

Review on Phytochemistry and Therapeutic Uses of Plants of Genus *Opuntia* and *Myroxylon*

Tanmay L Patwardhan^{1*}, Dr Vivek Chaurasia²

¹School of Pharmacy, Mansarovar Global University, Bhopal

²Associate Professor, School of Pharmacy, Mansarovar Global University, Bhopal

*Corresponding author: Tanmay L Patwardhan, School of Pharmacy, Mansarovar Global University, Bhopal

Email: patwardhan.tanmay@gmail.com | WhatsApp: +91 9168046948

Received: 25th May, 2026; Revised: 6th June, 2026; Accepted: 8th June, 2026; Available Online: 21st June, 2026

ABSTRACT

Background

Because of their many medicinal uses, plants of the genera *Opuntia* and *Myroxylon* have been practiced in traditional medicine. This paper investigates their phytochemical makeup and traditional therapeutic use.

Aim

This study aims to emphasize the potential of *Opuntia* and *Myroxylon* species in contemporary medicine by compiling the most recent information on their phytochemistry and medicinal uses.

Methods

Using databases including TOXNET, EMBASE, and PubMed, a thorough literature review was carried out. Relevant papers on phytochemical analysis and therapeutic applications were chosen and combined.

Results

Opuntia species, which include prickly pear cactus, are abundant in bioactive substances with therapeutic properties, such as polyphenols and betalains. Because *Myroxylon* species include substances like benzyl benzoate and derivatives of cinnamic acid, they generate balsam that has been used medicinally for purposes including wound healing and respiratory support.

Conclusion

Both traditional and contemporary medicine may benefit from the use of *Opuntia* and *Myroxylon* species, which may be able to cure skin disorders and chronic illnesses. To optimize the therapeutic advantages of bioactive compounds, future research should concentrate on sustainable production techniques, synergistic effects of bioactive compounds, and clinical validation.

KEYWORDS: *Opuntia*, *Myroxylon*, Phytochemistry, Therapeutic uses, Traditional Medicine.

How to cite this article: Patwardhan TL, Chaurasia V. Review on Phytochemistry and Therapeutic Uses of Plants of Genus *Opuntia* and *Myroxylon*. *Int J Drug Deliv Technol.* 2026;16(62s): 1104-1115. DOI: 10.25258/ijddt.16.62s.118

Source of support: Nil.

Conflict of interest: None.

1. INTRODUCTION :

People have relied on plants for their medicinal properties for a very long time. The medicinal and phytochemical properties of plants from the genera *Opuntia* and *Myroxylon* stand out among the various species of plant [1]. These plant species have a long history of medicinal usage, and modern science is continuing to uncover more about their bioactive components and potential medical applications.

The genus *Opuntia*, often known as prickly pear cactus, has over 200 species mostly inhabiting dry and semi-arid climates in the Americas. These plants' nutritional and medicinal properties, as well as their reputation for thriving in harsh environments, have made them popular for a long time [2]. Vitamins, minerals, flavonoids, polyphenols, and betalains are only a few of the bioactive components found in the cladodes (pads), fruits, and flowers of *Opuntia* species. These

substances possess antioxidant, anti-inflammatory, hypoglycemic, and antibacterial properties. Further investigation into the potential of *Opuntia* extracts for management of chronic ailments has shown their significance in both traditional and modern medicine [3].

Species like *Myroxylon peruiferum* and *Myroxylon balsamum* are inherent to America and are members of the genus *Myroxylon*. Balsam, a resinous substance with a pleasant aroma and many medicinal uses, is principal product of these species [4]. Therapeutic properties have made it a popular medicinal plant for centuries. The intricate combination of volatile oils, cinnamic acid derivatives, and other bioactive compounds in balsam is responsible for its therapeutic efficacy [5]. Research concentrated on their potential use in the treatment of respiratory illnesses, skin conditions, and microbial infections. New compounds with potential medicinal use have been

identified via studies of Myroxylon phytochemistry [6]. The *Opuntia* and *Myroxylon* genera are rich in bioactive compounds that have several potential medical uses. We learn more about their traditional usage and may pave the way for the development of novel natural product-based treatments thanks to the continuing research on these plants.

1.1 Opuntia Species

The cactaceae family includes the *Opuntia* species. Linnaeus coined the genus "cacti" to include all of the cactus species that were known at the time. The taxonomy of cacti was substantially refined in 1754 by Scottish botanist Philip Miller, who classified several species into the genus *Opuntia*. For the most part, fruit and flower traits were what Miller used to categorize *Opuntia* species [7].

1.1.1 Traditional Uses

There has a long history of using *Opuntia* species in many sectors, including as medicine, personal care, fuel, and agriculture. For instance, you may make a sauce out of the fruits and serve it with salads or vegetables. These fruits may be eaten in three different ways: fresh, cooked, or dried. In addition to being a natural sweetener, it contains dietary fibers [8].

According to prickly pear is a component in a wide variety of candies, jellies, and drinks [9]. Fruits and blooms of the *Opuntia* plant may potentially include natural culinary dyes. *Opuntia* gum is used to make cloth stiffer in the fabric business. Essential oils derived from plants, including seeds and flowers, are the building blocks of perfumes. Animals have been fed prickly pear bushes in many parts of the world since prehistoric times. Several possible medicinal uses exist for the plant. Table 1 shows that prickly pear juice from several species has been used for burn relief by both Native Americans and Americans [10].

Table 1: List of Opuntia species

Species	Native Region	Description
<i>Opuntia abjecta</i> [13]	Florida	Reaching a height of 15 to 25 cm, the plants are rather remarkable. A cladode's longest length ranges from 2.5 to 5 cm. More than four centimeters separate the spines. The leaves of <i>Opuntia abjecta</i> are shaped like teardrops. About 4 mm is the diameter of the seeds.
<i>Opuntia aciculate</i> [14]	Texas	The acicular and transient leaves of the 10-to 20-centimeter-long

		<i>Opuntia aciculate</i> plant are a notable feature. Legs measure 3–12 millimeters.
<i>Opuntia alta</i> [15]	Texas	The plants have distinct stems, small fruits, and can grow up to 450 cm in height.
<i>Opuntia ammophila</i> [16]	Florida	Plant itself is tall with gray-green cladodes. The flower buds' recurved tepals make them simple to identify.
<i>Opuntia anacantha</i> [17]	Northern Argentina	At 60 cm tall, the <i>Opuntia anacantha</i> cactus is a widely spreading shrub. lustrous, dark green stem segments, or joints, measuring 3.5–7 cm in width and 15–40 cm in length. The spines are 2-4 cm long, white, and irregular; they are not always present. Flowers: 4 cm long by 6 cm wide; yellowish-orange to orange in hue. The fruit can be any shade of reddish-purple and is long (3-5 cm).
<i>Opuntia anahuacensis</i> [18]	Texas, Mexico	The plants only reach a height of 30–60 cm. The fruit has a purple hue. The cladode form is unique, being obovate and having a neck.
<i>Opuntia arenaria</i> [19]	America	Little cladodes quantify 4-5 x 2-3 cm, while the plant itself is 150 cm long. The length of the spines may reach 3 cm, while the width and height of the cladodes can range from 20 to 30 cm. This little shrublet has tiny fruits that are around 2.5 cm in diameter. Fragrant, subglobose to short

		the golden flowers is frequently crimson.
<i>Opuntia blakeana</i> [29]	Southern Arizona	Shrubby plants that reach a height of 200 cm have dull green joints. Not present are spines. The crimson, conic leaves are 2–3 mm long. The obovate fruits are 4 cm long and the flowers are 5 cm long and have a rose tint. Seeds have a diameter of 4 mm.
<i>Opuntia boldinghii</i> [30]	Central America, West Indies	Growing to a height of 15-25 cm, the plants are impressive. Longest length of a cladode is 2.5 to 5 centimeters. More than four centimeters separate the spines. The leaves of <i>Opuntia abjecta</i> are shaped like teardrops. About 4 mm is the diameter of the seeds.

There is a long history of using prickly pear, particularly for the treatment of diabetes, in traditional Mexican folk medicine. The fruit is effective in treating a variety of ailments, including asthma, gonorrhoea, and diarrhoea. A number of medical conditions, such as hypertension, ulcers, dyspnea, glaucoma, liver problems, wounds, and dyspnea, have traditionally been treated using cladodes, which are fleshy stems [11]. In South Korea, this plant is used for a variety of medical purposes, including the relief of indigestion, burns, bronchial asthma, diabetes, and gastrointestinal distress. For a long time, people from Sicily have relied on prickly pear flower infusions for a variety of medical conditions, including whooping cough, arthritis, edema, wound infections, and diuretics. Prickly pear plants are another option for lowering the risk of erosion on hillsides [12].

Dry and semiarid areas are ideal for the 300+ species of xerophytic *Opuntia* cacti. Various names are used to describe these plants in local language. They are known as slipper thorn, prickly pear, and tuna in English. In Spanish, they are known as Fico d'india. In Azad Bharat, they go by the names nagphani, nagphana, and haththathoira. They are known as Hathlo thor and chorhthlo in Gujarati [31]. They are known as Snuhi in Sanskrit [32]. They are known as Chapati balli in Tamil. They go by the names Nagajemudu and Nagamulla

in Telugu. They go by the names Nagphani and Thuar in Urdu. Table 2 lists the various compounds found in *Opuntia* extracts [33].

Table 2: *Opuntia* species most prominent chemical components [34-51]

Chemical Name	PubChem CID	Molecular Weight (g/mol)	Molecular Formula
Aromadendrin	122920	288.356	C ₁₅ H ₁₂ O ₆
Taxifolin	439533	304.254	C ₁₅ H ₁₂ O ₇
Kaempferol	5280863	286.239	C ₁₅ H ₁₀ O ₆
Kaempferol 3-methyl ether	5468850	328.40	C ₁₈ H ₁₆ O ₆
Quercetin	5280343	302.238	C ₁₅ H ₁₀ O ₇
Quercetin 3-methyl ether	5280770	316.366	C ₁₆ H ₁₂ O ₇
Isorhamnetin	5281654	316.265	C ₁₆ H ₁₂ O ₇
Narcissin	5481663	624.548	C ₂₈ H ₃₂ O ₁₆
Picein	92123	298.291	C ₁₄ H ₁₈ O ₇
Androsin	164648	328.317	C ₁₅ H ₂₀ O ₈
3-o-β-d-glucopyranoside	5318755	478.507	C ₂₂ H ₂₂ O ₁₂
Benzyl-o-β-d-glucopyranoside	188885	270.292	C ₁₃ H ₁₈ O ₆
Gallic acid	370	170.12	C ₇ H ₆ O ₅
Lutein	5281243	568.886	C ₄₀ H ₅₆ O ₂
B-carotene	5280489	536.888	C ₄₀ H ₅₆
Zeaxanthine	5280899	568.886	C ₄₀ H ₅₆ O ₂
Cryptoxanthin	5281235	552.887	C ₄₀ H ₅₆ O
Betacyanins	56841626	550.473	C ₂₄ H ₂₆ N ₂ O ₁₃
Ascorbic acid	54670067	176.124	C ₆ H ₈ O ₆
A-tocopherol	14985	430.717	C ₂₉ H ₅₀ O ₂

1.2 Myroxylon Species

Among the materials included in the collection are manuals detailing the medicinal uses of *balsamum pereirae*, two species of *Myroxylon* [52]. The following databases were searched extensively: PubMed, EMBASE, and TOXNET. We looked for *Myroxylon balsamum*, *Myroxylon pereirae*, Peruvian balsam, and Peru balsam. Papers that were appropriate for the reference list were discovered by manual abstract screening. Associated with this list were pertinent citations from other sources [53-54]. Table 3 summarises the marketed drug data overview

Table 3: Marketed drug data overview

Herbal Substance	Description	Dosage and Administration	Regulatory Information

Myroxylon balsamum (L.) [55]	A remedy that has a variety of topical applications, including as an emollient, an antipruritic, a trophic barrier.	Ointment, 4.95 g/100 g	Application on the skin. For those who are 12 years old and above. Two times a day, apply. One week of usage is all it takes. France and TU together have been in existence since 1944.
------------------------------	---	------------------------	---

1.2.1 Data on medicinal use

Medications marketed throughout the European Union and its member states.

This synopsis does not cover everything. It correctly portrays the situation at the time it was made and is provided only for informative reasons.

1.2.2 Medicinal use and historical data

The Myroxylon pereirae tree, which produces Peruvian balsam, became a member of the U.S.P. in 1820. Since it originated in San Salvador and made its way to Spain via Lima, the tree is known as "Peru balsam" [56]. The medicine first appeared in pharmacies in Germany in the 17th century. You may find antibacterial and vulnerary properties in pure, alcoholic, or ointmented Peru balsam. Its peculiar internal usage is due to its stimulating expectorant qualities [57].

The pharmacopoeias of many countries include salvia de Peru. Reportedly, it has a little antibacterial effect. It heals bedsores and chronic ulcers when diluted with equal quantities castor oil [58]. When dealing with dermatitis or itchy skin, older folks may find that a plain ointment (12.5% concentration) works best. In order to treat hemorrhoid symptoms, it is an ingredient in many rectal suppositories. As a topical anti-scabies agent, benzoyl benzoate has mostly replaced Peru balsam [59].

Among Peru balsam's many traditional medical uses are its antibacterial properties and its effectiveness against parasites and wounds. Peru balsam ointment or an alcohol solution has a long history of usage as a rubefacient, parasiticide (for certain skin disorders), antibacterial, vulnerary, and local protective measure [60]. Used as an expectorant orally very seldom. Peru balsam has

antimicrobial properties as a vulnerary. It has only been used topically because swallowing it produces an inflammatory response. Burns, frostbite, cracks, erythema, pruritus, ulcers, infectious dermatitis, and a host of other small wounds have all been treated with it [61]. Table 4 shows the Historical Data Overview

Table 4: Historical Data Overview

Herbal Preparation	Documented Use / Traditional Use	Pharmaceutical Form	References
<i>Myroxylon balsamum</i> (L.6)	For burns, decubitus ulcers, frostbite, ulcer cruris, bruising from prosthetics, hemorrhoids, and infected and slow-healing wounds	Application on the skin. Preparations with 5-20%, not exceeding 10%, for a broad surface application	Blumenthal et al., 1998 (monograph first published 1986) [62]
Vulnerary [63]	used topically in the form of an ointment, alcoholic solution, or alone		
Wound balm [64]	Typical dosage: 0.5–2 g per day		
Eczema and pruritus [65]	Application on the skin. 12.5%-containing ointment		
Wound healing [66]	Application on the skin. diluted 1:2 in oil (ricin oil, for example) or 1–2% in ointment		
Scabies [67]	Application on the skin. 5-10:100 vaseline or 10-15:200 spir. dilut., either undiluted or diluted.		

It has also been used to treat the discomfort, itching, and congestion that come with acute bouts of piles and other anal illnesses in the form of suppositories. It has been included into inhalation mixtures after dissolving in heated water. Many medical manuals have described Peru balsam's traditional therapeutic use for at least 30 years, including 15 in the EU [68].

Table 5 shows the Herbal Preparation Use and its Overview.

Table 5: Herbal Preparation Use Overview [69]

Herbal Preparation	Pharmaceutical Form	Indication	Posology, Strength	Period of Medicinal Use
<i>Myroxylon balsamum (L.)</i>	Cutaneous use	A traditional herbal medicine used to help heal small wounds and relieve the symptoms of mild skin inflammations.	Adults and senior citizens: 5–10% balm in semisolid forms. Apply once a day.	Use period: one week. In France since 1944; (monograph first published 1986);

2. EMERGING RESEARCH AND NOVEL APPLICATIONS

2.1 Recent Advances in Opuntia Research

In recent years, the genus *Opuntia* has attracted considerable scientific interest beyond its traditional uses. Notably, studies now emphasize its role in nutraceuticals, functional foods, and potential as a biotechnological resource.

2.1.1 Opuntia as a Functional Food

The nutritional profile of *Opuntia* cladodes and fruits is outstanding, containing high levels of dietary fiber, pectin, mucilage, minerals (such as calcium, magnesium, and potassium), and vitamins C and E. These constituents contribute to cholesterol-lowering properties, improved bowel health, and glycemic control, which are vital in modern dietary management of obesity and metabolic syndrome.

Recent controlled trials have indicated that regular consumption of *Opuntia ficus-indica* fruit pulp can significantly lower postprandial blood glucose levels. This hypoglycemic effect is attributed to its ability to reduce carbohydrate absorption by

inhibiting alpha-glucosidase enzymes and slowing gastric emptying [70].

Moreover, the high antioxidant content, particularly betalains, is now being considered as a natural additive for enhancing shelf-life in food preservation industries. Encapsulation techniques are being developed to stabilize betalains extracted from *Opuntia* for use as natural colorants and antioxidants in packaged foods.

2.1.2 Anti-Cancer and Anti-Inflammatory Potential

Emerging in-vitro and in-vivo studies have demonstrated that *Opuntia* extracts can inhibit the proliferation of various human cancer cell lines, including colon, breast, and prostate cancer cells. The mechanism appears to involve induction of apoptosis, modulation of oxidative stress pathways, and suppression of pro-inflammatory cytokines [71]. While these findings are preliminary, they open pathways for developing dietary supplements or adjuvant therapies.

2.1.3 Bioremediation and Environmental Applications

In addition to human health benefits, *Opuntia* species are being explored for environmental sustainability. Due to their ability to thrive in arid regions with minimal water, they are used for soil erosion control and land reclamation in degraded landscapes. Recent studies have examined the use of *Opuntia* cladode biomass for phytoremediation of heavy metals and as a natural coagulant for wastewater treatment [72].

Moreover, biogas production from *Opuntia* biomass has emerged as a renewable energy source in regions with limited conventional feedstock. High mucilage content enhances anaerobic digestion efficiency, providing a sustainable energy solution for rural communities.

2.1.4 Advances in Myroxylon Research

Compared to *Opuntia*, the *Myroxylon* genus is less studied but equally promising due to its unique balsam composition. Traditionally known for wound healing and skin ailments, *Myroxylon* species are now being investigated for antimicrobial resistance management and novel pharmaceutical formulations.

2.1.5 Antimicrobial Resistance and Biofilm Control

Recent microbiological research has revisited Peru balsam and Tolu balsam for their potential to combat multi-drug resistant bacteria and biofilm-forming pathogens. Essential oils and benzyl benzoate derivatives from *Myroxylon balsamum* have demonstrated inhibitory effects on *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and fungal strains like *Candida albicans*. These properties could provide natural alternatives for topical formulations targeting resistant skin infections [73].

2.1.6 Novel Drug Delivery Systems

Pharmaceutical researchers are developing nanoemulsions and microencapsulation techniques

to improve the bioavailability of Myroxylon balsam compounds. Such approaches aim to enhance skin permeability and prolong the therapeutic effect while minimizing irritant reactions associated with balsam use in raw form.

2.1.7 Dermatological and Cosmetic Applications

Given its pleasant fragrance and skin-healing properties, Peru balsam is witnessing renewed interest as a natural ingredient in modern dermatological products. It is increasingly incorporated into creams for chronic wounds, psoriasis, and eczema, often in combination with other herbal extracts for synergistic effects [74].

3. PHARMACOLOGICAL VALIDATION: WHAT MODERN SCIENCE REVEALS

3.1 Phytochemical Characterization

Advancements in analytical techniques like LC-MS/MS and NMR spectroscopy have enabled comprehensive profiling of Opuntia and Myroxylon species. For instance, over 50 phenolic compounds, including quercetin, isorhamnetin, and kaempferol derivatives, have been identified in Opuntia ficus-indica cladodes and fruits. Similarly, Myroxylon balsams are rich in benzyl cinnamate, benzyl benzoate, and free cinnamic acid, explaining their antimicrobial and anti-inflammatory effects [75].

3.2 Toxicological Considerations

While generally recognized as safe for topical use, some Myroxylon balsam components can cause contact dermatitis in sensitive individuals. Recent toxicological assessments suggest that nanoencapsulation can reduce allergenicity while preserving therapeutic benefits. In contrast, Opuntia extracts are widely regarded as safe, though high doses may cause mild gastrointestinal upset due to mucilage and fiber overload.

4. BIOTECHNOLOGICAL INNOVATIONS & CULTIVATION PRACTICES

4.1 Tissue Culture and Genetic Improvement

Modern biotechnological methods are being applied to conserve and enhance these plants. In-vitro propagation through tissue culture is being developed for Opuntia species to produce disease-free, uniform planting material, supporting large-scale cultivation in arid zones [76]. Similarly, genetic studies on Myroxylon aim to identify cultivars with higher balsam yield and improved resistance to pests.

4.2 Sustainable Harvesting and Conservation

Unsustainable harvesting of Myroxylon trees for balsam extraction has raised concerns about biodiversity loss. Recent initiatives advocate for controlled tapping methods, certification of sustainable balsam, and community-based agroforestry systems to balance economic benefits with ecological preservation.

5. Translational Research and Future Directions

5.1 Integrative Medicine Approaches

Integration of Opuntia and Myroxylon-based products into evidence-based complementary medicine is gaining traction. For example, Opuntia supplements are marketed for diabetes management alongside conventional antidiabetic drugs, with studies indicating potential for reducing required drug dosages [77].

5.2 Clinical Trials and Regulatory Aspects

Despite promising preclinical results, robust clinical trials are limited. Regulatory approval requires stringent demonstration of safety and efficacy. Future research must prioritize well-designed randomized controlled trials to establish therapeutic dosages, pharmacokinetics, and long-term effects.

5.3 Value Addition and Global Market Trends

With the rise of the global market for herbal medicine, Opuntia and Myroxylon extracts hold significant economic potential. Standardization of extracts, development of high-value products (nutraceuticals, cosmeceuticals, and phytopharmaceuticals), and compliance with international quality standards (e.g., Good Agricultural and Collection Practices - GACP) can open new avenues for local communities and industry stakeholders.

The genera Opuntia and Myroxylon stand as powerful examples of how traditional botanical wisdom can be validated and harnessed through modern science. Their multifaceted uses — from functional foods and natural colorants to anti-cancer agents and wound-healing balms — showcase their versatility and promise for future drug discovery.

However, realizing this potential demands a multidisciplinary effort:

Pharmacologists should focus on elucidating mechanisms of action and synergistic interactions among phytochemicals.

Agronomists and biotechnologists must ensure sustainable and scalable cultivation.

Policy makers should incentivize conservation and fair-trade practices while supporting clinical validation through funding and international collaborations.

As global healthcare shifts towards integrating traditional knowledge with modern biomedicine, Opuntia and Myroxylon species deserve a prominent place (Table 6) on the research and development agenda. Ensuring sustainable use and equitable benefit-sharing will be key to transforming these time-honored plants into future pharmacological treasures.

Table 6: Value Addition and Global Market Trends

Aspect	Details
Economic Potential	- Rising global market for herbal medicines- High-value products: nutraceuticals, cosmeceuticals, phytopharmaceuticals- Compliance with international

	standards (e.g., GACP)- Economic opportunities for local communities and industry stakeholders
Examples of Applications	- Functional foods- Natural colorants- Anti-cancer agents- Wound-healing balms
Role of Stakeholders	Pharmacologists: Elucidate mechanisms of action; study synergistic interactions of phytochemicals. Agronomists & Biotechnologists: Ensure sustainable, scalable cultivation and harvesting. Policy Makers: Promote conservation, fair trade, clinical validation funding, and international collaborations.
Strategic Requirements	- Standardization of extracts- Sustainable use and conservation- Equitable benefit-sharing- Integration of traditional knowledge with modern biomedicine
Future Perspective	- Position <i>Opuntia</i> and <i>Myroxylon</i> as key resources in drug discovery and global health- Foster multidisciplinary research and responsible commercialization.

6. CONCLUSION:

Opuntia and *Myroxylon* plants have long played an important role in traditional medicine due to their wide range of medicinal uses and extensive phytochemical profiles. Polyphenols, flavonoids, and betalains are plentiful in *Opuntia* species, which includes the prickly pear cactus that have been investigated extensively [78]. These compounds provide *Opuntia* extracts their antibacterial, anti-inflammatory, and antioxidant properties, making them a great option for the treatment of chronic diseases including diabetes and cardiovascular disease. On the other hand, balsam produced by *Myroxylon* species, especially *Myroxylon balsamum* and *Myroxylon pereirae*, is famous for its significant medicinal utility. Peru balsam, derived from these plants, has a long history of usage as a soothing agent, anti-itch, and wound healer [79]. Thanks to its intricate chemical composition—which contains benzyl benzoate and cinnamic acid derivatives—it is pharmacologically useful in treating a variety of skin and respiratory problems. This work has shed light on the value of *Opuntia* and *Myroxylon* species in both traditional and modern medicine by clarifying their botanical, chemical, and pharmacological features [80]. More research is required to determine their entire

medicinal potential, validate traditional uses via clinical studies, and identify novel bioactive compounds for pharmaceutical development. The study of *Opuntia* and *Myroxylon* species demonstrates the ongoing collaboration between traditional knowledge and modern research. It opens up possibilities for the development of new drugs and natural treatments.

Future Direction

Future research on *Opuntia* and *Myroxylon* species should prioritize clinical trials to validate traditional uses and explore potential new medicinal applications. They may lead to the creation of novel drug combinations by studying the synergistic effects of their bioactive components. Recent advances in phytochemical profiling have the potential to lead to the discovery of novel molecules with pharmacological action. Sustainability in agricultural practices and other conservation efforts are essential for ensuring the continued availability and variety of these plants. By working together, pharmacologists, botanists, and traditional healers may enhance treatment outcomes by integrating indigenous wisdom with modern scientific understanding.

REFERENCES:

1. Miller P. The Gardeners Dictionary 4th ed., vol. 3. Printed and Sold by John and James Rivington, London. 1754.
2. Damasceno GA, Silva RM, Fernandes JM, Ostrosky EA, Langassner SM, Ferrari M. Use of *Opuntia ficus-indica* (L.) Mill extracts from Brazilian Caatinga as an alternative of natural moisturizer in cosmetic formulations. *Brazilian Journal of Pharmaceutical Sciences*. 2016 Sep;52(03):459-70.
3. Nallakurumban VA, NB S. Study on phytochemical and antioxidant properties of water apple (*Syzygium aqueum*) and chappathikalli (*Opuntia ficus-indica*). *International Journal For Research In Emerging Science And Technology*. 2015;2.
4. Pawar AV, Killedar SG, Dhuri VG. *Opuntia*: medicinal plant. *International Journal of Advance Research, Ideas and Innovations in Technology*. 2017;3(2):148-54.
5. DeFELICE MS. Prickly pear cactus, *Opuntia* spp.—a spine-tingling tale. *Weed technology*.
6. Chauhan SP, Sheth NR, Jivani NP, Rathod IS, Shah PI. Biological actions of *Opuntia* species. *Systematic reviews in Pharmacy*. 2010 Jul 1;1(2).
7. Stock AD, Hussey N, Beckstrom MD. A new species of *Opuntia* (Cactaceae) from Mojave Co, Arizona. *Cactus and Succulent Journal*. 2014 Mar;86(2):79-83.

RESEARCH PAPER

8. Mauseth JD. Structure–function relationships in highly modified shoots of Cactaceae. *Annals of Botany*. 2006 Nov 1;98(5):901-26.
9. Otálora MC, Wilches-Torres A, Gómez Castaño JA. Microencapsulation of Betaxanthin pigments from pitahaya (*Hylocereus megalanthus*) by-products: Characterization, food application, stability, and in vitro gastrointestinal digestion. *Foods*. 2023 Jul 14;12(14):2700.
10. Wang T, Sui Y, Du X, Zhang S, Chen L. A comprehensive review of post-harvest ripening, preservation and processing for *Actinidia arguta* (mini kiwi). *Journal of Stored Products Research*. 2025 May 1;111:102582.
11. Patti M, Aci MM, Tassone MR, Musarella CM. A review of *Opuntia ficus-indica* (L.) Mill. ethnobotany in Italy and North Africa. *Research Journal of Ecology and Environmental Sciences*. 2025;5:1111.
12. Henderson L. Alien weeds and invasive plants. A complete guide to declared weeds and invaders in South Africa. 2001.
13. Majure LC, Soltis DE, Soltis PS, Judd WS. A case of mistaken identity, *Opuntia abjecta*, long-lost in synonymy under the Caribbean species, *O. triacantha*, and a reassessment of the enigmatic *O. cubensis*. *Brittonia*. 2014 Jun;66(2):118-30.
14. Kumar D, Sharma PK. A review on *Opuntia* species and its chemistry, pharmacognosy, pharmacology and bioapplications. *Current Nutrition & Food Science*. 2020 Oct 1;16(8):1227-44.
15. Aymerich P, Font F. On the identity of *Opuntia elata* sl (Cactaceae) introduced in the Mediterranean region. A taxonomic and nomenclatural update. *Mediterranean Botany*. 2023;44:e80196.
16. Hosking JR, McFadyen RE, Murray ND. Distribution and biological control of cactus species in eastern Australia. *Plant Protection Quarterly*. 1988;3(3):115-23.
17. Baxter EM. *Opuntia aurea*—A New Species. *Cact Succ Soc Am J*. 1933:489-90.
18. Shaw J, Ferguson DJ. *Opuntia bentonii*: A Texas Gulf Coast beach cactus (Cactaceae: Opuntioideae). *Journal of the Botanical Research Institute of Texas*. 2025 Mar 10;19(1):17-26.
19. Hanttula MK, Valdez EW. First record and diet of the tri-colored bat (*Perimyotis subflavus*) from Guadalupe Mountains National Park and Culberson County, Texas. *Western North American Naturalist*. 2021 Mar;81(1):131-4.
20. Castellano J, Marrero MD, Ortega Z, Romero F, Benitez AN, Ventura MR. *Opuntia* spp. fibre characterisation to obtain sustainable materials in the composites field. *Polymers*. 2021 Jun 24;13(13):2085.
21. Griffith MP. Experimental hybridization of northern Chihuahuan desert region *Opuntia* (Cactaceae). *Aliso: A Journal of Systematic and Floristic Botany*. 2001;20(1):37-42.
22. Majure LC, Puente R, Griffith MP, Judd WS, Soltis PS, Soltis DE. Phylogeny of *Opuntia* ss (Cactaceae): clade delineation, geographic origins, and reticulate evolution. *American journal of botany*. 2012 May;99(5):847-64.
23. Mnqeta Z, Paterson ID. Biological control against *Opuntia aurantiaca* Lindley (Cactaceae) and the perceptions of land-users in the Eastern Cape Province of South Africa. *Biocontrol Science and Technology*. 2024 Dec 1;34(12):1165-77.
24. Stock AD, Lee K, Wellard B, Spallone P. New nomenclatural combinations and types for Cactaceae in Utah. *Haseltonia*. 2023 Mar;30(1):6-13.
25. Michael Powell A, Weedin JF. Chromosome numbers in Chihuahuan Desert Cactaceae. III. Trans-Pecos Texas. *American Journal of Botany*. 2001 Mar;88(3):481-5.
26. Majure LC, Ervin GN. The opuntias of Mississippi. *Haseltonia*. 2008 Dec;2008(14):111-26.
27. Fawcett S, Escalona M, Marimuthu MP, Nguyen O, Chumchim N, Beraut E, Seligmann W, Fairbairn CW, Toffelmier E, Miller C, Shaffer HB. A chromosome-level genome assembly of the beavertail cactus, *Opuntia basilaris*. *Journal of Heredity*. 2025 Nov;116(6):835-45.
28. Villaseñor JL. Checklist of the native vascular plants of Mexico. *Revista mexicana de biodiversidad*. 2016 Sep 1;87(3):559-902.
29. American Academy of Arts. Proceedings of the American Academy of Arts and Sciences. Metcalf and Company; 1893.
30. Vilorio-Matos A, Moreno-Alvarez MJ, Hidalgo-Báez D. ISOLATION AND IDENTIFICATION OF BETACYANIN FROM FRUITS OF *Opuntia boldinghii* Br. et R. BY HPTLC AISLAMIENTO E IDENTIFICACIÓN DE BETACIANINA PROVENIENTE DE FRUTOS DE *Opuntia boldinghii* Br. et R. POR HPTLC AILLAMENTO E IDENTIFICACIÓN DE BETACIANINA PROVINTE DE FRUTOS DE *Opuntia boldinghii* Br. et R.

- POR HPTLC. *CYTA-Journal of Food*. 2001 Dec 1;3(3):140-3.
31. Bermeo L. On the Same Ground: Images of the United States, Mexico, and Comanche Nation from around the time of the US-Mexican War (1846-1848). Harvard University; 2024.
 32. Britton NL, Rose JN. The Cactaceae: descriptions and illustrations of plants of the cactus family. *Cactus and Succulent Soc. of America*; 2018.
 33. Barba FJ, Garcia C, Fessard A, Munekata PE, Lorenzo JM, Aboudia A, Ouadia A, Remize F. *Opuntia ficus indica* edible parts: A food and nutritional security perspective. *Food Reviews International*. 2022 Jul 4;38(5):930-52.
 34. Paniagua-Zambrana NY, Bussmann RW, Romero C. *Opuntia ficus-indica* (L.) Mill. Cactaceae. In *Ethnobotany of the Andes 2020* Mar 31 (pp. 1-5). Cham: Springer International Publishing.
 35. Britton NL, Rose JN. A preliminary treatment of the Opuntioideae of North America. Smithsonian Institution; 1908.
 36. Albergamo A, Potortí AG, Di Bella G, Amor NB, Lo Vecchio G, Nava V, Rando R, Ben Mansour H, Lo Turco V. Chemical Characterization of Different Products from the Tunisian *Opuntia ficus-indica* (L.) Mill. *Foods*. 2022 Jan 7;11(2):155.
 37. Messina CM, Arena R, Morghese M, Santulli A, Liguori G, Inglese P. Seasonal characterization of nutritional and antioxidant properties of *Opuntia ficus-indica* [(L.) Mill.] mucilage. *Food Hydrocolloids*. 2021 Feb 1;111:106398.
 38. Engelmann G. Synopsis of the Cactaceae of the territory of the United States and adjacent regions. *Metcalf*; 1856.
 39. Kumar D, Sharma PK. A review on *Opuntia* species and its chemistry, pharmacognosy, pharmacology and bioapplications. *Current Nutrition & Food Science*. 2020 Oct 1;16(8):1227-44.
 40. Brolin K. Impact on plant diversity of introduced *Opuntia stricta* (Cactaceae) in southern Madagascar.
 41. Griffiths D. Illustrated Studies in the Genus *Opuntia*.-I. Missouri Botanical Garden Annual Report. 1908 Jan 1;1908:259-72.
 42. Raj AS, Acharya R, Patel BR. A Narrative Review on Ethnomedicinal Relevance and Species Diversity of *Opuntia* Genus in India. *Pharmacognosy Reviews*. 2023 Jan 1;17(33).
 43. Choi YJ, Wu X, Lee S, Pyo JS, Cho J, Cao S, Kang KS. Protective effects of methylnissofin and methylnissofin-3-O- β -d-glucopyranoside on TNF- α -induced inflammation in human dermal fibroblasts. *Toxicology in Vitro*. 2025 Apr 1;104:106005.
 44. Patel F, Upadhyay K, Mammen D, Robin E, Ramachandran AV, Baxi D. Phytochemical composition and antiproliferative activity of *Opuntia elatior* Mill.: In vitro and in silico studies on breast cancer cell line MCF-7. *Journal of Applied Biology & Biotechnology* Vol. 2024 Jan;12(1):117-27.
 45. Campanelli G, Francois E, Parupathi P, Devarakonda LS, Yang C, Kumar A, Levenson AS. The therapeutic efficacy and mechanism of action of gnetin C, a natural compound from the melinjo plant, in a preclinical mouse model of advanced prostate cancer. *Cancers (Basel)*. 2024;16:1344. DOI:10.3390/cancers16071344.
 46. Cupido M, De-Nova A, Guerrero-González ML, Pérez-Vázquez FJ, Méndez-Rodríguez KB, Delgado-Sánchez P. GC-MS analysis of phytochemical compounds of *Opuntia megarrhiza* (Cactaceae), an endangered plant of Mexico. *PeerJ Organic Chemistry*. 2022 Mar 22;4:e5.
 47. Walker CC, Schultz DM. William Taylor Marshall: his contributions to succulent plant study and a full bibliography of his published work. *Haseltonia*. 2023 Jul;30(1):27-48.
 48. Knechtel JW, Strickfaden H, Missiaen K, Hadfield JD, Hendzel MJ, Underhill DA. KMT5C leverages disorder to optimize cooperation with HP1 for heterochromatin retention. *EMBO reports*. 2024 Nov 19;26(1):153.
 49. Janik J, Paul RE. The encyclopedia of fruits and nuts. Wallingford, UK: CABI; 2008. p. XVIII:954.
 50. Naga Venkata Arjun U.V., Vidiyala N., Sunkishala P., Vidiyala P., Kumar Reddy K.T., Elumalai S., Bhutia S., Hussain Syed S., 2025, "Bio-inspired green synthesis of nanoparticles for psoriasis treatment: A review of current status and future directions". *Asian Journal of Green Chemistry*, 9, 373–403. DOI: 10.48309/AJGC.2025.503808.1680.
 51. Siddiqui F, Farooq AD, Kabir N, Fatima N, Abidi L, Faizi S. Toxicological assessment of *Opuntia dillenii* (Ker Gawl.) Haw. cladode methanol extract, fractions and its alpha pyrones: Opuntiol and opuntioside. *Journal of Ethnopharmacology*. 2021 Nov 15;280:114409.

52. Rice RS, Vera-Velez R, Falconer DJ, Belliveau NA, Cota-Sanchez JH. Macro- and micromorphological characterization of staminodes in the Plains Prickly Pear *Opuntia polyacantha* Haw.(Cactaceae). *Brazilian Journal of Botany*. 2022 Jun;45(2):665-78.
53. Jankowsky L, Brito JO, Jankowsky IP, Nolasco AM, Carvalho J. Use of solid timber waste as potential raw material for novel herbal drugs: multidisciplinary research, development, and innovation. *Mod Appl Pharm Pharmacol*. 2017;1(1):1-5.
54. Quiñonez-Bastidas GN, Navarrete A. Mexican plants and derivatives compounds as alternative for inflammatory and neuropathic pain treatment—A review. *Plants*. 2021 Apr 25;10(5):865.
55. Hong SM, Kamaruddin AH, Nadzir MM. A review on extraction, antimicrobial activities and toxicology of cinnamomum *Cassia* in future food protection. *Biointerface Res. Appl. Chem*. 2023;13(581):10-33263.
56. Villacís J, Armas C, Hang S, Casanoves F. Selection of adequate species for degraded areas by oil-exploitation industry as a key factor for recovery forest in the Ecuadorian Amazon. *Land Degradation & Development*. 2016 Oct;27(7):1771-80.
57. Simas NK, Lima ED, Conceição SD, Kuster RM, Oliveira Filho AM, Lage CL. Produtos naturais para o controle da transmissão da dengue: atividade larvicida de *Myroxylon balsamum* (óleo vermelho) e de terpenóides e fenilpropanóides. *Química nova*. 2004;27:46-9.
58. Moya R, Wiemann MC, Olivares C. Identification of endangered or threatened Costa Rican tree species by wood anatomy and fluorescence activity. *Revista de Biología Tropical*. 2013 Sep;61(3):1113-56.
59. Herrero-Jáuregui C, Guariguata MR, Cárdenas D, Vilanova E, Robles M, Licona JC, Nalvarte W. Assessing the extent of “conflict of use” in multipurpose tropical forest trees: A regional view. *Journal of environmental management*. 2013 Nov 30;130:40-7.
60. de Barros Machado T, Leal IC, Kuster RM, Amaral AC, Kokis V, de Silva MG, dos Santos KR. Brazilian phytopharmaceuticals—evaluation against hospital bacteria. *Phytotherapy Research*. 2005 Jun;19(6):519-25.
61. Herm C, Steigenberger G. Natural resins and balsams from an 18th century pharmaceutical collection characterized by Fourier-Transform Infrared Microspectroscopy. In 11th Infrared and Raman Users Group Conference 5-7 November 2014 Museum of Fine Arts, Boston 2014 Nov 5 (p. 47).
62. Villaseñor JL. Checklist of the native vascular plants of Mexico. *Revista mexicana de biodiversidad*. 2016 Sep 1;87(3):559-902.
63. Ferreira CA, Guillen JG, Buendia RH, Alanya OD, Aliaga DC, Centeno WG, Miranda BS, Mateo SM, Utos TC, Echeverry AV, Tomazello Filho M. Identification of 20 species from the Peruvian Amazon tropical forest by the wood macroscopic features. *Cerne*. 2023 Jul 17;29:e-103134.
64. Sartori AL, De Azevedo Tozzi AM. Comparative leaflet anatomy in *Myrocarpus Allemão*, *Myroxylon L. f* and *Myrospermum Jacq.* (Leguminosae–Papilionoideae–Sophoreae) species. *Botanical Journal of the Linnean Society*. 2002 Nov 1;140(3):249-59.
65. Marin WA, Flores EM. *Myroxylon balsamum* (L.) Harms. Tropical tree seed manual. USDA Forest Service, Washington, DC. 2008.
66. Tucker SC. Floral ontogeny in Sophoreae (Leguminosae: Papilionoideae). I. *Myroxylon* (*Myroxylon* group) and *Castanospermum* (*Angylocalyx* group). *American Journal of Botany*. 1993 Jan;80(1):65-75.
67. Courel B, Adam P, Schaeffer P. Triterpenoids from Balsams: Useful Markers to Recognize Genuine, Adulterated and Archaeological Resins. In 29th International Meeting on Organic Geochemistry (IMOG) 2019 Sep 1.
68. Tan S, Tam MM, Nixon RL. Allergic contact dermatitis to *Myroxylon pereirae* (Balsam of Peru) in papaw ointment causing cheilitis. *Australasian journal of dermatology*. 2011 Aug;52(3):222-3.
69. Bárcenas RT, Yesson C, Hawkins JA. Molecular systematics of the Cactaceae. *Cladistics*. 2011 Oct;27(5):470-89.
70. 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. *The American journal of clinical nutrition*. 2004 Aug 1;80(2):391-5.
71. Morales-Tapia, A.A., González-Jiménez, F.E., Vivar-Vera, G., Del Ángel-Zumaya, J.A., Reyes-Reyes, M., Alamilla-Beltrán, L., Barojas-Zavaleta, J.E., Cooper-Bribiesca, B.L. and Jiménez-Guzmán, J.,

RESEARCH PAPER

2022. Use of freeze-drying and convection as drying methods of the xococonostle by-product and the effect on its antioxidant properties. *Revista Mexicana de Ingeniería Química*, 21(2), pp. Alim2692-Alim2692.
72. Sáenz C, Sepúlveda E, Matsuhira B. Opuntia spp mucilage's: a functional component with industrial perspectives. *Journal of arid environments*. 2004 May 1;57(3):275-90.
73. Aguilar-Sandí D, Solano-Quesada G, Vargas-Ramírez E, Monge-Vargas AA, Irías-Mata A, Barboza-Barquero L. Phenological observations, oil characteristics and equilibrium isotherm of Myroxylon peruiferum seeds (Fabaceae). *Agronomía Mesoamericana*. 2022 Dec;33(spe1).
74. Chuskit R, Joshi J, Gupta I, Bandral C, Kaur S, Kaur S, Batish DR, Singh HP. Antileishmanial activity of essential oil from a high-altitude herb, *Heracleum pinnatum*: an in vitro and in silico analysis. *Journal of Essential Oil Bearing Plants*. 2024 May 3;27(3):818-37.
75. Martinez RM, Melo CP, Pinto IC, Mendes-Pierotti S, Vignoli JA, Verri WA, Casagrande R. Betalains: A narrative review on pharmacological mechanisms supporting the nutraceutical potential towards health benefits. *Foods*. 2024 Dec 3;13(23):3909.
76. Giraldo-Silva L, Ferreira B, Rosa E, Dias AC. Opuntia ficus-indica fruit: A systematic review of its phytochemicals and pharmacological activities. *Plants*. 2023 Jan 25;12(3):543.
77. Frati AC, Jiménez E, Ariza CR. Hypoglycemic effect of Opuntia ficus indica in non insulin-dependent diabetes mellitus patients. *Phytotherapy research*. 1990 Oct;4(5):195-7.
78. Zitterl-Eglseer K, Mascherbauer C, Zimmermann E, Litschauer B, Zitterl W, Thalhammer JG. Dermatological compatibility of different Peru balsams (*Myroxylon balsamum* Harms) and their main compounds nerolidol and benzyl benzoate in dogs evaluated by means of patch testing. *Korrektur-Fahne*. 2012 Jan 1:101.
79. Custódio DL, Veiga-Junior VF. True and common balsams. *Revista Brasileira de Farmacognosia*. 2012;22:1372-83.
80. Schottenhammer A. "Peruvian balsam": an example of transoceanic transfer of medicinal knowledge. *Journal of ethnobiology and ethnomedicine*. 2020 Nov 9;16(1):69.