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A CRITICAL REVIEW ON THE WONDERS OF CACTUS

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ABSTRACT

Globally, the interest in cactus dates back many thousands of years. The ancient Mesoamerican civilizations and particularly to Aztec culture forms the basis of its origin and history. This plant can be employed both as a medicine and a source of nourishment. Cactus contains many attractive and valuable compounds, and should be highly valued for the protection and development of arid and semi-arid zones around the world. Cactus can form the basis for life for resource-poor people living in these marginal areas. As the plant's full potential has yet to be shared as an important option for these populations and for all humankind the present review work was carried out that highlights on its conventional understanding and application. Also, technological characteristics reviewed suggest attractive quality parameters for consumers. Furthermore, strategies to formulate cactus into juices, pulp and puree were explored as it holds promising markets. The fruit and cactus stem can be used to prepare many value-added products. Further product innovations may revolutionize pharmaceuticals, nutraceuticals, food and beverages industry as cactus possesses various therapeutically strategic properties like anti-ulcer, anti-inflammatory, neuro-protective, anti-cancer, anti-viral, anti-diabeteic, hepato-protective and antioxidant activities. Thus, it is envisaged that commercial applications of cactus must be encouraged.

KEYWORDS: *Prickly pear, Cactaceae, Cactus, Opuntia, juice, pulp and puree.*

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INTRODUCTION

Prickly pear is the general term used to describe over ten members of the Cactaceae family. Their species is *Opuntia* that is generally found in America. They have spines and is thick. Its fruit shape is that of a pear, have spines and hence because of fruit it is named as *Prickly Pear*. This shrub has no leaves. Its branches are flat and are called joints and pads. The leaves have sharp edge, are tiny and thick. Mainly they have purple or red appearance. When the shoot is young these tiny leaves are observed and generally shed off soon after they are seen. Another term is *Areloes* that are dots spread over fruits and pads from which there is growth of bristles. Generally, the budding pads or roots develop from these Areole. The appearance is mainly yellow and large of the flower, red of the fruit skin (Land Protection 2007). This fruit represents culture of Mexico is sweet, juicy, has numerous seeds and have a high content of sugars. It is slightly acidic and contains several minerals (Gutierrez-Moreno K.). Hasan (2011) had also indicated that they contain fair levels of vitamins like B_1, B_6, E and A. Salim (2009) had also indicated that *Opuntia ficus-indica* fruit contains minerals like calcium, magnesium, sodium, potassium, phosphorus and iron. The leaves are consumed as fresh vegetables, canned, added to casseroles and other cooked dishes, and used in salads. These can be processed to drinks and candies by adopting fermentation technology, can be consumed as dry or fresh product (Donald 1990). The mucilage of plant also contains sugars and acids (Samahy 2006). A combined approach of gel filtration chromatography and reverse-phase HPLC can be adopted to isolate a 6.5 kDa protein from *Opuntia indica* (Uchoa 1998). They have hexoses 8-85% w/w and pentoses in 0.98% w/w. Also, they possess the flavonoid Isorhamnetin and its glucoside as the flavonoid components of the flowers alongwith penduletin, luteolin, kaempferol, quercetin and rutin. Other reports have indicated that plants of the Cactaceae family contain flavonol 3-O-glycosides, flavonones, and flavanonols. Moreover, cactus pear fruit contains betalain pigments that are good natural food colorants (Salim 2009, Butera 2002). Also, the fruits of *Opuntia ficus indica* are a source of ascorbic acid and other organic acids present are maleic, malonic, succinic, tartaric and oxalic.

In 1995, researcher Scheinvar stated that the term *Opuntia* had coined from a Greek village called Beocia, that meant as Opus, where he saw a plant with spines similar to *Opuntias* found in America. There are eleven subgeneras of Opus like *Brasiliopuntia, Tephrocactus Grusonia* to name a few (Bravo Hollis 1978, Pimienta Barrios 1994). Generally, the fruits of cactus are very juicy, oval shaped, have long berry and thick peel. There are many seeds in pulp. Approximately 32-54% is peel, 44 to 66% is seeds, and 1 to 15% is pulp (Arrizon Calderon 2006, Piga 2004). However, due to certain technological problems associated with its juice production, only few commercial products are produced at the industrial level (Zorgui 2008). Cactus has over 1400 species and 125 genera and is also found in the basin of the Mediterranean and Africa (Manpreet 2012). The genus *Opuntia* have about 200-300 cactus species that grow all over the world in arid and semi-arid zones. Many countries like Spain, Argentina etc are involved in its cultivation commercially. In olden times Opus was used for cosmetic and medicine purposes. The term ‘nopales’ or ‘nopal’ is used for flattened stem segments that are morphologically incorrectly designated as cactus leaves (Dr. Daniel Schmid 2007). They are capable to produce nutritious fruits, cladodes that are tender, sweet and edible with green vegetables and salad dressings. Many products with value addition like body lotions, jam, shampoo etc. can be processed from its stem and fruit. It can be adopted to add flavors at industrial scale (Pareek 2002), applied as medicine as it has anti-inflammatory properties and used to cure many medical conditions (Park 1998), hypoglycemic effects (Frati 1990), inhibition of stomach ulceration (Galati 2003), neuroprotective effects (Dok-Go 2003). Also, it holds antioxidant properties and used for

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treating diabetes, burns, bronchial, asthma and indigestion in many countries over the world (Kim 2006). The cacti in India do not belong to one species, i.e., *Opuntia dillenii*, but three to four species are spread in many parts of the country like in south India *Opus dillenii* is seen, similarly *Opus vulgaris* in north India. *Opuntia elatior Mill* is found in western India (Manpreet 2012). Moreover, it has different vernacular names in India like *Hathlo thor, chorhthlo* (Gujarati), *Haththathoira, Nagphana, Nagphani* (Hindi), *Snuhi, Vajrakantaka, Bahushala* (Sanskrit), *Nagadali, Nagakkali, Chapati balli* (Tamil), *Nagamulla, Nagajemudu* (Telugu), *Nagphani, Thuar* (Urdu) (Chauhan 2011). The following figure 1 represents a typical Prickly Pears.

Figure 1: The Prickly Pears

(Source:https://www.google.co.in/search?q=prickly+pear&biw=1366&bih=655&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi34Mbe2ZzLAhXOCY4KHcBNC_EQ_AUIBigB#imgrc=HlFWWgYsIOJvxM%3A)

TECHNOLOGICAL CHARACTERISTICS

The Prickly Pears fruit soluble solids content reaches values above 15% that is superior to that found in other fruits like apricot and peach (Pimienta 1990, Schmidt-Hebbel 1990, SepuH lveda 1990). It is a very useful component for processing the fruit into concentrated juices or dehydrated products. The pulp of fruit contains glucose upto 52% and fructose upto 46% (Sawaya 1983a, Russel 1987, SepuH lveda 1990, Kuti 1994). The calorific value of the pulp according to Sawaya (1983a) and Schmidt-Hebbel (1990), is about 50 Kcal 100 g^{-1}, comparable to different similar fruits. The other components present in cactus pear pulp are protein (0·21–1·6%), fat (0·09–0·7%), fiber (0·02–3·15%) and ash (0·4–1%), all of which are similar to other fruits (Paredes 1973, Askar 1981, Sawaya 1983a, Pimienta 1990, SepuH lveda 1990, Rodriguez 1996). It has high amounts of free amino acids. Also, characteristics of Prickly pear, in comparison with other fruits, are their high content of serine, c-amino butyric acid, glutamine and methionine (Askar 1981). They show a high levels of ascorbic acid, which can reach levels near 40 mg 100 g^{-1} (Pimienta 1990, SepuH lveda 1990, Rodriguez 1996), also concentration of vitamin C is higher than that of apple, grape and banana (Cheftel 1983, SaHenz 1985). As Na and K levels are appropriate the patients with blood pressure and renal problems are benefitted (SepuH lveda 1990, Rodriguez 1996). Furthermore, calcium and phosphorus represents three-quarters of the minerals of the body and are found fundamentally in bones, which serve as an important reservoir. Furthermore, the Prickly pears are rich in calcium and phosphorus (Sawaya 1983a, SepuH lveda 1990). As it has good levels of pectin it can be used to produce jams and juices. It is somewhat difficult to produce gels (SepuH lveda 1990, Rodriguez 1996). There are a variety of colors like green, orange found of its fruits. Thus, has attractive quality parameter for consumers.

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JUICE, PULP AND PUREE TECHNOLOGIES

The major application of Prickly pear is in the production of pulp and juices. This work was initially done by Paredes and Rojo (1973) on *Opuntia ficus indica*. These authors used citric acid to reduce the pH value to 4·3, sodium benzoate (500 p.p.m.) and a thermal treatment for 5 min at 90ºC; the juice was vacuum canned in enameled tin. The results showed that the product had a pleasant flavor and taste and was without microbiological problems. Espinosa (1973) studied the *Opuntia ficus indica* juice and found several difficulties in its preservation. Another possibility related to cactus pear juices was concentrated juice production (Almendares 1992). As the a_w of the concentrates is relatively low it will not allow microbes to proliferate and thus shall enhance juice shelf-life. The study showed that concentrated juices could be obtained with 63-67ºBrix, the juice was prepared in an α-Laval centrifuge vacuum evaporator, at approximately 40ºC, the stability of juice against microorganisms growth was good, but the sensorial analyses found the acceptability was only 5·0 (1-9 points scale). This unsatisfactory ranking was due to damage to the color and herbaceous aroma that appeared after the concentration process (SaHenz 1993, SaHenz 1996a). Color changes were observed during thermal treatment in pasteurized and concentrated juices of green cactus pear (SaHenz 1993), where chlorophyll plays an important role, the color was determined by the Hunter color parameters, corresponding to lightness (L*), red-green dimension (a*) and yellow-blue dimension (b*). There was a loss of green color as L* was reduced due to thermal treatment. Nevertheless, studies done at different storage temperatures (2, 10, 20 and 27ºC) of concentrated cactus pear juices showed that at room temperature the juice will become dark and H* will be changes, alongwith temperatue and time. SaHenz (1997a) had observed pH effects ranging from 5·2 and 4·0 alongwith thermal treatment effects ranging from 80ºC during 10 minutes in opus and concluded that it presented a high stability to both the pH and thermal treatment variations that is a clear advantage over the green cactus pear juice by the purple cactus pear juice. The authors tested three treatments: (1) A natural juice, without modification of pH (pH = 5·2) and without thermal treatment, (2) Another natural juice, without modification of pH (pH = 5·2) and with thermal treatment, and (3) A third with modification of pH (pH = 4·0) and thermal treatment (80ºC for 10 min). They concluded that a* and b* parameters value would influence the juice tone. Despite the 3 procedures resulted in a red-purple color, some appeared more reddish. The acidification of the juice and the thermal treatment applied for its conservation and microbiological stability caused a visual change in the color, but the purple reddish color characteristics of this fruit juice remained.

In relation to microbiological stability, Carrandi (1995) observed in pasteurized juice that was treated for 19 seconds at 100ºC that there was a marked color and change in flavor and the presence of microorganisms that caused damage to the juice. To prevent the action of bacteria and fungi, the same author modified the pH of the juice and lowered it to 5, however, this change was not enough to prevent the spoilage of lactic bacterial growth such as *Lactobacillus*. In the same study the use of additives such as sodium sorbate or sodium propyl p-hydroxybenzoate at levels of 200 p.p.m. was also not enough to preserve the juice. Other more drastic thermal treatments, such as bottle juice treatment for 19 minutes ate 100ºC gave good results for microbiological stability, but the final product did not resemble the original fresh juice due to changes in color and flavor. Bunch (1996) reported the production of a frozen puree in the U.S.A. as the most versatile and stable product. It was made from purple cactus pear and had some percentage of pineapple juice, it could be used in a number of beverages and food dishes. Also, Thomas (1998) described, in detail, a flow diagram for the production of red cactus pear puree. The authors reported 3 cfu g^{-1} coliforms, lactic acid bacteria and *E. coli*, as well as 10 cfu g^{-1} aerobics, yeast and molds. The same authors reported obtaining a cactus pear puree concentrate, a 65ºBrix, vacuum-dehydrated

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product used as a flavoring ingredient for pastries and ice cream. Mixed drink flavorings using this cactus pear puree were developed, in a twelve kg pail that was frozen. Saenz and Sepulveda (1999) prepared several blends of purple cactus pear juice and pineapple juice, with good results. However, although the pineapple juice helped to improve the acidity of the blend, its aroma and taste affected the delicate aroma and taste of the cactus pear juice. Another alternative would be the use of only citric acid to improve the acidity of the blends. Barbagallo (1998b) obtained a 36% puree that was concentrated from the opus 'Gialla' and compared the product with the natural pulp, the color, aroma and flavor of the product were in the lines of those like natural pulp, the acidity was modified with citric acid to 4 pH. They concluded that the concentrated puree could be a good ingredient for the candy industry as a semi-processed product. A very important property of the juice is its rheological behavior in terms of the industry's pump design and also of the sensory quality of the products. The rheological properties of different concentrated cactus pear juices were studied by SaHenz and Costell (1990), and found that most of them were pseudoplastic and to fit well within the Ostwald model wherein 0·981 was the value of r^2. Nevertheless, depending on the type of juice pressed, the rheological behavior changed, for example, pressed juices changed to Newtonian in Brix reading of 40º or lower. Other researchers have attempted to obtain clarified juices. It is known that the juices without pulp can be concentrated to a higher degree of solids content, with advantages in terms of both their conservation and the reduction of transport and storage space. The application of pectinolytic enzymes was also tries for this purpose with a treatment at 40ºC for 48 hours, and also citric acid was added into it. There is a different thermal treatment for juice packaged in glass bottle and ans. Both treatments show color changes due to pasteurization. Addition of artificial colorants can control this color change (Yagnam 1991). Using a NOVO prepared with a mix of pectolitic enzymes and a high activity of arabanase, SaHenz (1996b) have clarified cactus pear juice with success. Thus, several research have indicated cactus juice, pulp and puree technologies are strategic.

THERAPEUTIC APPLICATIONS

Since long many worldwide attempts have been made to use Prickly pears for various applications. In the year 1983, Ibanez-Camacho had suggested that its Nopales can be used to treat diabetes Mellitus. The same year, Frati-Munari (1983) had indicated that intake of the nopales before meals may be useful in management of some hyper-lipidemia, diabetes mellitus, and obesity. The subsequent year, Fernandez-Harp (1984) had showed that blood glucose and insulin test values were lower in patients treated with nopales. Furthermore, Alberto C. Frati-Munari (1988) had studied on hypoglycemic effect of *Opuntia streptacantha Lemaire* in NIDDM and had showed that stems of *O. streptacantha Lem.* can result into a hypoglycemic effect in patients with NIDDM. The mechanisms of these effects were unknown, but a increased insulin sensitivity was suggested. In the year 1990, Fernandez M. L. had indicated that Prickly pear ingestion has the potential to lower cholesterol, an effect which may well be explained by the pectin content of the cactus. Moreover, the effect of the Prickly pear over the metabolism of the low-density lipoproteins was tudied by FernaHndez (1990), suggesting, through its results, that the extract of Prickly pear would act in a similar way to that of other compounds used to decrease cholesterol levels. During the same year, Frati-Munari (1990) had studied the hypoglycemic effect of *Opuntia ficus indica* stems, and found that glycemia decreased in all patients tested following ingestion of *Opuntia ficus indica,* and reached statistically significant levels after 110 and 160 minutes. Thereafter, RammHrez (1995) presented a review of evidence on the reduction effect of *Opuntia* in the serum glucose, and with access to eight different reports they concluded that this meta-analysis suggested *Opuntia* had a strong glucose reduction effect. The next year, A. Ahmad (1996)

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had studied on the antiviral properties of extract of O*puntia streptacantha* and had concluded that *Opuntia streptacantha* inhibited intracellular virus replication and inactivated extracellular virus. There was inhibition of both DNA and RNA virus replication, for instance, pseudorabies virus, herpes simplex virus, equine herpes virus, influenza virus, respiratory syncytial virus and human immunodeficiency virus. Subsequently, Israel Castaneda-Andrade (1997) had studied on hypoglycemic effect of an *Opuntia streptacanta Lemaire* dialysate and had indicated that *Opuntia streptacantha Lemaire* possesses a fiber-independent substance. This has potential to reduce glycemic effects in NIDDM patients. They had observed decrement of about 60 mg/dl over basal glycemia three hours after the dialysate was administered and that the placebo also produced a hypoglycemic effect of about 50 mg/dl in the NIDDM patients studied. The same year, Ing Juan Jose Lopez Gonzalez (1997) had studied on Prickly pear fruit industrialization and had suggested that importance of this species is related to the fact that it can be used as a fruit, as a vegetable and forage. The fruit can be used to make Prickly pear fruit cheese,, Melcocha, Colonche, Honey, Wine and Jelly. Also, in order to produce 1 kg Melcocha or Prickly pear fruit cheese, at least 11 kg of fruit is required. Also, Gutierrez-Moreno K. et. al. had investigated wine production from Prickly Pears and had showed that a culture formed by *Saccharomyces cerevisia* and *Pichia fermentans* can be used as a starter inoculum for Prickly pear juice fermentation, and that at conditions of 15°C on juice of 16°Bx containing 100 g/L of Potassium Metabisulfite allow to obtain a fermented alcoholic beverage with a unique agreeable aroma and flavor.

During the next decade, A. Budinsky (2001) had suggested that Prickly Pears have significant cardiovascular benefit and that the regular ingestion of *Opuntia robusta* is able to significantly reduce in-vivo oxidation injury in people suffering from familial hypercholesterolemia. Moreover, G.R. Rodriguez-Hernandeza (2005) had done spray-drying of Cactus Pear juice (*Opuntia streptacantha*) and studied its effect on the physicochemical properties of powder and reconstituted product. The reconstituted product showed a slight change of total color with respect to natural juice and a significant effect of the maltodextrin concentration was found in this property. In the year 2007, another group of researchers led by Dr. Daniel Schmid had studied on *Opuntia* Cactus extract to treat sensitive and dry skin and had indicated that the ingredient can be used in sun care products and skin care products to soothe sensitive and dry skin. Furthermore, Anaberta Cardador Martinez (2011) had suggested that anti-oxidants can be extracted from the by-products of cactus in a cost effective manner and had also proved that peels have a high anti-oxidant properties than its seeds.. Generally, fruits with light-green or yellow-brown peel have higher antiradical activity and Trolox equivalent antioxidant capacity (TEAC) values compared with those with red-purple peel. Recently, Manpreet Kaur (2012) had reviewed on the pharmacological actions of *Opuntia ficus indica* and had documented that it has neuro-protective, anti-ulcer, anti-inflammatory, antioxidant, anti-cancer, anti-viral, hepatoprotective and anti-diabeteic activities.

Several other researchers have also documented traditional use of *Opuntia* fruits and young stems to treat diabetes, hypertension, asthma, burns, edema, and indigestion (Castaneda Andrade 1997, Galati 2001, 2003, Trejo Gonzalez 1996). In the year 2005, Cerezal and Duarte had used the cactus pear pericarp to formulate marmalade and indicated that the seed meal have potential use as a dietary fiber source for human consumption, for the extraction of oil (El Kossori 1998, Ramadan Morsel 2003a, 2003b), or for the extraction of D-xylans (Habibi Mahrouz 2002, 2005). Mainly, the Prickly Pears are widely known and a commonly used herbal treatment for glucose control in Central and South America (Roman-Ramos 1995). Isorhamnetic-3-glucoside was reported to be one of the many active flavonoids isolated from *Opuntia* (Ginestra 2009). In preclinical studies the opus pectin, seed oil, and powder have significantly lowered total cholesterol, low-density

lipoprotein (LDL)-cholesterol, and triglyceride levels (Fernandez 1992, Li 2005, Ennouri 2006, Oh and Lim 2006). Also, favorable effects on dyslipidemia were confirmed in a pilot study of 24 nondiabetic male subjects. Specifically, *Opuntia robusta* pectin have lowered total cholesterol by 12%, LDL cholesterol by 15%, triglycerides by 12%, blood glucose by 11%, and insulin levels by 11% (Wolfram 2002). Two controlled short-term studies of 14 and 22 human subjects, respectively, had reported decreased fasting glucose and insulin levels in patients with type 2 diabetes (Frati 1990, El Kossori 1998). Thus, several studies indicate that Prickly-pears can be a strategic fruit having several applications in food and nutraceuticals industries.

CONCLUSION

As per the prior art search done, Prickly pear fruit (*Opuntia*) is a representative icon of Mexican culture and is considered a healthy and nutritive fruit with unique sensorial characteristics. Prickly pear fruit has a juicy sweet smooth fruit with many seeds, very rich in sugars. It has high nutritional value. For domestic purposes, they can serve as sources for fruits, vegetables and have medicinal plus cosmetic applications. Many value-added products can be processed from its fruits and stem like jam, wine juice, squash, shampoo, pickle, creams to name a few. Moreover, its seeds can be used as flavoring agents. Its technological characteristics suggest attractive quality parameters for consumers. Also, its juice, pulp and puree technologies holds promising markets. Thus, it is concluded that commercial applications of Prickly pear must be encouraged as it has many therapeutic significance like anti-ulcer, anti-inflammatory, neuroprotective, anti-cancer, anti-viral, anti-diabeteic, hepatoprotective and antioxidant properties.

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