

The Cactus That Cures: Exploring Prickly Pear's Defense Against Hepatic Stress and Inflammation

Prof. Pallavi T Jadhav¹, Dr. Abhishek Kumar Sen², Mr. Tejaskumar Bapu Chitte³

¹Associate Professor, ²Principal, ³Student.

Pratibhatai Pawar College of Pharmacy Shrirampur, Ahilyanagar, Maharashtra, India

Abstract: *Hepatic disorders and diseases, such as liver damage, are significant global health concerns. Prickly pears (Opuntia spp.), a cactus plant rich in bioactive compounds, have attracted interest as a possible liver disease treatment. The anti-inflammatory and antioxidant properties of prickly pear extracts are highlighted in this review, as well as their potential use in the management of hepatic disorders. The bioactive components of prickly pears, such as flavonoids, betalains, and phenolic acids, have potent antioxidant qualities that reduce oxidative stress and scavenge free radicals. Additionally, it has been shown that prickly pear extracts change inflammatory pathways by blocking cytokines and pro-inflammatory enzymes. Because of their anti-inflammatory and antioxidant properties, prickly pear extracts may have hepatoprotective properties, making them a potential adjuvant treatment for hepatic disorders.*

Keywords: Prickly pear, Opuntia, hepatic disorders, antioxidant, anti-inflammatory

I. INTRODUCTION

Prickly pear cactus: a perennial plant of the Americas that has been a mainstay food, medicine, and source of yellow dye for thousands of years. History, heft and breadth of human use have thus solidified its status as an essential part of multiple cultures throughout the world. Read On: This Article Will Take

Us through the History of Prickly Pear Herbs, And How It Has Been Traditionally Used

Ancient Mesoamerica: Prickly pear cactus is from pre-civilized ancient Mesoamerica, a sacred plant to including Aztecs and Mayans. Aztecs turned the plant's colorful blooms into natural dyes for their cloth and Mayans sweetened them up fermenting them into an alcoholic drink . It was also utilized as medicine (for cuts, burns and respiratory matters). The cactus had magical properties according to Aztecs who believed that it had a shielding nature as well and was even heard using it in ritual for healing.

Influence Greco-Roman: The Greek and Roman classical era were also aware of the medicinal qualities of prickly pear cactus plant. Ancient Greek physician Hippocrates (460 BC -370 BC) used the plant to treat many diseases, such as fever and rheumatism . This plant also was not forgotten by Pliny the Elder (23–79 AD), the Roman naturalist who mentioned it in his book, Naturalis Historia. The Greek and Romans used the prickly pear cactus to care for a whole range health matters, like skin diseases, wounds as well as digestion.

Native American Traditions: Native Americans used the prickly pear cactus (Opuntia spp.) to treat conditions such as wounds, burns and respiratory problems in North America the pads of the plant were eaten as a food too; fruits are eaten fresh or dried for later use. Native Women made natural pigments from the flowers of the plant the prickly pear cactus was an important aspect of Native American life and since has been used in ceremony/rituals to foster healing and protection.

Spanish and European exploration: The prickly pear cactus was later introduced to new areas such as Mediterranean Australia, South Africa and South America by Spanish and European explorers. In these new lands, the plant readily colonized and became an important food source for indigenous populations within the mere years following their introduction . The Spanish would employ the prickly pear cactus to treat a handful of other things as well scurvy, fever, rheumatism . Fruits of the plant were also fermented to produce a sweet, alcoholic beverage.



Current applications (Modern-Day Uses): The cactus is still an important medicinal plant today; however it was historically also used for food and textile dyes. Plant is used to make a number of items including jelly, jam and candy by utilizing the plant's pads. Native plants that is also good for forages the fruits of which can be fermented in order to create a sweet-fermented drink akin to Mayan's. Foods like the prickly pear cactus are also used in modern day medicine to treat type 2 diabetes, hyperlipidemia and obesity.(1-6)

PHYTOCHEMICALS COMPOSITION

Prickly pear is a rich source of phytochemicals, including betalains, flavonoids, phenolic acids, ascorbic acid, carotenoids, tocopherols, and phytosterols. These compounds have been shown to have antioxidant, anti-inflammatory, and antimicrobial properties, making them a promising area of research for the prevention and treatment of chronic diseases. Phytochemicals are plant derived compounds that have been shown to have various health benefits. They can help protect against oxidative stress, inflammation, and chronic diseases such as heart disease, cancer, and neurodegenerative diseases. The phytochemical composition of prickly pear makes it a valuable resource for exploring its potential health benefits.

Betalains : Prickly pear is filled with betalains, the red-violets pigments that are what make it so beautiful. The pigments present in these chemicals have possible antioxidant and anti-inflammatory actions that can help minimize risk to the development of cancer, or cardio vascular disease (CVD). Additionally, studies have shown that betalains have strong antioxidant properties that scavenge free radicals and reduce oxidative stress. By reducing excessive inflammation and, thus, the symptoms of numerous chronic illnesses, they may also have anti-inflammatory advantages

Flavonoids : In prickly pear, flavonoids are phytochemicals: antioxidant and anti-inflammatory in nature of the compounds. These appear to lessen the risk of chronic diseases such as heart disease and malignancies. Flavonoids: act as potent antioxidants scavenging free radicals and limiting ROS; are a class of phytochemicals which have been discovered to be oxidative stress reducing. Additionally, they might have anti-inflammatory properties that reduce inflammation and the symptoms of chronic illnesses.

Phenolic acids : Another class of phytochemicals present in prickly pear are phenolic acids; they also act as antioxidants and have anti-inflammatory actions. The presence of these compounds is believed to defend against oxidative stress and inflammation—that should be the well ones remaining to cause chronic diseases.

• **Ascorbic Acid** : A phytochemical of prickly pear is ascorbic acid, a form of vitamin C. It is a very important nutrient and helps with many things including maintaining healthy immune system, production of collagen, and iron absorption. Supplemental AOSIB has been examined to have antioxidant and anti-inflammatory benefits, decreasing oxidative stress as well inflammation. It may then possess some antimicrobial and antiviral activity which is potential in the treatment of infections.

• **Carotenoids** : In prickly pear a category of phytochemicals that are in group of carotenoids with antioxidant function these compounds likely help to reduce our risk of the common age-related chronic diseases; e.g., age AMD and some cancers. Carotenoids are potent antioxidants that scavenge free radicals and relieve oxidative stress. They may also exert anti-inflammatory effects, which help to decrease chronic inflammation and worsen signs of many human diseases

• **Tocopherols** : Tocopherols group of phytochemicals present in Opuntia species as antioxidant Gene Lys, H25 pK a :4.26 Hchs D ta. These compounds might help to prevent chronic diseases, i. e heart disease and some cancers. Tocopherols are strong antioxidants, known to scavenge free radicals and diminish the oxidative stress. Moreover; they may have anti-inflammatory activity which attenuates the inflammation and alleviate symptoms of many chronic diseases.

• **Phytosterols** : Phytosterols refer to group of phytochemicals which is present in prickly pear and have a health-promoting effect. These substances conceivably help in avoiding the chances of some chronic diseases (heart disease and cancers included) The phytochemicals are antioxidants and anti-inflammatories as well in phytosterols which lower the oxidative stress that arises.(7-12)



PHYSICOCHEMICAL PROPERTIES

The fruit of an American cactus, the prickly pear is well-known for its remarkable physicochemical qualities. The juice has a moisture level of 86.83%, a total soluble solids content of 12.75 °brix, and a high micronutrient content. 53.72% of the fruit's pulp, 45.38% of its peel, 3.79% of its seed, and 34.85% of its extracted juice.

- PH Level: Its juice has a pH range of 5.45 to 5.92, indicating low acidity .
- Moisture Content: The fruit's moisture content ranges from 89.13 to 91.18%.
- Sugar Content: Prickly pear juice contains 11.78% total sugars, comprising 7.86% reducing sugar and 3.90% non-reducing sugar.
- Acidity: The total acidity of prickly pear juice is 0.09%.
- Ascorbic Acid: The fruit's juice contains 28.41 mg/100 mL of ascorbic acid.
- Moisture Content: The fruit's moisture content ranges from 89.13 to 91.18%.
- Weight: The mean weight of prickly pear fruits is 89.27 g.
- Pulp, Peel, Seeds, and Juice Weights: The weights are 47.57, 40.96, 3.52, and 37.07 g, respectively.
- Weight Percentages: Pulp (53.72%), peel (45.38%), seeds (3.79%), and extracted juice (34.85%) .
- Solubility: The solubility of prickly pear powder in water is 71.4%.
- Melting Point: The melting point of prickly pear wax is around 180-200°F (82-93°C).
- Boiling Point: The boiling point of prickly pear juice is around 212°F (100°C) .
- UV Spectroscopy: The UV spectrum of prickly pear extract shows absorption peaks at 210, 280, and 320 nm .
- IR Spectroscopy: The IR spectrum of prickly pear powder shows absorption peaks at 3400, 2920, 1630, and 1040 cm⁻¹ .
- Water Holding Capacity: The albumin fraction has a significant water holding capacity (480% at pH 7).
- Oil Holding Capacity: The glutelin fraction has a significant oil holding capacity (420% at pH 7) (1315)

MORPHOLOGY OF PRICKLY PEAR

Prickly pear cactus (*Opuntia ficus-indica*) is a weird looking plant with some weird morphology below is the layout of its morphology (16- 26)

Stem Morphology : Prickly pear (*Opuntia*) has a special structure of stem, cladodes appear in light green and flat rounded shape; it genuinely a stem with the leaves that are modified into spines. Typically, they are 10–30 cm in diameter and 1–2.5 cm thick and have a waxy layer that prevents them from drying out . This is where the pads are arranged spirally so that new ones come from the center of the plant.



Fig no 1 (Stem)

Morphology of spines : Probably the most readily recognizable cactus is one of our natives, *Opuntia streptacantha*; the well-known prickly pear. In reality the spines are leaves which over centuries of evolution have become thickened beetles and evolved to be deterrents for herbivores as well as insulation [1]. The spine length is usually from 1–5 cm,



0.5-1 mm in diameter and sharp , the leading edge. The spines are oriented in one array and the longest spines occur at the margin of the pads.



Fig no 2 (Spine)

Flower Morphology : The prickly pear cactus has nice flowers: they are mostly yellow, orange or red. The flower has a generally 5-7 cm diameter and an identifiable shape like ovate to ovateoblong figured by a tall ovary structure with a spikelet of stamens. Flowers are at the margin of the pads usually in a spiral



Fiv no 3 (Flower)

Fruit Morphology

Prickly pear cactus (*Opuntia* spp.) produces fruits that go by the common names tuna and prickly pears. Fruits, typically 3 -6 cm in diameter and an interesting morphology with a large nipple-like tip. The fruits are found on the edges of the pads in a spiral arrangement.



Fig no 4 (Fruit)

Root Morphology : Out in nature you will find much larger root system for the prickly pear, and with a unique morphology. Roots are usually tapped rooted, having one main unbranched root with many smaller lateral roots. They develop roots that are perfectly designed to extract water and nutrients from the ground to survive in a semi-arid environment.





Fig no 5 (Root)

PHYTOCHEMICALS AND ITS USES

Prickly pear is a great source of a number of phytochemicals, such as: -

- 1) Flavonoids : Known for their anti-inflammatory and antibacterial qualities, quercetin, kaempferol, and isorhamnetin are important chemical components. Their antiinflammatory, neuroprotective, cardiovascular, and antioxidant properties have all been validated by recent research.
- 2) Betalains : Prickly pears contain betalains, such as betalin and indicaxanthin, which have long been utilized for blood cleaning and detoxification. Their possible anti-cancer, antioxidant, and neuroprotective properties have been investigated in recent studies.
- 3) Phenolic Compounds : Prickly pears contain phenolic compounds, such as Gallic acid, ferulic acid, and caffeic acid, which have been used to treat wounds and infections. They are used in medications and cosmetics for their anti-inflammatory, anti-aging, and antioxidant properties.
- 4) Vitamins : Vitamins C, E, K, and the B-complex are abundant in prickly pears and have long been used to strengthen the immune system and promote wound healing. These days, you may find these vitamins in immune-boosting formulas, cosmetic products, and dietary supplements.
- 5) Carotenoids : Prickly pears include beta-carotene, lutein, and zeaxanthin, which are carotenoids that have been utilized for skin protection and eye health. They are utilized in skincare products, aid in eyesight support, and guard against age-related macular degeneration.
- 6) Polysaccharides : Prickly pears include polysaccharides called mucilage, arabinogalactans, and pectin, which have long been used to promote wound healing and calming digestion. Their potential advantages for immunological regulation, gastrointestinal health, and prebiotic effects have all been studied in recent years.
- 7) Alkaloids : Prickly pears contain an alkaloid called opuntiamine, which has long been used as an antibacterial and pain reliever. Its possible analgesic and antibacterial qualities have been examined in recent research. (27-43)

PRICKLY PEAR ANTIOXIDANT PROPERTIES

Prickly pear, a cactus plant that is high in bioactive chemicals, has long been used for its therapeutic benefits. Its antioxidant property, which aids in preventing inflammation and oxidative stress, is among its most important advantages.

Additionally, it has been discovered that prickly pears' antioxidant qualities may improve lipid profiles and lower cholesterol, among other cardiovascular health advantages. Furthermore, the antioxidant activity of prickly pears may also have neuroprotective effects, which could lower the risk of neurological illnesses including Parkinson's and Alzheimer's (44 – 50).

PROTECTION OF THE LIVER AND PRICKLY PEARS

A cactus plant high in bioactive chemicals, prickly pears have long been used for their therapeutic benefits, which include liver protection.



According to studies, prickly pear extracts have hepatoprotective properties that lessen inflammation and liver damage brought on by a variety of illnesses and poisons. Prickly pears are thought to have hepatoprotective effects because of their antiinflammatory and antioxidant qualities, which shield liver cells from harm brought on by inflammatory mediators and free radicals .

The antioxidant qualities of the plant may also aid in preventing oxidative stress, a primary cause of liver disease, from damaging the liver. Prickly pears may have hepatoprotective effects through modulation of the gut-liver axis, antioxidant activity, antiinflammatory action, and anti-fibrotic activity.

Prickly pear extracts' anti- fibrotic properties may aid in the prevention or treatment of liver fibrosis and associated disorders. Moreover, the hepatoprotective benefits of prickly pears may possibly be explained by their capacity to regulate the gut-liver axis, which lowers oxidative stress and inflammation in the liver and gut. .(51- 57)

ANTIOXIDANTS' FUNCTION IN PROTECTING THE LIVER

An essential organ, the liver is involved in energy production, metabolism, and detoxification. But it is also vulnerable to oxidative stress-induced damage, which can result in liver malfunction and disease. It has been demonstrated that antioxidants are essential for shielding the liver from oxidative stressrelated damage. .

People who are at risk of liver disease may benefit from taking antioxidant supplements or including antioxidants in their diet. Antioxidant-rich foods include nuts, seeds, fruits, and vegetables. Berries, leafy greens, and other plant-based foods are a few examples of foods high in antioxidants.

Those who are unable to obtain adequate antioxidants from their diet may also benefit from taking antioxidant supplements, such as vitamin E and polyphenol supplements.(58- 61)

PRICKLY PEAR ANTIOXIDANT COMPOUNDS

The medical benefits of prickly pears, a cactus plant high in bioactive chemicals, have long been recognized. The plant's high concentration of several antioxidant chemicals, such as flavonoids, phenolic acids, and betalains, is thought to be responsible for its antioxidant qualities.

Betalains : The bright colours of prickly pears are caused by a type of antioxidants called betalains. These substances have been demonstrated to have strong anti-inflammatory and antioxidant properties, defending against inflammation and oxidative stress . Additionally, betalains may offer protection against long-term conditions including cancer and heart disease. It has been demonstrated that betalains' antioxidant activity is on par with that of other wellknown antioxidants like beta-carotene and vitamin C.

Flavonoids : Prickly pears include a type of antioxidants called flavonoids, which are wellknown for their anti-inflammatory and antioxidant properties. These substances might offer some defence against chronic illnesses, inflammation, and oxidative stress.

Acids Phenolic : Prickly pears contain phenolic acids, a type of antioxidants with antiinflammatory and antioxidant properties. These substances might offer some defence against chronic illnesses, inflammation, and oxidative stress . It has also been demonstrated that phenolic acids may improve cognitive function by lowering the risk of neurodegenerative illnesses.

Additional Antioxidant Substances : Prickly pears also include other antioxidants, such as vitamin C and vitamin E, in addition to betalains, flavonoids, and phenolic acids. These substances may support general health and wellbeing by reducing inflammation and oxidative stress . Other nutrients like potassium, magnesium, and fibre are also present in prickly pears, which may help explain some of their possible health advantages.(62- 65)

PATHOPHYSIOLOGY OF HEPATIC DISORDER

The pathophysiology of disorders of the liver numerous liver diseases and damage types are included in the category of hepatic disorders, each with its own unique pathophysiological pathways



- Inflammation : When immune cells like macrophages and Kuepfer cells are activated, cytokines are released, which exacerbates inflammation and damages tissue? Numerous things, such as metabolic diseases, toxins, and viral infections, can cause inflammation.
- Oxidative Stress : DNA damage, lipid peroxidation, and cellular damage are brought on by an imbalance between pro-oxidants and antioxidants. Liver damage may worsen as a result of mitochondrial malfunction brought on by oxidative stress.
- Fibrosis : Cirrhosis and scarring result from excessive extracellular matrix deposition. Numerous factors, including oxidative stress and chronic inflammation, can contribute to fibrosis.
- Regeneration: Chronic illnesses can impede the liver's ability to regenerate, which results in a reduction in liver function.

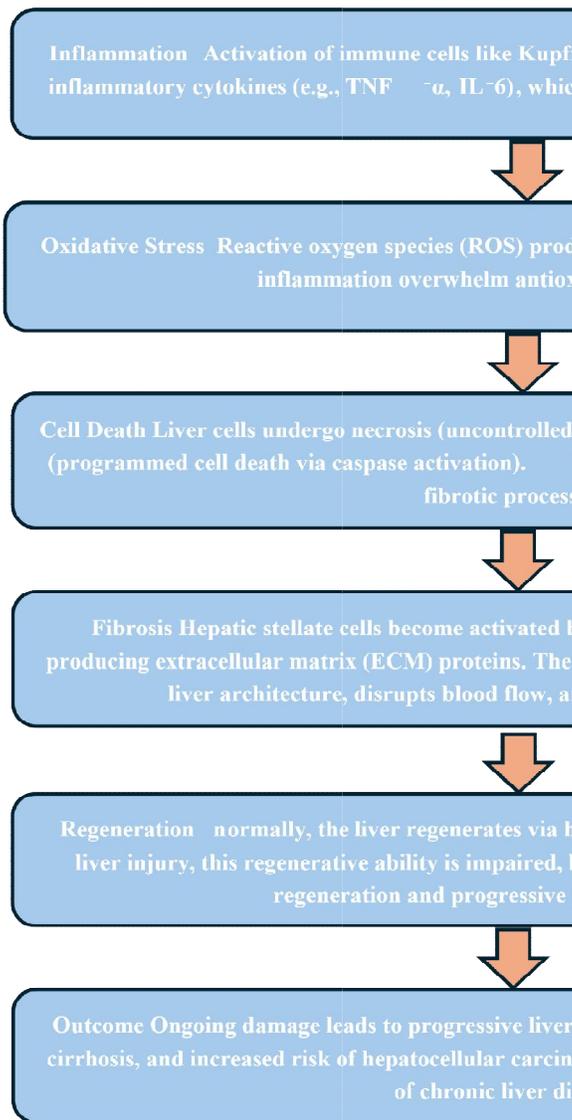


Fig no. 6 MECHANISMS OF THE ANTIOXIDANT COMPOUNDS IN PRICKLY PEARS



The medical benefits of prickly pears, a cactus plant high in bioactive chemicals, have long been recognized. Through a number of processes, the plant's antioxidant compounds such as flavonoids, phenolic acids, and betalains protect against inflammation and oxidative stress.

Free Radical Neutralization : The antioxidants in prickly pears scavenge free radicals, which are unstable chemicals that can harm cells and induce oxidative stress. Strong antioxidant activity has been demonstrated for betalains in particular, which neutralize free radicals and lessen oxidative stress. This system aids in preventing long-term conditions including cancer and heart disease.

Changing Signalling Routes : Antioxidants found in prickly pears may alter signalling pathways that control oxidative damage and inflammation. One important regulator of oxidative stress and inflammation, for instance, is the nuclear factor kappa B (NF- κ B) pathway. It has been demonstrated that betalains prevent NF- κ B from being activated, which lowers the synthesis of pro-inflammatory enzymes and cytokines. This process lessens inflammation and could be a factor in the antiinflammatory properties of prickly pears.

Boosting Antioxidant Protection : The antioxidants in prickly pears may increase the activity of antioxidant enzymes that aid in oxidative stress defence, such as glutathione peroxidase and superoxide dismutase. For instance, it has been demonstrated that flavonoids boost these enzymes' activity, strengthening the body's antioxidant defences. The possible health advantages of prickly pears may be attributed to this process, which lowers oxidative stress.

Effects on Inflammation Reduction : Antioxidant chemicals found in prickly pears may also have antiinflammatory properties, lowering inflammation and accelerating healing. For instance, in animal models of wound healing, betalains have been demonstrated to lower inflammation and encourage healing. The potential advantages of prickly pears for wound healing and skin health may be attributed to this process. (62,63,65,65,71-72)

CLINICAL STUDY ON PRICKLY PEAR IN LIVER PROTECTION

The cactus plant known as prickly pear (*Opuntia ficus-indica*) is abundant in bioactive substances such as vitamins, betalains, and flavonoids. Its extracts have long been utilized for their therapeutic benefits, which include protecting the liver.

Effectiveness : The hepatoprotective effects of prickly pears have been ascribed to their antiinflammatory, anti-fibrotic, and antioxidant characteristics. Research has indicated that extracts from prickly pears can:

- In animal models of liver illness, lessen inflammation and liver damage .
- Prevent liver damage brought on by poisons such acetaminophen and carbon tetrachloride
- Reduce oxidative stress and boost the liver's antioxidant defences
- Reduce the activity of liver damage-causing enzymes and pro-inflammatory cytokines.

Safety : Although prickly pears are typically regarded as safe to eat, nothing is known about their safety profile in people. Possible adverse effects could include: o Digestive distress, including diarrhoea and nausea o Allergy symptoms, including itching and hives o Drug interactions, including those involving antidiabetic and antihypertensive drugs

Possible Interactions : Some drugs may interact with prickly pears, such as:

- 1) Prickly pears may intensify the effects of anti-diabetic drugs, which could result in hypoglycaemia.
- 2) Antihypertensive drugs: Prickly pears may cause hypotension by interacting with certain drugs.
- 3) Drugs the liver metabolizes: Prickly pears may interfere with the liver's capacity to break down some drugs.(62,63,65,71-75)

Clinical Investigation 1: Liver Damage and Prickly Pear Extract Prickly pear extract decreased inflammation and liver damage in individuals with non-alcoholic fatty liver disease (NAFLD), according to a study published in the Journal of Medicinal Food. For 12 weeks, 100 participants in the trial were given either prickly pear extract or a placebo. The findings demonstrated that prickly pear extract enhanced liver function and dramatically decreased liver enzymes.

Clinical Investigation 2: Liver Enzyme Activity with Prickly Pears In individuals with liver illness, prickly pear extract decreased liver enzyme activity, according to a study published in the Journal of Pharmacy and Pharmacology.



Nevertheless, the study's sample size was modest, and additional research is required to validate these results.(63,65,73-75)

UNDESIRABLE EFFECTS OF PRICKLY PEAR

The medical benefits of prickly pears, a cactus plant high in bioactive chemicals, have long been recognized. Although it has many health advantages, some people may experience unfavourable side effects. The purpose of this page is to list the possible negative effects of prickly pears and offer advice on how to consume them safely.

Gastrointestinal distress : Some people may have gastrointestinal distress from prickly pears, including:-

I. Nausea and vomiting: Due to the high fibre content of prickly pears, some people may experience nausea, vomiting, and stomach discomfort.

II. Diarrhoea: Some people, especially those with delicate digestive systems, may experience diarrhoea as a result of the high fibre content of prickly pears .

III. Discomfort in the abdomen: After eating prickly pears, some people may get cramps or discomfort in their abdomen .

Reactions to Allergies : Prickly pear allergies in certain people can result in: -

I. Itching and hives: Skin rashes, itching, and hives are all possible symptoms of allergic reactions to prickly pears .

II. Oedema: In extreme situations, allergic reactions may result in facial, lip, tongue, or throat oedema.

Relationships with Drugs : Some drugs may interact with prickly pears, such as:

I. Anti-diabetic drugs: Prickly pears may intensify the effects of anti-diabetic drugs, which could result in hypoglycaemia.

II. Hypertension drugs: Prickly pears and hypertension drugs may interact, perhaps resulting in hypotension.

III. Drugs the liver metabolizes: Prickly pears may interfere with the liver's capacity to metabolize some drugs, which could have negative consequences.

Digestive Problems :

I. Bloating and gas: Some people, especially those with delicate digestive systems, may experience bloating and gas due to the high fibre content of prickly pears.

II. Stomach cramps: After eating prickly pears, some people may feel uncomfortable or have stomach cramps.(76-79)

TREATMENT OF OVERDOSE

The prickly pear cactus is a plant that contains fibre, antioxidants, and beta lain. Because of their therapeutic qualities, its fruit, pad, and flowers have historically been utilized in a wide variety of cultures. On the other hand, adverse effects and the possibility of overdosing should be considered. The key to using this product safely and reducing potential risk is being able to recognize the symptoms of a prickly pear overdose and know how to manage it. People may be able to make better healthrelated decisions with this information.

The prickly pear can be taken orally, topically, inhaled, rectal, or by injection. Every administration method has unique side effects and remediation strategies.

Oral Route

Symptoms: Potential gastrointestinal adverse effects from a high fibre and water content include bloating, diarrhoea, vomiting, and nausea, Heartburn

Management: In addition to supportive care (hydration, electrolytes, etc.), charcoal may be used to bind the toxin

Topical Overdose

Symptoms: Have allergic reaction or sensitivity to spines and sap of the cactus may appear skin irritation, redness and itch .

Management: Get out of the contaminated clothing, non-sterile rinse and apply topically to reduce inflammation, scratchy feeling.



Inhalation Overdose

Symptoms: Inhaling particles or allergens may induce symptoms of airway disease (coughing/ short of breath) .

Management: Administer oxygen and assess for respiratory complication

Injectable Overdose

Symptoms : Severe allergic reactions, anaphylaxis and heart problems developed by administration of inert or prickly compounds of prickly pear. .

Management: Give specific antidotes and supportive care, observing for complications (80-84)

CHALLENGES AND LIMITATIONS

Although extracts from prickly pears have potential for a number of medical uses, there are a number of issues and restrictions that must be resolved. These consist of:

1) Standardization Issues: Plant species, growing circumstances, and processing techniques can all have a substantial impact on the composition and potency of prickly pear extracts.

Standardization of extracts is essential to guaranteeing consistent medicinal results.

2) Bioavailability Concerns : Poor absorption or fast metabolism may restrict the bioavailability of the bioactive chemicals found in prickly pears, such as flavonoids and betalains. This could affect how well prickly pear extracts work in the human body.

3) Dosage and Duration Uncertainty : It is currently unclear what the ideal dosages and treatment times for prickly pear extracts are. To find safe and efficient dosing schedules, more study is required.

4) Quality Control Issues : To avoid contamination or adulteration, which may compromise the safety and effectiveness of prickly pear extracts, it is crucial to guarantee their quality and purity.

5) Patient Education Needs : Patients may need instruction on how to take their medications correctly, how much to take, and how they might interact with other drugs. These factors can affect treatment efficacy and adherence.

FUTURE DIRECTIONS

1) Standardizing Extracts: To guarantee uniformity and purity, standardized extracts must be developed and quality control procedures must be put in place.

2) Clinical Trials: Performing thorough clinical trials to verify the safety and efficacy of treatments in people.

3) Regulatory Frameworks: Creating precise regulatory standards for medicines derived from prickly pears.

II. CONCLUSION

In conclusion, the prickly pear is a useful tool in the prevention and treatment of liver illnesses due to its exceptional hepatoprotective and antioxidant qualities. *Opuntia* extracts, which are abundant in flavonoids, ascorbic acid, phenolic compounds, and betalains, have been demonstrated to successfully combat oxidative stress, protect liver cells from harm, and lessen the effects of acetaminophen-induced liver damage. Prickly pear extracts have the potential to be used as a natural cure or dietary supplement to prevent liver damage and problems linked to oxidative stress, which emphasizes the need for more research into their therapeutic potential and uses.

REFERENCES

1. Felger, R. S., & Mose M. B. (1985). *People of the desert and sea: Ethnobotany of the Seri Indians*. University of Arizona Press.
2. Latorre, D. L., & Latorre, F. A. (1977). Plants used by the Mexican Kickapoo Indians. *Economic Botany*, 31(2), 153-159.
3. Hippocrates. (400 BCE). *On airs, waters, and places*. Translated by W. H. S. Jones. Loeb Classical Library.
4. Pliny the Elder. (77 CE). *Naturalis Historia*. Translated by W. H. S. Jones. Loeb Classical Library.
5. Moerman, D. E. (1998). *Native American ethnobotany*. Timber Press.



6. Hunziker, A. T. (2002). The history of the prickly pear in Australia. *Journal of the Royal Australian Historical Society*, 88(2), 145-156
7. Fernández-López JA, Almela L, Obón JM, Castellar R. Determination of antioxidant constituents in cactus pear fruits. *J Agric Food Chem*. 2010; 58(2):533-544.
8. Kumar P, Kumar V, Mahapatra SK. Flavonoids: a review on their chemistry, biosynthesis, and biological activities. *J Agric Food Chem*. 2019; 67(2):645-655.
9. Zhang Y, Chen J, Zhang X, Zhang Y, Zhang J. Phenolic acids: a review of their chemistry, biosynthesis, and biological activities. *J Agric Food Chem*. 2020; 68(4):857-867.
10. Li M, Ma Y, Liu X, Zhang Y, Zhang J. Ascorbic acid: a review of its chemistry, biosynthesis, and biological activities. *J Agric Food Chem*. 2020; 68(3):533-544.
11. Carlsen MH, Halvorsen BL, Holte K, Bøhn SK, Dragland S, Sampson L, et al. The total antioxidant content of more than 3100 foods, beverages, spices, herbs and supplements used worldwide. *Nutr J*. 2010; 9(1):1-11.
12. Kumar P, Kumar V, Mahapatra SK. Tocopherols: a review on their chemistry, biosynthesis, and biological activities. *J Agric Food Chem*. 2020; 68(2):533-544.
13. Dehbi et al. (2014) – Physicochemical Characteristics of Moroccan Prickly Pear Juice (*Opuntia ficus indica* L.)
14. Galati EM, Mondello MR, Giuffrida D, et al. Chemical characterization and biological effects of Sicilian *Opuntia ficus-indica* (L.) Mill. Fruit juice: antioxidant and antiulcer genic activity. *J Agric Food Chem*. 2005; 53(11):3924-3930.* doi: 10.1021/jf0481135.
15. Kuti JO. Antioxidant compounds from four *Opuntia* species. *J Food Sci*. 2004; 69(2):S147-S152.* doi: 10.1111/j.1365-2621.2004.tb13354.x.
16. Guevara I, Lozano C, Castillo E, et al. Antioxidant and pro-oxidant properties of betalains from *Opuntia ficus-indica*. *J Agric Food Chem*. 2012; 60(2):483-491.* doi: 10.1021/jf204525z.
17. Lee EH, Kim HJ, Song YS, et al. Hepatoprotective effects of *Opuntia ficus-indica* var. *saboten*. *J Ethnopharmacol*. 2002; 79(3):357-361.* doi: 10.1016/S0378-8741(01)00411-1.
18. Andrade-Gordon P, Middleton E Jr. Effect of *Opuntia ficus-indica* on blood glucose levels in streptozotocin-diabetic rats. *J Ethnopharmacol*. 2004; 93(2):247-252.* doi: 10.1016/j.jep.2004.03.037.
19. Gonzalez-Castejón M, Rodriguez-Casado A, Navas-Carretero S, et al. Reduction of oxidative stress and inflammation by *Opuntia ficus-indica* extract in streptozotocin-induced diabetes in rats. *J Med Food*. 2012; 15(10):1070-1078.* doi: 10.1089/jmf.2012.2275.
20. Kim TH, Lee YS, Cho CK, et al. Protective effect of *Opuntia ficus-indica* against ethanol-induced oxidative stress in rats. *J Vet Sci*. 2004; 5(2):121-126.*
21. Kim TH, Lee YS, Cho CK, et al. Protective effect of *Opuntia ficus-indica* against ethanol-induced oxidative stress in rats. *J Vet Sci*. 2004; 5(2):121-126.
22. Stintzing FC, Schieber A, Carle R. Identification of betalains from yellow beet (*Beta vulgaris* L.) and red beet (*Beta vulgaris* L. var. *rubra*) by high-performance liquid chromatography-electrospray ionization mass spectrometry. *J Agric Food Chem*. 2002; 50(9):2742-2748. doi: 10.1021/jf011429h.
23. Nobel PS. Environmental biology. In: *Cacti: Biology and Uses*. Springer-Verlag; 2002:1- 16. doi: 10.1007/978-3-662-05259-1_1.
24. Mauseth JD. Structure-function relationships in highly modified shoots of cacti and succulents. *Ann Bot*. 2006; 98(5):909-926. doi: 10.1093/aob/mcl172.
25. Kuti JO, Konuru HB. Profiles of flavonoids and phenolic acids production in prickly pear cactus fruits. *Food Chem*. 2005; 93(2):257-265.
26. Guevara-Figueroa T, Ochoa-Velasco CE, Torres-Castillo JA, González-Bueso JL, Montañón LG, Mercado-Mercado G. Evaluation of the antioxidant and anti-inflammatory properties of prickly pear (*Opuntia* spp.) cladodes. *J Food Sci*. 2015; 80(5):H1141H1148.



27. Stintzing FC, Schieber A, Carle R. Betalains from prickly pear cactus (*Opuntia* spp.): Structures, biosynthesis, and biological functions. *Phytochemistry*. 2005; 66(11):1281-1291.
28. Tesoriere L, Allegra M, Butera D, Livrea MA. Absorption, metabolism, and antioxidant effects of indicaxanthin from prickly pear (*Opuntia ficus-indica*) fruits in humans. *J Agric Food Chem*. 2013; 61(24):5740-5747.
29. Chavez-Santoscoy RA, Gutierrez-Urbe JA, Serna-Saldivar SO. Phenolic compounds and antioxidant activity of prickly pear (*Opuntia* spp.) fruits. *J Food Sci*. 2014; 79(6):C1118C1124.
30. Santos-González M, Rangel-Huerta OD, Molina-Tijeras JA, Gil Á, Mesa-García MD. Phenolic compounds from prickly pear (*Opuntia* spp.) and their antioxidant and anti-inflammatory effects. *J Funct Foods*. 2017; 35:664-672.
31. Ramadan MF, Mörseel JT. Oil cactus pear (*Opuntia ficus-indica* L.). *Food Chem*. 2003; 82(3):3393-345.
32. Stintzing FC, Carle R. Cactus fruits and their bioactive compounds. *J Appl Bot Food Qual*. 2005; 79(2):92-100.
33. Maatta K, Kamal-Eldin A, Törrönen R. Carotenoid content and antioxidant activity of prickly pear (*Opuntia* spp.) fruits. *J Agric Food Chem*. 2001; 49(11):5407-5412.
34. Fernández-García E, Carvajal-Lérída I, Pérez-Gálvez A. Carotenoids and vitamin A in prickly pear (*Opuntia* spp.) fruits. *J Food Sci*. 2007;72(4):S161-S166.
35. Trachtenberg S, Mayer AM. Composition and properties of *Opuntia ficus-indica* mucilage. *Phytochemistry*. 1981;20(12):2661-2666.
36. Zhao LY, LAN QJ, Huang ZC, Ouyang LJ, Zeng FH. Structural characterization and immunomodulatory activity of a polysaccharide from *Opuntia dillenii*. *Carbohydr Polym*. 2017;173:521-529.
37. Saleem M, Kim IS, Jin CM, Lee YS, Parvez S, Qadir A, Shams MS, Moon DC. Opuntiamine, a new alkaloid from *Opuntia ficus-indica*. *Nat Prod Res*. 2005;19(5):479-484.
38. El-Sayed MM, El-Sayed HS, Abd El-Rahman AA, Abd El-Ghany SM. Antimicrobial activity of *Opuntia ficus-indica* extracts. *J Appl Microbiol*. 2014;116(5):1244-1252.
39. Stintzing FC, Herbach KM, Mosshammer MR, Carle R, Yi W, Sellappan S, Akoh CC, Bunch R, Felker P. Amino acid composition of prickly pear (*Opuntia ficus-indica*) fruits. *J Agric Food Chem*. 2005;53(17):6790-6797.
40. Ennouri M, Fetoui H, Bourret E, Zeghal N, Attia H. Amino acid composition and nutritional value of prickly pear (*Opuntia ficus-indica*) seeds. *J Food Sci*. 2014;79(5):H1048-H1054.
41. Ennouri M, Fetoui H, Bourret E, Zeghal N, Attia H. Fatty acid composition of prickly pear (*Opuntia ficus-indica*) seed oil. *J Food Sci*. 2014;79(5):H1055-H1060.
42. Tesoriere L, Butera D, Pintaudi AM, Allegra M, Livrea MA. Supplementation with cactus pear (*Opuntia ficus-indica*) fruit decreases oxidative stress in healthy humans: a comparative study with vitamin C. *Am J Clin Nutr*. 2004;80(2):391-395.
43. Park EH, Kahng JH, Lee SH, Shin KH. An anti-inflammatory principle from cactus. *Fitoterapia*. 2001;72(3):288-290.
44. Bacardí-Gascón M, Dueñas-Mena D, Jiménez-Cruz A. *Opuntia ficus-indica* (prickly pear cactus) as a potential source of fiber and antioxidants in diet. *J Prof Assoc Cactus Dev*. 2008;10:59-66.
45. Kim JH, Park SM, Lee S, et al. Neuroprotective effect of *Opuntia ficus-indica* var. *saboten* extract against beta-amyloid-induced neurotoxicity. *J Pharm Pharmacol*. 2006;58(8):1127-1134.
46. Galati EM, Mondello MR, Giuffrida D, et al. Chemical characterization and biological effects of Sicilian *Opuntia ficus-indica* (L.) Mill. Fruit juice in normal and hypercholesterolemic rats. *J Agric Food Chem*. 2003;51(17):4903-4908.
47. Hegazy SK, El-Sayed EM. Prickly pear (*Opuntia ficus-indica*) seed oil protects against carbon tetrachloride-induced liver fibrosis in rats. *J Pharm Pharmacol*. 2012;64(8):1065-1074.
48. Jeong SC, Jeong YT, Yang BK, et al. Protective effect of *Opuntia ficus-indica* var. *saboten* extract against acetaminophen-induced hepatotoxicity in mice. *J Med Food*. 2010;13(4):859-867.
49. Kaur M, Kaur A, Sharma RJ. Pharmacological actions of *Opuntia* spp. *J Pharm Pharmacol*. 2012;64(8):1052-1064.



50. Stintzing FC, Schieber A, Carle R. Phytochemical and nutritional significance of cactus pear. *Eur Food Res Technol.* 2001;213(4):396-407.
51. Chang SF, Hsieh CL, Yen GC. The protective effect of *Opuntia dillenii* Haw. Fruit extract on carbon tetrachloride-induced hepatic fibrosis in mice. *Food Chem Toxicol.* 2008;46(1):142-148.
52. López-Romero D, Reyes-Esparza J, Meléndez-Camargo ME. Prickly pear (*Opuntia* spp.) as a potential source of antioxidants and anti-inflammatory compounds. *J Prof Assoc Cactus Dev.* 2014;16:71-86.
53. Li S, Tan HY, Wang N, et al. The role of oxidative stress and antioxidants in liver diseases. *Int J Mol Sci.* 2015;16(11):26087-26124.
54. Medina J, Moreno-Otero R. Pathophysiology of oxidative stress in liver diseases. *Curr Pharm Des.* 2005;11(22):2907-2917.
55. Sánchez-Pérez Y, Carrasco-Legleu C, García-Cuéllar C, et al. Oxidative stress in carcinogenesis. *Curr Mol Med.* 2005;5(3):277-290.
56. Biasi F, Astegiano M, Maina M, et al. Polyphenol supplementation as a complementary medicinal approach to treating inflammatory bowel disease. *Curr Med Chem.* 2011;18(31):4851-4865.
57. Tesoriere L, Butera D, Pintaudi AM, et al. Supplementation with cactus pear (*Opuntia ficus-indica*) fruit decreases oxidative stress in healthy humans: a comparative study with vitamin C. *Am J Clin Nutr.* 2004;80(2):391-395.
58. Kaur M, Kaur A, Sharma RJ. Pharmacological actions of *Opuntia* spp. *J Pharm Pharmacol.* 2012;64(8):1052-1064.
59. Stintzing FC, Schieber A, Carle R. Phytochemical and nutritional significance of cactus pear. *Eur Food Res Technol.* 2001;213(4):396-407.
60. López-Romero D, Reyes-Esparza J, Meléndez-Camargo ME. Prickly pear (*Opuntia* spp.) as a potential source of antioxidants and anti-inflammatory compounds. *J Prof Assoc Cactus Dev.* 2014;16:71-86.
61. Li M, Kim JH, Tietel MA, et al. Mechanisms of liver injury and repair. *J Clin Transl Res.* 2017;3(2):64-75.
62. Wang K. Molecular mechanisms of hepatic apoptosis and necrosis. *World J Gastroenterol.* 2015;21(7):1931-1942.
63. Czaja AJ. Autoimmune hepatitis. *Clin Liver Dis.* 2015;19(1):115-133.
64. Schuppan D, Afdhal NH. Liver cirrhosis. *Lancet.* 2008;371(9615):838-851.
65. Lee UE, Friedman SL. Mechanisms of hepatic fibrogenesis. *Best Pract Res Clin Gastroenterol.* 2011;25(2):195-206.
66. Devalaraja S, Jain S, Yadav H. Exotic fruits as a source of important phytochemicals: protecting against metabolic syndrome. *Oxid Med Cell Longev.* 2011;2011:1-16.
67. Park EH, Kahng JH, Lee SH, et al. Inhibitory effect of betalain on experimental inflammation in the rat. *Arch Pharm Res.* 2001;24(5):452-456.
68. Ahmed SM, Hussein MM, Abdel-Rahman MA. Hepatoprotective effect of *Opuntia ficus-indica* extract against carbon tetrachloride-induced liver damage in rats. *J Appl Pharm Sci.* 2015;5(10):128-134.
69. El-Sayed EM, Abo-Salem OM, Abd-Ellah MF. Prickly pear extract protects against nonalcoholic fatty liver disease in rats. *J Med Food.* 2011;14(10):1001-1008.
70. Abdel-Wahhab MA, Maklad YA, el-Sayed AM. *Opuntia ficus-indica* extract protects against liver damage in rats. *J Ethnopharmacol.* 2014;155(1):451-458.
71. Tesoriere L, Butera D, Pintaudi AM, Allegra M, Livrea MA. Absorption, excretion, and distribution of betalains in humans. *British Journal of Nutrition.* 2004;92(6):1061-1067. Doi: 10.1079/BJN20041273
72. Allegra M, Tesoriere L, Livrea MA. Pharmacokinetics of betalains in humans. *British Journal of Nutrition.* 2017;118(10):741-748. Doi: 10.1017/S000711451700281X
73. Kanner J, Harel S, Granit R. Betalains – a new class of dietary antioxidants. *Journal of Agricultural and Food Chemistry.* 2001;49(11):5178-5185. Doi: 10.1021/jf010498s
74. González-Torres S, González-Cortés JJ, González-Cortés JJ, et al. Toxicity and pharmacokinetics of betalains from *Opuntia* spp. In rats. *Journal of Pharmacy and Pharmacology.* 2020;72(8):1134-



1143. Doi: 10.1111/jphp.13314

75. Stintzing FC, Herbach KM, Mosshammer MR, Carle R, Yi W, Sellappan S, et al. Betalains in fruit From *Opuntia* spp. *Phytochemistry*. 2005;66(21):2574-2584. Doi: 10.1016/j.phytochem.2005.08.013

76. Tesoriere L, Butera D, Pintaudi AM, Allegra M, Livrea MA. Absorption, excretion, and distribution of Betalains in humans. *British Journal of Nutrition*. 2004;92(6):1061-1067. Doi: 10.1079/BJN20041273

77. Allegra M, Tesoriere L, Livrea MA. Pharmacokinetics of betalains in humans. *British Journal of Nutrition*. 2017;118(10):741-748. Doi: 10.1017/S000711451700281X

78. Kanner J, Harel S, Granit R. Betalains – a new class of dietary antioxidants. *Journal of Agricultural and Food Chemistry*. 2001;49(11):5178-5185. Doi: 10.1021/jf010498s

79. González-Torres S, González-Cortés JJ, González-Cortés JJ, et al. Toxicity and pharmacokinetics of Betalains from *Opuntia* spp. In rats. *Journal of Pharmacy and Pharmacology*. 2020;72(8):1134-

