1]

Products from Fruits	Products from Cladodes	By-products from Fruits and cladodes
Juice, nectar, pulp, puree	Lacto-fermented pickles	Oil from seeds
Jam, jelly	Candy	Oil from fruit pomace
Fruit leather	Jam	Pigments from pomace
Syrup, sweetener	Flour	Diatary fibre and mucilage from cladodes
Bioethanol, wine, "colonche"	Cooked Vegetable	
Canned fruit	Ethanol	
Frozen fruit	Edible coating	
Juice concentrate		
Spray-dried juice power		

[1]According to (Stintzing *et al.*2005, Ramadan *et al.*2003, Joubert *et al.*1993, Sawaya *et al.*1983, Sáenz et al.2000, Bustos *et al.*1981, Essa *et al.*2002, Ewaidah *et al.*1992, Lee *et al.*2000, Moreno *et al.*2003, Sépúlveda et al.2000, Sáenz et al.2001, Moßhammer et al.2005).

Processed Products

Peeled cactus pears in syrup:

Whole cactus pears without skins were prepared in syrup with the addition of sucrose, and a phosphoric and citric acid mixture (50% v/v) to obtain in the final product, pH = 4.0–4.2, water activity (A_w) = 0.96 (≈ 20°Brix). The calculation of sucrose concentration in the syrup to obtain the A_w in equilibrium was performed using Ross equation that is expressed as $A_{w\ equilibrium} = (A_{w\ fruit})\ (A_{w\ syrup})$, where Aw fruit and Aw syrup are the initial water activities of the fruit and the sucrose syrup, respectively.Water activity ≈ 0.99 for fresh cactus pears was assumed, but the value $A_{w\ syrup} = 0.97$ was calculated. The sucrose syrup concentration was determined by Norrish equation according to $A_{w\ sucrose\ syrup} = X_1 \exp(-KX_2^2)$, where $X1$ and $X2$ are water and sucrose molar fractions, respectively, and K value is a constant whose value is 6.47 for sucrose (Alzamora 1997; Welti and Vergara 1997; Barbosa-Canovas *et al.* 2003). PCPS was also prepared using added potassium sorbate, ascorbic acid and calcium chloride in concentrations of 1,000, 500 and 120 ppm, respectively. The relation of weight drained to syrup was considered in 60:40 (w/w), and it was poured and sealed in glass jars of 440 mL of capacity with twist-off lids (Cerezal and Duarte 2004).

Sweetened pulp from cactus pears with partial addition of their skins:

Ground cactus pear fruits, without skins and seeds, with skins ground incorporated (in pulp–skins relation of 3:1), sucrose addition to obtain in the final product, Aw = 0.94 (ª40°Brix); pH = 3.2–3.4 was obtained by the addition of phosphoric acid solution, 50%, as well as potassium sorbate, ascorbic acid and sodium bisulphate in concentrations of 1,000, 500 and 100 ppm, respectively. They were poured and thermally sealed in polyethylene bags (Cerezal and Duarte 2005b).

Marmalade from cactus pear skins:
Ground cactus pear skins were mixed with sucrose, citric acid and potassium sorbate to obtain in the final product a soluble solid concentration of 63°Brix, pH = 4.0 and 250 ppm, respectively. They were poured and sealed in glass jars of 440 mL capacity with twist-off lids (Cerezal and Duarte 2005b). The main physical and chemical characteristics of the three products are shown in Table. The sensorial evaluation conducted by trained tasters, directed only to the texture characteristic (PCPS) and consistency (SPCPS and MCPS), produced the results that are shown in Table 2. In these cases, the technique of characterization by means of scale by attributes was used. All characteristics were evaluated on a 10-cm linear scale, with verbal anchors on the extremes. However, each attribute had a maximum value of 5 points (Cerezal and Duarte 2004, 2005b).

Table7. Composition data of the Processed Products

Determinations (Average of five observations)	PCPS	SPCPS	MCPS
Soluble solids (°Brix)	19.8	40.0	63.5
Moisture content (%)	75.48	50.41	37.03
Total solids (%)	24.25	49.59	62.97
pH	4.20	3.34	3.94
Acidity (% citric acid)	0.10	0.33	0.25
Crude fiber (%)	2.30	0.19	-
Pectin (%)	0.08	0.28	-

CONCLUSIONS

If we consider that a number of uses and application of cactus-pear fruits are possible, we realize the importance of this crop to human food, in all its aspects. The health-promoting capacity of cactus pear, although not yet confirmed clinically, might be very attractive to the growing market for "nutraceutical foods". The importance of extractable colorants from some cactus-pear varieties should not be forgotten. The increasing demand for natural rather than synthetic colorants for drinks and dairy products could benefit cactus pear. Sophisticated analytical approaches and innovative processing technologies will open new avenues to further promote the use of cactus pear stems, fruits and flowers in food, medicine, cosmetic, and pharmaceutical industries.

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