IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A REVIEW ON: CACTUS: PHYSICO-CHEMICAL COMPOSITION, PHARMACOLOGICAL PROPERTIES AND NUTRITIONAL IMPORTANCE. (FAMILY: CACTACEAE)

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ABSTRACT

Cactus is one of the most widely distributed plants in the xeric environment and has special characteristics. The major species of cacti used for livestock includes Opuntia ficus-indica Mill., O. lindheimeri Engelm, O. ellisiana, O. engelmannii Salm Dyck, O. chrysacantha Berg, O. amyclae, O. rastrera Weber, O. stricta Haw, and Nopalea cochenillifera Salm Dyck. Cactus species are plants that grow in the arid and semiarid regions of the world. Some Opuntia species are wild, and fruit is not suitable for human nutrition, but plants can be used as forage for animal nutrition. 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.

KEYWORDS – Cactus , Opuntia, Cactus pear, Cactaceae, Antioxidant, Physico-chemical Composition , Pharmacological Properties .

INTRODUCTION

Drylands occupy approximately 40 % of terrestrial surface and 2 billion people live in these areas. In addition, climate change is Increasing temperatures and the frequency and severity of droughts in different regions of the world (FAO, 2019). Cactus is an important forage resource for arid and semiarid regions. In Mexico, cactus utilization as a forage is based on wild cactus population. In other countries such as Brazil, Tunisia, South Africa, and Morocco, cactus fodder is produced in cultivated or-chards, which could have a multi-use purpose (fruit/forage/industrial processed products) or only fodder. It is a source of water and energy for ruminants and other type of animals, mainly during the dry season of the year. Cactus represents a live forage reserve and is an important resource to increase food security in semiarid regions (Ben Salem et al., 2002). Cacti produce a high amount of succulent Biomass, with a high palatability, even under environmental conditions that are limiting for other types of forage (Ben Salem et al., 2002).Crassulacean acid metabolism (CAM) is the photosynthetic mechanism of cacti (Leegood, 2013).The typical chemical composition of cacti includes low concentration of dry matter (5–15% DM), crude protein, fiber (ADF, acid detergent fibre and NDF, neutral detergent fibre), with digestibility being usually greater than other warm-climate forages (Batista et al., 2009;

Monteiro et al., 2018; In´Acio et al., 2020).The term Cactus is derived from an ancient Greek word 'kaktos',Which was used by Theophrastus to demarcate the spiny plants. Cactus has a great economical value as it is the no of Wild/ornamental plant of the family Cactaceae. It is also referred to As 'new world' plants (Shetty et al., 2012).. It is also considered as an energy source as It contains 14% glucose (Salim et al., 2009).Physiologically it exhibits CAM metabolism, Which has a mechanism to tolerate the environmental stress, mostly .The unavailability of water (Gibson and Nobel, 1986; Anderson,2001; Bensadón et al., 2010). Morphologically, the stem of cacti is Modified and become fleshy, flat and cylindrical or globular and Forms cladode. The pollination and the seed dispersal take place With the help bats, birds and insects (Gibson and Nobel, 1986;Godýnez-Alvarez et al., 2002; Godý´nez-Alvarez, 2004). Cactus (plural cacti, cactuses or cactus) is described as a distinct flora that can be found in the arid areas around the world. The Cactaceae family has mainly a tropical distribution, comprises 124 genera and 1438 species distributed in the world (del Socorro Santos-Díaz & Camarena-Rangel, 2019). For instance, in America, cacti were used as food, medicine, and cosmetics, even before the time of Christopher Columbus (Lema-Rumińska & Kulus, 2014; Shetty, Rana, & Preetham, 2012). Some commercial products, such as shampoos and soaps, are mainly produced from cactus species. Food products like biscuits, candies, puddings, and cakes could also be sourced out from cacti (de Lucena et al., 2013.

Scientific Classification

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Order:	Caryophyllales
Family:	Cactaceae

Subfamilies

- Cactoideae
- Maihuenioideae
- Opuntioideae
- Pereskioideae

https://en.m.wikipedia.org/wiki/Cactus

HISTORY OF CACTI & SUCCULENTS

Origin of the Names

The word Cactus comes from the Greek word kaktos, used in classical Greek for a species of spiny thistle, and was used as a generic name for all Cactaceae native to the Americas. The Succulent is so named for these plants amazing water retaining ability.

Ancient History

Cacti and Succulents have been known about since the time of the Aztecs in Mexico and Incas of Peru. They were an important symbol to them in the forms of healing, cosmetic products and divination, to feel at one with their gods. Tenochtitlan (the earlier name of Mexico City) means "place of the sacred cactus". Representations of the plants could be seen as decorations on their buildings, pottery and other discovered artifacts.

European Discoveries

Real scientific interest was not shown in the Cactus until the 14th & 15th centuries. Christopher Columbus brought the first Melocactus to Europe. The plants which he discovered are considered "New World Plants" because they come from the Americas. However, Cacti and Succulents can be found on every habitable continent. "Old World Plants" such as Aloes can be found in Africa.

(https://www.theinkrag.com/cactus_corner_project/historycc.html)

VARIOUS USES OF CACTUS

As Fruit

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The fruits of cactus vary in weight from 50 to 150 gm depending on the environmental conditions and its origin. It's a berry with oval and elongated shape. The pericarp is very thick and the pulp is theconsumable part of it. It consists of mainly water, which is 84 to 90%, and reducing sugar 10 to 15%. The fruits of Opuntia ficus indica are widely used as eatable. The fruit is also known as 'dragon fruit' or pitaya. Some of the cactus is widely cultivated for the fruit.e.g. Opuntia tuna, O. streptacantha and O. cardona. The fruits of cactus have a short shelf life, this is due to low acidity and high pH value that varies from 5.3 to 7.1. (Shetty et al., 2012). Fruits have vitamins, amino acid and minerals. The usual edible part of the fruit is 54.18% (Bekir, 2004). Cactus contains betalains pigment which gives colour and used in making ice creams and yoghurts (Stintzing and Carle, 2005).

As Vegetables

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The young or tender vegetative parts of wild cactus which lack glochids and spines are used as vegetables and salads (Russell and Felker, 1987)

As Fodder

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It **is** fed tocattle the spines are burnt and then used in feeding cattle in drought prone areas. Though it is low in protein content, but it is used in semi-arid regions to feed dairy cattle fodder. It imparts good flavour to milk and imparts good colour to butter (Salimetal.,2009).

TRADITIONAL USES OF CACTUS PLANT

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Different parts of Opuntia monacantha Haw. Can be used to treat different types of diseases. Its latex can be used for constipation; its mucilage can be used to treat piles, pox strains, rheumatism, and leprosy; its fruit can be used for gonorrhea and syphilis; and the stem can be used as a cathartic and treatment for dysentery (Arshad et al., 2014; Chetry et al., 2018). The fruit of O. ficus-indica is used in Italy as a diuretic, and for digestive disorders, while in Mexico it is used to treat wounds; in Morocco to treat stretch marks and wrinkles; in Turkey for joint dislocation, tonsillitis, and anemia; in India as an antispasmodic, diuretic, emollient, astringent, treatment for diarrhea, colitis, irritable bowel syndrome, and benign prostatic hypertrophy; in Peru for liver and kidney inflammation; and in Pakistan as a digestion enhancer (Ahmet Sargin, 2015; de la Cruz, Malpartida, Santiago, Jullian, & Bourdy0, 2014; Erbay, Anıl, & Melikoğlu, 2016; Khan & Ahmad, 2015; Maroyi, 2017; Messaoudi et al., 2015; Pandita, Pandita, & Pandita, 2013; T. Tuttolomondo et al., 2014). Melocactus bahiensis

(Britton & Rose) Luetzelb., which is mainly distributed in the northern part of eastern Brazil, was only used in Brazil to treat amoeba, catarrh, cough, and whooping cough (de Lucena et al., 2013). Opuntia engelmannii Salm- CTDyck ex Engelm is common in south-central and southwestern United States and northern Mexico. Its use as a medicinal plant for diabetes was only reported in Mexico (Estrada-Castillón et al., 2018).

MEDICINAL USES

- **Anti-cancerous effect of cactus**

The anti-cancer effect was shown by the cactus pear fruit extract,and found that it inhibits the proliferation of in vitro cervical,ovarian and bladder cancer cell lines. (Camacho-Chab et al., 2016).

- **Antioxidant effect**

The fruits and vegetative parts of different varieties of cactus, largely Opuntia contains many antioxidants e.g. Ascorbic acid, carotenoid, reduced glutathione, cysteine, taurine, and flavonoids such as quercetin, kaempferol and isorhamnetin (Tesoriere et al., 2005).

- **Antiviral effect**

The intracellular replication of DNA and RNA viruses, e.g., herpes simplex virus type 2, equine herpes virus, pseudorabies virus, influenza virus, respiratory syncitial virus and HIV can be stopped by the cactus stem extract of Opuntia streptacantha in mice and humans (Ahmad et al., 1996).

- **Anti-inflammatory effect**

Genus Opuntia has been used for its analgesic and anti-inflammatory effect. The fruit extract of Opuntia dillenii (Loro et al., 1999) and the lyophilized cladode have been used for anti-inflammatory effect.

- **Antidiabetic effect**

Now a day Italian herbalists are using Opuntia species to reduce glycemia (Cicero et al., 2004). The prickly pear extract exerts a hypoglycemic effect on non-diabetic, diabetic induced rats and diabetic humans (Ibanez-Camacho et al., 1979; Ibanez-Camacho et al., 1983; Frati-Munari et al., 1988; Frati et al., 1990).

- **Anti-hyperlipidemic and hypercholesterolemic effect**

The reduction in cholesterol in humans and modification in low density lipoprotein (LDL) is caused by the intake of the cactus pear extract (Gurbachan and Felker, 1998; Fernandez et al., 1992; Frati,1990; Stintzing et al., 2001; Stintzing and Carle, 2006).

Cholesterol

Both the cactus pad and the cactus fruit are high in fir, which can lower cholesterol levels in the blood.

Blood sugar

Some research shows that people who ate cactus pads on a regular basis had lower blood sugar than those that didn't. More research is needed to determine the reasons for this.

Immune system

Cactus fruits are an excellent source of vitamin C, which is one of the best immune boosters. Regular doses of vitamin C increase the production of white blood cells, which can help your body fight off viruses.

Digestion

The betalain and potassium content in cactus are good for digestion. Potassium helps your body absorb nutrients, while betalains are anti-inflammatory and help to protect your digestive tract.https://www.webmd.com/diet/health-benefits-cactus)

PHARMACOLOGICAL PROPERTIES OF CACTUS PLANT

- **Antimicrobial potential**

The immature and mature cladode extract of O. ficus-indica exhibited antimicrobial activity against both Gram-negative (Escherichia coli, Salmonella enterica ser. Typhimurium Enterobacter aerogenes) and Gram-positive bacteria (Enterococcus faecalis, Staphylococcus aureus). (Blando, Russo, Negro, De Bellis, & Frassinetti, 2019). Seed oils from O. albicarpa and O. ficus-indica exhibited antibacterial activities against Escherichia coli, Staphylococcus aureus, Listeria monocytogenes, Pseudomonas aeruginosa and antifungal activity against Saccharomyces cerevisiae and Candida albicans (Ramírez-Moreno et al., 2017). The methanolic leaf extract of Pereskia grandifolia exhibited antibacterial activity against Pseudomonas aeruginosa, Staphylococcus aureus, and Bacillus subtilis (Philip et al., 2009).

- **Antiviral potential**

The cladode extract of O. streptacantha demonstrated antiviral activity against both DNA and RNA virus, herpes simplex, equine herpes, pseudorabies, influenza, respiratory syncytial, and human immunodeficiency virus. The extract inhibited intracellular virus replication and inactivated extracellular virus (Ahmad, Davies, Randall, & Skinner, 1996).

- **Antioxidant Capacity**

The by-products obtained from cladodes and fruits of O. ficus-indica exhibited antioxidant potential as studied by ABTS and FRAP assays (Bensadón, Hervert-Hernández, Sáyago-Ayerdi, & Goñi, 2010). The antioxidant potential is attributed mainly to the presence of phenolic compounds like ferulic acid, rutin, and isorhamnetin, etc. that are effective radical scavengers (Enza Maria Galati et al., 2003).

- **Antidiabetic potential**

The antidiabetic effect can be attributed to the partial reduction of D-glucose intestinal absorption, free radicals quenching, and inhibition of pancreatic β-cells injuries. The oil containing linoleic acid and oleic acid may be responsible for the said activities. Similarly, several other studies have also demonstrated that boiled cactus stems and crude extracts of O. ficus-indica could reduce postprandial glycemia , serum insulin, and plasma glucose-dependent insulinotropic peaks in the diabetic patient (López-Romero et al., 2014; Roman-Ramos, Flores-Saenz, & Alarcon-Aguilar, 1995).

- **Anti-ulcer potential**

The methanolic root extract of O. ficus-indica f. inermis demonstrated gastroprotective ability against an ethanol-induced ulcer in rats (Alimi et al., 2010). The lyophilized cladodes of O. ficus-indica were reported for their anti-ulcer potential in ethanol-induced ulcer in rats. The ultrastructural observations of gastric mucosa revealed the protective action of cladode against ethanol-induced ulcers. The protective effect may be due to the mucilage of O. ficus-indica (E. M. Galati, Monforte, Tripodo, d'Aquino, & Mondello, 2001).

- **Cardioprotective potential**

Consumption of O. ficus-indica dried leaves exhibited a rapid increase in HDL cholesterol levels concomitantly with a decrease in LDL cholesterol and triglycerides in women affected with metabolic syndrome, indicating the hypocholesterolemic effect of the plant (Linarès, Thimonier, & Degre, 2007). The randomized clinical trials (RCT) study indicated that supplementation with O. ficus indica decreased the percentage of body fat, blood pressure, and total cholesterol and cardiovascular risk factors (Onakpoya, O'Sullivan, & Heneghan, 2015).

- **Neuroprotective potential**

The polysaccharide extracted from O. milpa also exhibited neuroprotective activity against cerebral cortex and hippocampal slices from H2O2-induced injury by normalization of neuroprotective biochemical markers like acetate dehydrogenase (LDH), superoxide dismutase (SOD), glutathione (GSH), and total antioxidant competence (T-AOC) level (Xianju Huang, Li, Guo, & Yan, 2008). The polysaccharides isolated from O.dillenii exhibited neuroprotective activities against brain ischemia-reperfusion injury in rats under in vivo conditions and. They reduced the oxidative stress-induced damage in the PC12 cells under in vitro conditions (X. Huang,

Li, Li, & Guo, 2009). The methanol extract of O. ficus-indica also has a neuroprotective action against N-methyl-D-aspartate NMDA, kainate KA and OGD oxygen deprivation oxygen, inducing neuronal alterations in cultures of mouse cortical cells (J. H. Kim et al., 2006)

NUTRITIONAL IMPORTANCE OF CACTUS

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 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. (Sudzuki and others 1993).

PHYSICO-CHEMICAL COMPOSITION

Vitamin

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. (Stintzing and Others2000).

Amino Acid

Cactus fruits contain high levels of amino acids, especially proline, taurine and serine (Uchoa and others 1998), whereas cactus cladodes, the major amino acid detected is glutamine, followed by leucine, lysine, valine, arginine, phenylalanine and isoleucine. Fruit seeds and pulp can be considered as very good sources of amino acids and proteins (El-Mostafa and others 2014).

Mineral Contents

Mineral content of cactus (mg/100g)

Mineral	Fruit pulp	cladode
Calcium	27.6	5.64-17.95
Calcium carbonate	--	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

Nutrients per serving

A 1-cup serving of raw, unsalted cactus contains:

- Calories: 24
- Protein: 1.98 grams
- Fat: 0.135 grams
- Carbohydrates: 5 grams
- Fiber: 3.3 grams
- Sugar: 1.72 grams

(https://www.webmd.com/diet/health-benefits-cactus)

CULTIVATION

P://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.icarda.org%2Fsites%2Fdefault%2Ffiles%2Fstyles%2Fdefault%2Fpublic%2Fimages%2F2019-04%2Fdscn9390-min.jpg%3Fitok%3DhFJjMs47%2C%2520https%3A%2F%2Fwww.icarda.org%2Fthemes%2Fcustom%2Ficarda%2Fshare-image.png&tbnid=UZXDHe_3_YGB_M&vet=1&imgrefurl=https%3A%2F%2Fwww.icarda.org%2Fmedia%2Fnews%2Fcactus-catching-india&docid=RA0ixYf41nE2QM&w=4608&h=3456&hl=en-US&source=sh%2Fx%2Fim%2Fm6%2F4

Propagation of Cactus plants or Opuntia

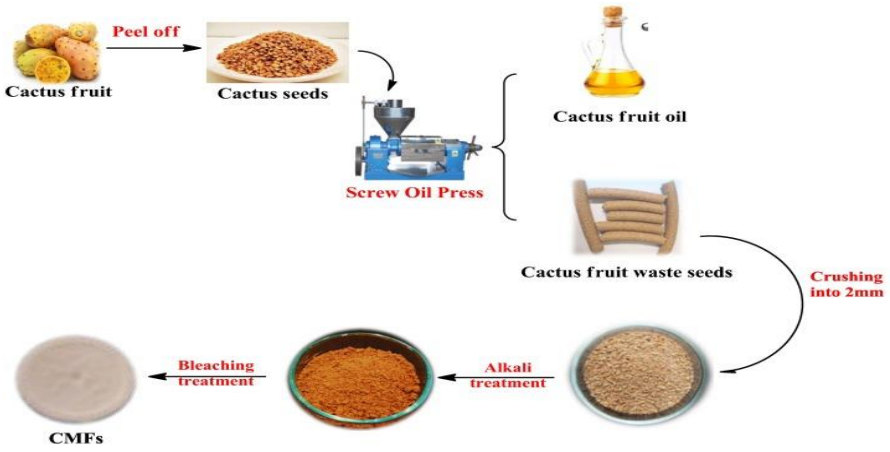
• Select the available edible Opuntia plants near your field. Opuntia is nothing but the edible cactus plants.

• Cut the leaf of that Opuntia plant or some flat leaves and sow them in your Cactus Farm. Within a few days, it produces new plants and flowering also starts as soon as the plant attains its vegetative phase.

Harvesting in Cactus Farm

• Harvesting is done when the plant attains a height of 4 to 6 mt. At those times, harvest the flattened leaves and do pack the leaves immediately after harvesting in order to prevent the loss of shelf life of the cactus leaves. However, the shelf life of cactus leaves is comparatively higher than other crops.(https://www.agrifarming.in/cactus-farming-cultivation-practices-of-cactus#:~:text=Only%20you%20need%20is%20a,quantity%20of%20water%20and%20maintenance)

EXTRACTION OF BIOACTIVE COMPOUNDS



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The vast literature available shows that the conventional extraction methods using organic solvents are the most frequently used for the extraction of bioactive compounds from cactus plants (fruits pulp and peel, seeds, cladodes, leaves, and flowers), although there also reports on the use of advanced techniques like SFE (Fathordoobady et al., 2019; Sharif et al., 2015), ultrasound-assisted extraction (Espinosa-Muñoz et al., 2017), and sonication (Mena et al., 2018; Moussa-Ayoub et al., 2014). Numerous reports described the extraction of bioactive molecules, mainly betalains and phenolics, from fruits of Opuntia spp. using solvents like acetone (Kıvrak et al., 2018), ethanol: formic acid: water (50:5:45 v/v/v) (Albano et al., 2015), methanol: water (60:40) (Betancourt et al., 2017), methanol (80%) acidified with formic acid (1%) (Mena et al.,2018), among other.

DIFFERENT TYPES OF CACTUS

1. **Angel wing**
2. **African milk tree cactus**
3. **Christmas cactus plant**
4. **Ladyfinger cactus**
5. **Parodia cactus**
6. **Old lady cactus**
7. **Rat tail cactus**

1. Angel wing

https://images.app.goo.gl/UEMxTD3H6VAwMsxB9

2.African milk tree cactus

https://images.app.goo.gl/9NmDmakJdunLooPX6

3.Christmas cactus plant

https://images.app.goo.gl/miWeq8gammGq6S6DA

4. Ladyfinger cactus

4.**Ladyfinger cactus**

https://www.google.com/imgres?imgurl=https%3A%2F%2Fstrapi.myplantin.com%2Flarge_main_041538e5-ba08-4dc5-8cbb-e8b6cc30e00c.webp&tbnid=pbCRE_ty1-

cZNM&vet=1&imgrefurl=https%3A%2F%2Fmyplantin.com%2Fplant%2F898&docid=PsrR22PMg_8OIM&w=750&h=1000&hl=en-IN&source=sh%2Fx%2Fim%2Fm1%2F4

5.Parodia cactus

https://images.app.goo.gl/hocKzMX8ndvGgTUd6

6. Old lady cactus

https://images.app.goo.gl/n5V9YMjUPWT6e46P8

7.Rat tail cactus

https://images.app.goo.gl/YCGdgcdV6P2YaNuw

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