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REVIEW PAPER

Nutritional Importance of Cactus: A Review

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ABSTRACT

Cactus (*Opuntia ficus indica*)originated in Mesoamerican civilizations particularly to the Aztec culture. Tender cactus leaves, flowers and fruits can be eaten as a vegetable in many parts of the world. It contains highly important nutrients, such as betalains, amino compounds including taurine, minerals, vitamins, as well as antioxidants so that it is having excellent and wide scope for nutraceutical and food industry to prepared value added products from it. This review presents an overview of the nutritional, medicinal, and physiological properties of this fruit.

Keyword *Cactus, Opuntia, Nutritional food, Antioxidants, betalains.*

Interest in *Opuntia* (also known as *cactus pear*) dates back many thousands of years. Its origin and history are closely related to the ancient Mesoamerican civilizations and particularly to the Aztec culture. Archaeological evidence confirms that these plants were first cultivated by indigenous populations who settled in the semi-arid regions of Mesoamerica (Pimienta 1990). Cactus pear and other cacti were probably among the plants and animals brought to Spain by Christopher Columbus as samples of the exotic flora of the New World. When the Spaniard Hernán Cortés arrived in the Valley of Mexico in 1519 he was amazed at the attractive and delicious fruits of the *nopalli* plant (Náhuatl term for cactus pear plant), called *nochtli* in Náhuatl (Barbera 1999). The *Opuntia* species is known by different names in the various countries where it is found. The original name, in the Náhuatl language, is *nochtli*. Notwithstanding, the Spanish renamed the plant *chumbera* and the fruit *higo de las Indias*(Indian fig), which today is known as *higo chumbo.* In Italy, it is known as *ficod'India,* in France as *figue de Barbarie* and in Australia, South Africa and the United States, as prickly pear. This is slowly evolving into the name cactus pear, to reduce the negative connotation of the word 'Prickly' (meaning 'with spines'). In Israel, it is known as *sabras*, meaning 'spiny outside but sweet inside'. In Eritrea and Ethiopia, it is called *beles*. In India, it is called in a local dialect *nagphani* or *andatorra* or *chapathi balli* depending on the region. In Brazil, it is known as *palma forrageira* because it is cultivated mainly as forage for livestock.

Opuntias are creeping or upright shrubs that can grow to 3.5–5 m high. The succulent and jointed cladodes (stems)have an oval or elongated racquet shape that can grow up to 60–70 cm long depending on the amount of water and nutrients available (Sudzuki and others 1993). When the cladodes are around 10–12 cm long they are tender and can beaten as a vegetable. The areoles have two types of spine in their cavity: small and large. The small ones, grouped in large numbers, are called 'glochids' (*aguates* in Mexico) and the large ones are modified leaves according to some authorities (Granados and Castañeda 1996). When people come into contact with the plant, spines are released that may penetrate the skin, and this can be a serious impediment when harvesting, processing and eating the fruit.

In most parts of the world the plants flower once a year, although in Chile, under certain environmental conditions and with water supplied during summer, there is a second flowering in autumn (March), which explains the origin of the name *inverniza* for this fruit (Sudzuki and others1993).Chessa and Nieddu(1997) and Ochoa (2003) described the types of fruit – ovoid, round, elliptical and oblong with flat, concave or convex borders. Colours vary through red, orange, purple, yellow and green with pulp of the same colours. The epidermis of the fruit is similar to that of the cladode, including areoles and abundant glochids and spines, which differ from cladodes in that they remain even after the fruit has over-ripened. The thickness of the fruit peel is variable, as is the amount of pulp. The latter contains many seeds, normally eaten with the pulp. Some fruit show aborted seeds, which increases the proportion of edible pulp. Given the preference in some markets for seedless fruit or for fruit with low seed content, genetic improvement as focused upon identification and multiplication of varieties with this characteristic (Mondragón-Jacobo 2004).

The growing demand for nutraceuticals is paralleled by an increased effort in developing natural products for the prevention or treatment of human diseases. According to several studies demonstrating both cactus fruit and cladode yielding high values of important nutrients, such as betalains, amino compounds including taurine, minerals, vitamins, as well as further antioxidants, the cactus pear (*Opuntia spp.*) appears to be an excellent candidate for the inclusion in food. Even though Native Americans and ancient medicine have realized its anti-diabetic and anti-inflammatory function, *Opuntia spp.* have hardly been considered in the development of health promoting food, most probably due to the scattered information available. In addition, cactus pear has been mainly ignored by the scientific community until the beginning of the1980s when several studies and reports were published on their biological functions. More recent investigations on the chemical components and the nutritional value of *Opuntia spp.* have attracted attention both in food, nutritional, and even pharmacological science. However, the scarcity of studies into the respective mechanism of positive actions on human metabolism still renders cactus products unpopular and thus undeveloped. Therefore, the present review provides an overview on *Opuntia* fruit and cladode constituents including their pharmacological actions described so far to offer a scientific basis for future studies and to achieve a more widespread recognition of this valuable crop. The human medical potential of *Opuntia* depends on its tissue composition several research studies have been carried out on the chemical composition of the cladodes than the fruits, because of a larger utilization of the cladodes as forage for animal food (Hegwood 1990).

The fruits of cactus pear, a plant spread over the Mediterranean and other warm areas of the planet, are characterized by phytochemicals such as betalains (Piattelli and others1964),unique pigments poorly represented among edible vegetables. Beneficial properties of these fruits have recently emerged. The previous report showed that a 2 weeks supplementation with fruits of the Sicilian cactus pear decreased the level of plasma markers of oxidative stress and of lipid hydroperoxides of circulating low-density lipoprotein(LDL) in healthy humans, an effect which has appeared independent of the consumption of vitamin C with the fruit (Tesoriere and others2004). Betanin and indicaxanthin, the betalain pigments occurring in the cactus pear fruit, long known as safe foodcolorants have recently been investigated as antioxidant compounds. Because of their redox properties these molecules can scavenge effectively variousradicals generated in chemical as well as biological systems. Both phytochemicals have been shown to inhibit microsomal membrane oxidation and the oxidation of human LDL in vitro. More importantly, as dietary components, betanin and indicaxanthin are bioavailable and have recently been evaluated in human plasma and LDL over an 8 h period after the consumption of cactus pear fruits. To further investigate the post-absorptive distribution of betalains, in this work we checked the presence of betanin and indicaxanthin in human red blood cells (RBCs) after a meal consisting of cactus pear fruit pulp.

Physico- Chemical composition

In order to utilize the plant industrially it is essential to ascertain the chemical composition of its different parts. This helps in determining the most appropriate processing technologies and the conditions required to achieve safe, nutritious and high-quality products. The fruits and cladodes are widely used for food, but the flowers are considered as a vegetable and can be eaten as such Changes in the pH and the soluble solids and fiber content occur during ripening and must betaken into account when processing fruit or cladodes to produce the best possible products (Villegas 1997). The different parts of cactus pear are shown in the figure 1.

The fruit are non-climacteric fruit and it is very important to collect them at the optimal ripened stage for processing and/or marketing and/or consumption. Inglese (1999) and Cantwell (1999)proposed different parameters to define the best time for harvesting the fruit: size, fill of the fruit, changes in peel colour, firmness of the fruit, depth of the flower cavity or receptacle, total soluble solids content (TSS) and fall of the glochids. As there is no single index for harvest, a number of authors recommend that this should be defined for each type of fruit in each cropping area. The TSS increases rapidly as the pulp begins to expand (e.g. 40–50 days after fruit set) and when the colour of the peel begins to change. When the peel coloration is halfway towards that of the fully ripened fruit, the TSS is12–15 percent, depending on the cultivar. At this stage, the fruit is at its best quality for consumption or storage. Although the TSS increases slightly in fully ripened fruit, by this stage the fruit is not in the best condition for storage and is

Cladode **Flowers** **Fruits**

Fig. 1. Different parts of cactus pear

Table 1. Physical changes and composition of pear fruits during ripening

State of ripening	Weight (g)	Diameter (cm)	Pulp %	Firmness ($Kgcm^{-2}$)	TSS (^{0}Brix)	Acidity (%)	pH	Vit C Mg/100g
Unripe	86	42–44	44	4.6	7.5	0.08	5.2	12
Green	102	47–49	57	3.7	8.8	0.04	6.1	18
Intermediate	105	49–53	63	2.7	10.1	0.03	6.2	18
Ripe	112	50–54	65	2.4	11.5	0.02	6.3	26
Over ripe	108	49–53	75	2.2	12.5	0.02	6.4	28

Source: (Sáenz and Berger 2006)

too soft for handling. Table 1 indicates the most significant changes taking place in *Opuntia amyclaea* during ripening (Sáenz and Berger2006).

The sugar, TSS and vitamin C content increase considerably during the ripening process, while firmness and acidity fall. The changes described for *Opuntia amyclae* are similar to those reported for fruit of other *Opuntia* spp. (Barbera and others1992; Kuti 1992).However, not all *Opuntias* show the same behavior during ripening. Studied these changes in three *Opuntias* commonly consumed in Mexico: *Opuntia ficusindica, Opuntia sp.* and *Opuntia streptacantha*, which are early-, medium- and late-ripening varieties respectively. Harvest time (ripeness for consumption) was determined in the field by producers and based on the colour and texture of the fruit.The pH level evolves as ripening progresses. This is clear in the cases of *Opuntia streptacantha*, *Opuntia ficus-indica* and *Opuntia* spp. The first species shows low pH values (of around pH 3) when ripening is incipient, which later increases to pH 6. The other two species do not show any changes in pH during ripening, with values remaining constant at close to pH 6. The increase in TSS content in all three species reaches similar levels of around 14 ºBrix (Barbera and others1992; Kuti 1992).

The loss of fruit firmness with ripening has also been noted by Nieddu and others (1997) for fruits of cultivar *Gialla* grown in Sardinia, Italy. The chemical composition of the edible parts of the fruit is generally published by national authorities in tables of the chemical composition of foods, and is typical of the plants that cover the entire country or specific regional zones. However, plant composition varies depending on a variety of factors, including areas of cultivation. In the case of fruit, for example, chemical composition is affected by ripening. It is essential to have some knowledge of the characteristics of the species and its adaptation to local conditions before starting to process it. The edible part of the cactus pear fruit consists of pulp and seeds. Pulp yield is an important factor to consider for processing and studies by various authors have shown that the quantity of peel varies according to the zone of cultivation. Sepúlveda and Sáenz (1990), working with *Opuntia ficus-indica* cultivated in Chile, found that the proportion of peel was 50.5 g (100 g)-1 of pulp, and 49.6 g(100 g)-1 of edible components (pulp and seeds) of which 78.9 g (100 g)-1 was pulp and 20.1 g (100 g)-1was seeds. For fruit cultivated in Saudi Arabia found 88 g (100 g)-1 of pulp and 12 g (100 g)-1 of seeds in edible components forthe same species. In Argentina, the percentage of pulp found was 54.7 g (100 g)-1 and 42.3 g (100 g)-1of peel and seeds (Rodríguez and others 1996).A number of authors have conducted studies on the chemical composition of the cactus pear fruit (Sawaya and others 1983). Table 2 shows the chemical composition of the edible part of fruit from plants cultivated in different regions of the world: Argentina, Chile, Egypt, Mexico and Saudi Arabia. Water is the main component of the fruit, which is valuable

Table 2. Chemical composition of the pulp of cactus pear fruit reported by different author

Parameter	a	b	c	d	e	f
Moisture (%)	85.1	91	85-90	85.6	83.8	84.2
Protein (%)	0.8	0.6	1.4-1.6	0.21	0.82	0.99
Fat (%)	0.7	0.1	0.5	0.12	0.09	0.24
Fibre (%)	0.1	0.2	2.4	0.02	0.23	3.16
Ash (%)	0.4	--	--	0.44	0.44	0.51
Total sugar (%)	--	8.1	10-17	12.8	14.06	10.27
Vit C mg/100g	25	22	4.6-44	22	20.33	22.56

Source: (a) Askar and El-Samahy (1981); (b) Muñoz de Chávez and others(1995); (c) Pimienta(1999); (d) Sawaya and others(1983);(e) Sepúlveda and Sáenz (1990); (f) Rodríguez and others(1996).

Table 3. Chemical composition of cactus pear fruit pulps (%)

Parameter	Green fruit	Purple fruit	Orange fruit
Moisture	83.8	85.98	85.1
Protein	0.82	0.38	0.82
Fat	0.09	0.02	-
Fiber	0.23	0.05	-
Ash	0.44	0.32	0.26
Total sugar	14.06	13.25	14.8
Vitamin C	20.33	20	24.1
β-carotene	0.53	-	2.28
Betanin	-	100	-

Source: Saenz and Sepulveda (2001),Saenz and Moreno (1995) Sepulveda and Saenz (1990)

in arid and semi-arid regions. Water content is protected by the peel, which is thick and rich in mucilage. The mucilage binds the water strongly and helps prevent fruit dehydration. Variations can be attributed to: the location of plants; the agronomy of cultivation; the application of fertilizers and irrigation use; climate; and genetic differences between the varieties (Muñoz de Chávez and others1995).

There are insignificant variations in the chemical composition of the fruit of *Opuntias* of different colours (Table 3) (Sáenz andSepúlveda 2001; Sáenz and others1995; Sepúlveda and Sáenz 1990). The studies explored macroelements and mineral components of *Opuntias* of different colours: green, purple and orange fruit were considered with pulp of the same colour. The variations in content of some of the minerals in the fruits can be attributed to their different origins those used for *O. ficus-indica* with pH in the region of 6.0 or more. The lower pH of *O. xoconostle* is a protective factor that inhibits the growth of harmful micro-organisms, which makes products obtained from this species safer for consumers.

Vitamins

Vitamins are nutritionally important cactus pear fruit constituents (table 4). Lipid fraction of fruit and seed of cactus contain fat-soluble vitamin E or tocopherols (Ramadan and others2001). The vitamin E homologues isoforms gamma- and delta-tocopherol are the main components, amounting to about 80% of the total vitamin E content found in fruit pulp. Vitamin E is well known for its antioxidant property, which improve the stability of the fatty oil. Ascorbic acid is 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 B2, and vitamin B3 have been reported (Stintzing and others2000).

Table 4. Distribution and contents of vitamins in the fruit and cladode(Mg/100g)

Vitamin	Fruit	Cladode
K	53.2	---
C	20-25	7-22
B1	---	0.14
B2	---	0.60
B3	---	0.46
α-Tocopherol	84.9	---
β-Tocopherol	12.6	---
γ-Tocopherol	7.9	---
σ-Tocopherol	422	---
Total vitamin E	527.4	---

Amino acid

Phytochemical investigation of cactus contains great number of amino acids, it also include eight essential amino acids also. Cactus fruits contain high levels of amino acids, especially proline, taurine and serine (table 5) (Uchoa and others 1998), whereas cactus cladodes, the major amino acid detected is glutamine, followed by leucine, lysine, valine, arginine, phenylalanine and isoleucine. Fascinatingly, Proline and taurine are two predominant amino acids, which represent 46% and 15.78% of the total amino acid content, respectively in cactus fruit. Thus, fruit seeds and pulp can be considered as very good sources of amino acids and proteins (El-Mostafa and others 2014).

Mineral Content

Based on earlier research, it is concluded that cactus fruit pulp is considered a rich source of minerals (Table 6), especially calcium, potassium and magnesium. In pulp, potassium is present at 161 mg/100 g, exceeding the concentration of other minerals like calcium and magnesium

Table 5. Amino acid contents of fruit and cladode from prickly pear

Amino acid	Cladode (g/100g)	Fruit juice (mg/L)^2
Alanine	0.6	87.2
Agrenine	2.4	30.5
Asparagine	1.5	41.6
Asparaginic acid	2.1	Trace
Glutamic acid	2.6	66.1
Glutamine	17.3	346.2
Glycine	0.5	11.33
Histidine	2.0	45.2
Isoleucine	1.9	31.2
Lycine	1.3	20.6
Metheinine	1.4	55.2
Phenylanine	17	23.3
Serine	3.2	174.2
Threonine	2.0	13.3
Tyrocine	0.7	10.3

Source: Majdoub and Others 2001

(El-Mostafa and others 2014).

Bioactive components

The presence of phenolics has been detected in cactus pulp fruit (Askar and El-Samahy 1981,2005). The antioxidative effect of cactus pulp was due to presence of major flavonoids i.e. quercetin, kaempferol and isorhamnetin (Kuti 1992). Earlier literature shows 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. Furthermore, polyphenolic compounds found in cactus 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. Flavonol derivatives detected in *Opuntia ssp.* have been recently compiled. 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.

Several researchers have been reported that cactus pear as a new source of fruit oils (Ramadan and Mörsel2003). Fruit pulp contains 0.1-1.0% of oil, representing about8.70 g total lipid/kg pulp on dry weight compared to 98.8 g total lipids/kg for seeds (Ramadan and Mörsel2003). 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). These oils are a rich source of essential fatty acids as well as sterols (Table 7). Linoleic acid, as well as beta-sitosterol and campesterol (90% of the

Table 6. Mineral Content of Cactus (mg/100g)

Mineral	Fruit Pulp	Cladode
Calcium	27.6	5.64-17.95
Calcium oxalate	---	11.5-14.3
Magnesium	27.7	8.80
Sodium	0.8	0.3-0.4
Potassium	161	2.35-55.20
Iron	1.5	0.09
Phosphorus	---	0.15-2.59
Zinc	---	0.08
Manganese	---	0.19-0.29

Source : El-Mostafa and others 2014

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. 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 and others 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.

Table 7. Sterols contents in the various parts of the *cactus* (g/kg)

Constituents	Pulp	Seed
Campesterol	8.74	1.66
Stigmasterol	0.73	0.30
Lanosterol	0.76	0.28
β-Sitosterol	11.2	6.75
Δ5-Avenasterol, Δ7-Avenasterol	1.43	0.29
Δ7-Avenasterol	---	0.05

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 (Figure 1). While their characterization in cactus flowers has been scarce, their identification in cactus pear fruit has been of renewed interest recently(about 100mg /100g). In addition to color, the same pigments have shown antioxidant properties being higher than for ascorbic acid. In conclusion, the specific particularities of cactus pear make it useful in several areas: nutrition, traditional medicine and further industrial applications. betanin and indicaxanthin incorporate in RBCs after the consumption of cactus pear fruit pulp and may support the hypothesis that these compounds are involved in the increased resistance of the cells to induced oxidative

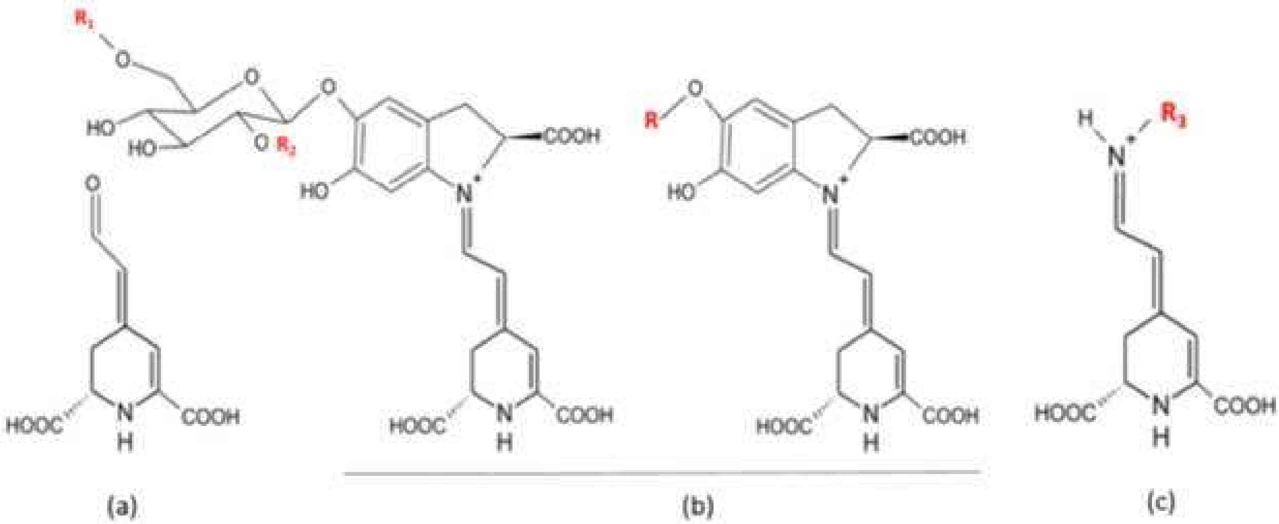

Fig. 2. General structure of (a) Betalamic acid, (b) Betacyanins (c) Betaxanthins (El-Mostafa and others 2014).

injury (Stintzing and others 2002).

NUTRACEUTICAL IMPORTANCE

As with numerous fruits and vegetables cactus plants have also been reported to be beneficial to health. These effects are demonstrated in the treatment of several diseases. However, most accessible information on pharmacological studies deal with cactus stems rather than the fruit, the former being even less frequently encountered in non-producing countries.

Anti-cancer effect

According to the recent studies, the cactus pear fruit extract (i) inhibits the proliferation of cervical, ovarian and bladder cancer cell lines *in vitro,* and (ii) suppresses tumor growth in the nude mice ovarian cancer model *invivo (*El-Kossori and others1998). These studies proven that inhibition was various dose i.e. 1, 5, 10 and 25% cactus pear extract with treatment time of 1, 3 or 5days as per the *in vitro*-cultured cancer cells. The intra-peritoneal administration of cactus extract solution into mice did showed weight in animal, which shown that cactus did not have toxic effect. More importantly, tumor growth inhibition was comparable to the synthetic retinoid N-(4-hydroxyphernyl) retinamide (4-HPR), which is currently used as a chemo-preventive agent in ovarian cancer chemoprevention (Supino and others 1996; Veronesi and others1999). Growth inhibition of cultured-cancer cells was associated with an increase in apoptotic cells and the cell cycle arrest at the G1-phase. Additionally, the persuaded growth inhibition appears on the P53n pathway, which is the major tumor suppressor. Annexin IV was increased and the VEGF decreased in the tumor tissue obtained from animals having received the cactus solution. The constituents and mechanism of action by cactus pear extract is not yet explicated. However, first an extrinsic effect through an activation of membrane death receptors such as tumor necrosis factor, nuclear factor kappa B, Fas appears to be feasible. Secondly, intrinsic actions via the mitochondria, playing a pivotal role by releasing a number of molecules favorable to the induction of apoptosis such as Bax, AIF, cytochrome C, reactive oxygen species such anion superoxide may be considered. Further investigations are needed to identify the potential active component(s) and the respective underlying mechanisms (Zou and others2005).

Anti-oxidant properties

The antioxidative action is one of many mechanisms by which fruit and vegetable substances might exert their beneficial health effects (Steinmetz and Potter 1996). The presence of several antioxidants has been identified in the fruits and vegetables. More recently, the antioxidant properties of cactus pear were reported due to presence of betalains (betanin and betaxanthin) (Osuna-Martínezand others 2014; Stintzing and others 2002). Various*in vitro* studies have reported the beneficial effect of colorless phenolics and betalains (Tesoriere and others 2004). These are generally attributed to the ability of antioxidants to neutralize reactive oxygen species such as singlet oxygen, hydrogen peroxide or suppression of the xanthine/ xanthineoxidase system, all of which may induce oxidative injury, i.e. lipid peroxidation. Polyphenolics are antioxidants with well-known cardioprotective, anticancer, antiviral and antiallergenic properties (Carbo and others 1999). Polyphenols are also potential modulators of the transcription factors' activities (Ahmad and others 2000),which is more likely through a calcium-dependent pathway. Indeed, cactus polyphenolics induce a rise of the intracellular pool of calcium ions from the endoplasmic reticulum and thus perturb the expression of the interleukin, which is associated with the S-phase transition in human Jurkat T-cells . These effects remain to be verified in cancer cells(Aires and others 2004).

Anti-viral effect

An interesting study by Ahmad and others (1996) on started that administration of a cactus stem extract(*Opuntia* *streptacantha*) to mice, horses, and humans inhibits intracellular replication of a number of DNA- andRNA-viruses such as Herpes simplex virus Type 2, Equineherpes virus, pseudorabies virus, influenza virus, respiratory syncytial disease virus and HIV-1. Aninactivation of extra-cellular viruses was also reported by the same authors. However, the active inhibitory component(s) of the cactus extract used in this study was not investigated, and as of yet, no further study dealt with this specific topic.

Anti- inflammatory effect

Numerous studies have evocated the analgesic and anti-inflammatory actions of the genus *Opuntia* byusing either the fruit extract from *Opuntia dillenii* (Loro and others1999),the lyophilized cladodes (Galati and others 2001), or the phytosterols fromfruit and stem extracts. Identifiedbeta-sitosterol as the active anti-inflammatory principle from the stem extract. Gastric lesions in rats were reduced byboth stem and fruit powders (Galati and others 2001).Finally, betanin and betaxanthin stimulated an inhibitory effect on the chlorination activity of myeloperoxidase at neutral rather than at pH 5 (Allegra and others 2005).

Anti-diabetic (type II) effect

The prickly pear cactus stems have been used traditionally to treat diabetes in Mexico (Domínguez1995). Nowadays, *Opuntia spp.* is amongst the majority of products recommended by Italian herbalists that may be efficacious in reducing glycemia (Cicero and others 2004). Some studies have demonstrated the hypoglycemic activity of the prickly pearcactus extract on non-diabetics and diabetic-induced rats or diabetic humans (Ibanez-Camacho and Roman-Ramos 1979). In a study on rats, the combination of insulin and purified extract of cactus (*Opuntia fuliginosa* Griffiths) was found to reduce blood glucose and glycated hemoglobin levels to normal (Trejo-González and Others1996). In this study, the oral dose of extract (1 mg/kg body weight per day) necessary to control diabetes contrast with the high quantities of insulin required for an equivalent hypoglycemic effect. A recent study has proven that, when rats' feed with diets containing cactus seed oil (25mg/kg) decreases the serum glucose concentration, which is associated with a glycogen formation in the liver and skeletal muscle (Ennouri and others 2006). These observations were explained by a potential induction of insulin secretion, converting glucose to glycogen. In the forthcoming, it should be recalled that a clear differentiation between stem and fruit constituents are required to pin down the mostpharmacologically active plant parts (Trejo-González and others 1996).

Anti- hyperlipidemic and hypercholesterolemic effects

Earlier literature reviewed that cactus pear lower down blood cholesterol levels inhuman and alter low density lipoprotein (LDL) composition (Frati 1992; Galati and others 2001). Biological activity of cladodes of Opuntia ficus indica have found that the cholesterol, LDL and triglyceride of plasma levels of rats were significantly decreased after 30 days of a daily administration (1 g/kg) of lyophilized cladodes of *cactus.* Sterols, which consists of the bulk of the unsaponifiables in any oils have ability to lower blood LDL-cholesterol by approximately 10–15% (Ennouri and others 2006). They also noted decrease in plasma total cholesterol and LDL (VLDL) cholesterol with no effect on HDL-cholesterol concentrations after addition of seed oil (25 g/kg) to the diet of rats. Overall, the effects of cactus are generally attributed to the high fiber content of the cladodes, although other bioactive constituents (such as beta-carotenes, vitamin E and beta-sitosterol) may be involved (Fernandez and others 1992)

Further positive health effects

Traditionally in folk medicine, cactus fruits, cladodes or flower infusions have been utilized to treat other ailments such as ulcers, allergies, fatigue and rheumatism, and as an antiuric and diuretic agent(Galati and others 2004). Alleviating effects towards alcohol hangover symptoms have been addressed recently and were associated withreduced inflammatory responses after excessive alcohol consumption. Amongst the flavonoids extracted from either the cactus stem or fruit, quercetin 3-methyl appears to be

Table 7. Nutraceutical activity of different parts of *Opuntia ficus indica*

Nutraceutical Importance	Plant part used	References
Anticancer effect	Pear fruit extract	Zou and others 2005; Veronesi and others 1999; El Kossoriand others1998; Supino and others 1996;
Antioxidant effect	Pear fruit extract	Aires and others 2004; Tesoriere and others 2004; Stintzing and others 2002; Ahmad and others 2000; Carbo and others 1999; Steinmetz and Potter 1996;
Antiviral effect	Stem extract	Ahmad and others 1996
Antiimflammatory effect	Fruit extract	Allegra and others 2005; Galati and others 2001; Loro and others 1999
Antidiabetic effect	Stem extract	Ennouri and others 2006; Cicero and others 2004; Trejo-González and Others 1996 López 1995; Ibanez-Camacho and Roman-Ramos 1979
Anti- hyperlipidemic and hypercholesterolemic	Cladodes	Ennouri and others 2006; Galati and others 2001; Fernandez and others 1992Frati 1992

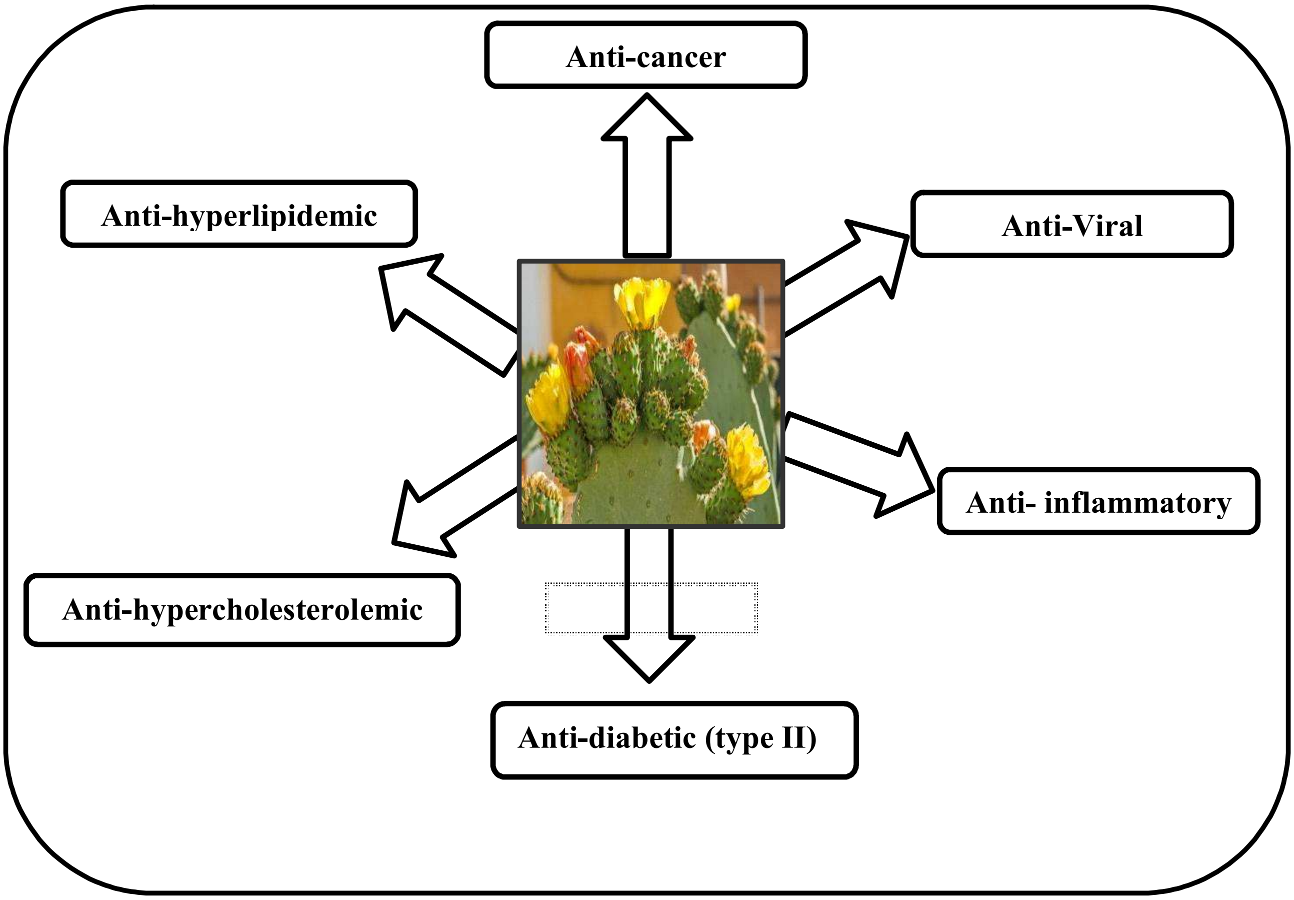

Fig. 3. Principal functional and medicinal effects of cactus.

the most potent neuro protector (Dok-Go and others 2003). The cactus flower extract was able to exert an effect on benign prostatic hyperplasia(BPH) through the inhibition of aromatase and 5a reductase activities, both of which are involved in and rogenaromatization and testosterone reduction. A diuretic effect was reported to be promoted by ingestion of flower, cladode and especially fruit infusions in a rat feeding trial. Though *Opuntia spp.* glochids may induce dermalirritations, peeled *Opuntia* fruits or cladodes appear to be nonallergenic. More recently reported a protective effect of cactus juice against carbon hydrochloride(CCl4)-induced hepato-toxicity in rats (Jonas and others 1998; Yoon and others2004).

FUTURE SCOPE:

From the presented data, it appears that *Opuntia spp.* has been subject to intensive exploitation due to its great compositional diversity. Nowadays, this hidden knowledge needs to be discovered and re-evaluated. Sophisticated analytical approaches and innovative processing technologies will open new avenues to further promote the use of cactus pear stems, fruits and flowers infood, medicine, cosmetic, and pharmaceutical industries. An increasing demand would help encourage farmers to increase their acreage and thus also help to counterbalance erosion and increasing atmospheric CO2 levels. Although much research still needs to be done,concerted actions of taxonomists, plant breeders agriculturists, food technologists, nutritionists and pharmacologists will help discover and understand the big potential of the *Opuntia* cactus. The exact botanical classification of the respective *Opuntia* spp. Under investigation and the growing location and time of harvest are prerequisites for analytical and pharmacological studies. The exact plant parts used in the extraction and processing conditions need to be accurately documented to allow proper data evaluation. However, beside nutritional and clinical investigations, increasing the worldwide production for the reduction of market prices, breeding for a higher pulp yield, optimization of harvest procedures, selection of cactus species for higher betalain content, use of enzymes to achieve a higher yield during processing, consideration of a greater variety of hues for food colouring purposes and investigation of other genera within the Cactaceae are still necessary to improve the nutritional and economic feasibility of cactus pear.

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