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REVIEW PAPER

An Overview of Phytochemistry, Medicinal Uses, And the Applications of *Cacti* as an Alternate Food Source

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Abstract

Cacti (family Cactaceae) are drought-tolerant succulents of significant ecological, nutritional, and medicinal value, widely distributed from Canada to Patagonia and cultivated globally, particularly Opuntia ficus-indica. Their adaptive features, specialized water-storing tissues, reduced leaves, and protective spines enable survival in extreme environments and support their expanding role in agriculture. Phytochemical investigations reveal substantial quantities of alkaloids, flavonoids, saponins, polysaccharides, and phenolic compounds. Quantitative studies report phenolic contents of 120–450 mg GAE/100 g, flavonoids of 30–80 mg/100 g, saponins of 0.5–2.5%, and polysaccharides comprising 10–17% of the dry biomass. These compounds contribute to documented antioxidants, anti-inflammatory, antimicrobial, and antihyperglycemic activities. Nutritionally, edible cacti such as O. ficus-indica provide 3–7% dietary fiber, 12–17 mg of vitamin C per 100 g, and high levels of calcium and magnesium, supporting metabolic and gastrointestinal health. Their fruits and cladodes are incorporated into diverse food products, including juices, jams, fermented beverages, and functional food formulations. Cactus cultivation further supports livestock feed production, soil conservation, and sustainable agriculture in semi-arid regions where conventional crops fail. Recent evidence highlights the therapeutic potential of cactus-derived bioactive compounds in managing chronic metabolic disorders, modulating lipid and glucose profiles, and reducing oxidative stress. Increasing global demand for sustainable, climate-resilient crops and natural functional ingredients underscores the growing relevance of cacti. Overall, the integration of phytochemical richness, nutritional value, and environmental resilience positions cacti as promising resources for future nutraceutical, pharmaceutical, and food industry applications.

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Introduction

The cacti plants flourish in arid areas or locations with little rainfall, featuring adaptations like succulent tissues for water retention, reduced or nonexistent leaves, and pointed spines to minimize water loss and discourage animal consumption. Moreover, cacti hold both cultural and economic importance for many indigenous communities across the Americas, as they utilize them in traditional healing, medicine, and artistic expressions (Nobel, 2003). This piques interest in learning more about the cystic compounds in cacti, their uses, and how they can be utilized as an advantageous tool in contemporary medicine and technology.

The prickly pear, recognized as Opuntia species, belongs to the Cactaceae family and originates from the dry and semi-dry areas of Mexico and the southern United States (Loukili et al., 2022). In the 16th century, Opuntia species were introduced to North Africa and Europe by marine traders (Bouzouba et al., 2016; Kadda et al., 2022). Among these species, *Opuntia ficus-indica* and *Opuntia dillenii* have been extensively utilized for their agricultural and medicinal purposes in different nations (Loukili et al., 2024).

Opuntia ficus-indica is a cactus crop with a great history of domestication, and based on Bayesian phylogenetic analyses, it is likely closely related to prickly pears from central and southern Mexico. Domestication is centrally located in Mexico, and its taxonomic concept may include polyphyletic clones (Griffith, 2004). Farmers from Malawi and Mozambique (n=450) were queried about their use of cactus (*Ficus-indica*) as fodder for small ruminants in the dry season. The farmers were aware of cactus as medicine, fruit, ornamental, and live fence, but had little to no knowledge of cactus as fodder (Macalane et al., 2021). This study describes the phytochemistry, medicinal uses, and current-day use of cacti as alternative sources of food for animals, and as a natural source of bioactive compounds for food, medicine, and cosmetics. This review has been designed to provide a comprehensive overview of cacti, focusing on their phytochemistry, medicinal uses, and application as an alternative food source. It delves into the rich bioactive compounds responsible for their health benefits, such as antioxidants and anti-inflammatory properties, and explores the nutritional value of edible species like *Opuntia ficus-indica*.

Current scenario of cacti utilization

Cacti are increasing in numbers in agricultural systems and the wild world. The most important economic species in the world is the *Opuntia ficus-indica* (L.) mill., which is grown in Mexico (230 ha), Malta, Spain, Sicily, Italy (70 ha), Greece, Libya, Tunisia (600 ha), Morocco (150 ha), Algeria (150 ha), Lebanon, Syria, Egypt, Saudi Arabia, Yemen, Israel, Chile, Brazil (600 ha), Turkey, France, Bulgaria, Portugal, Albania, Cyprus, and the United States (Waal et al., 2015; Kauthale et al., 2017). The cacti grow persistently and successfully from sea level to 5100 meters above sea level in Peru, and in other areas of the world range from Canada to Patagonia and Argentine territory. The original best cactus pear cultivars were first recorded in Zacatecas, San Luis Potosí, Aguascalientes, Jalisco, and Guanajuato, Mexico, in the 1940s & 1950s. Cactus pear is now the most economically viable and dependable cash crop. In semi-arid areas, soils and agriculture are limited to rain-fed agriculture in central Mexico. Cactus has supplanted maize or dry beans as a cash crop plant in areas susceptible to drought, and cactus has increased all producers' incomes in areas that have received moderate changes (Dubeux et al., 2017).

Opuntia, a genus of cactus, is under investigation for its possible role in preventing and controlling chronic diseases. In Morocco, efforts are being made to enhance cactus farming and integrate it into everyday eating habits. Opuntia-derived feed contains bioactive compounds with antioxidative, anticancer, and neuroprotective properties (Rahimi et al., 2019). Many regions of the world have long been home to cactus pear cultivation; however, India has not yet adopted the practice for commercial purposes. At Phalton, India's Nimbkar Agricultural Study Institute, Dr. Peter Felker of Texas, USA, brought 33 Opuntia clones to India in 1987 as part of an Indo-US collaborative study program on the plant.

According to Singh (2003), all of the introduced clones grew well in western Maharashtra's semi-arid agroclimatic conditions, and some of them even produced fruit. No literature is available regarding the cultivation of Cactus pear, as well as its application in Nepal to date. This plant has been used ornamentally throughout the country (Figure 1).

Figure 1
Opuntia spp. from Biratnagar, Nepal

Phytochemical composition of cacti

Cacti possess a unique phytochemical profile rich in diverse bioactive compounds that contribute to significant nutritional and therapeutic benefits. Major phytochemicals include alkaloids, flavonoids, saponins, polysaccharides, and phenolic compounds**,** each present in measurable and biologically relevant quantities. Alkaloids such as mescaline, found in species like *Lophophora williamsii*, generally occur at concentrations ranging from 0.1–3.0% of dry weight**,** exhibiting psychoactive properties that have drawn scientific interest regarding their effects on mood and consciousness (Zhang et al., 2024). Flavonoids, including quercetin and kaempferol, typically occur at 30–80 mg/100 g fresh weight**,** providing strong antioxidant and anti-inflammatory activity (Tunç et al., 2025). Studies also show that cactus mucilage contains notable amounts of saponins, ranging from 0.5–2.5% dry weight**,** contributing to their antimicrobial and immune-enhancing properties (Feugang et al., 2006). Polysaccharides, particularly mucilage and pectin, constitute a substantial portion of cactus biomass, accounting for 10–17% of dry weight and playing key roles in hydration and digestive health (Gómez-López et al., 2010). Phenolic compounds, including caffeic acid and chlorogenic acid, are present at 120–450 mg gallic acid equivalents (GAE)/100 g fresh weight**,** supporting anti-cancer, anti-diabetic, and antioxidant functions (Tunç et al., 2025).

The cactus varieties Opuntia and Nopalea possess significant amounts of bioactive compounds such as flavonoids, phenolics, alkaloids, and polysaccharides. The plant gains its antioxidant, anti-inflammatory, and antimicrobial characteristics from these compounds. Quercetin, kaempferol, and isohamnetin are flavonoids found in cactus fruits that exhibit powerful antioxidant properties, helping to neutralize free radicals and reduce oxidative stress as per Mena et al. (2019). Cactus fruits contain betalains, which not only enhance their antioxidant capacity but also provide their distinctive coloration, as demonstrated by Piga et al. (2020). The health benefits associated with the fruits and cladodes of cacti are largely attributed to their rich content of secondary metabolites, including phenolic compounds, carotenoids, and betalains (Figure 2).

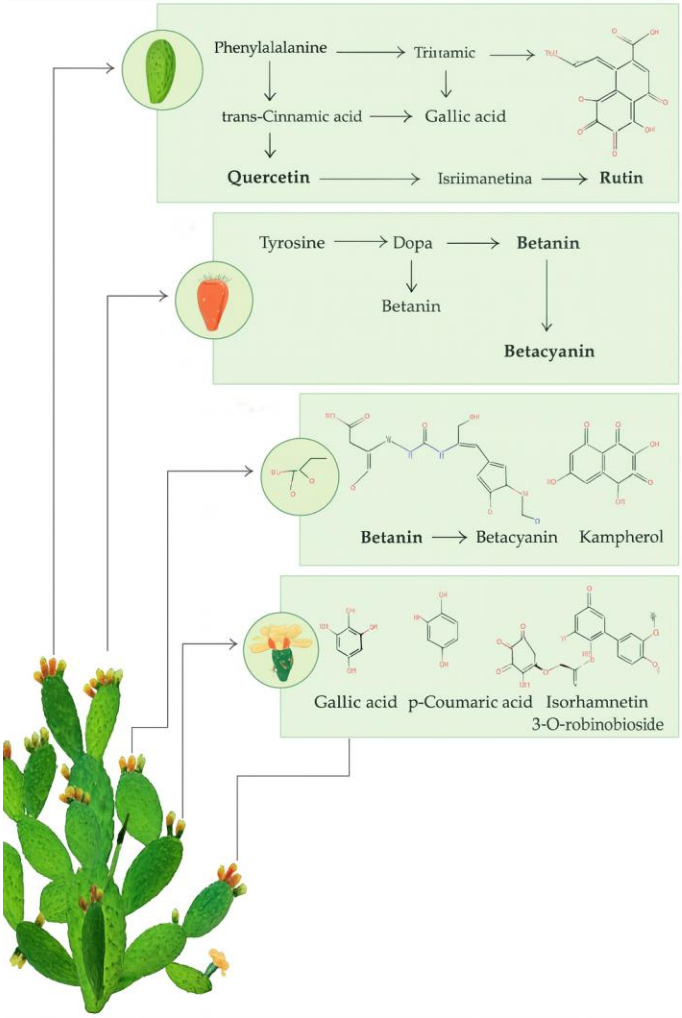

Figure 2
Main compounds found in cacti with biosynthetic pathways (Monteiro et al., 2023).

Medicinal applications of cacti

Due to their rich phytochemical profile, cacti have numerous medicinal uses. Several other studies reported on cactus compounds with anti-cancer effects, including flavonoids and phenolic acids, which are believed to inhibit tumor growth and enhance the effectiveness of traditional cancer treatments (Tunç et al., 2025). Intending to treat a variety of illnesses such as inflammatory conditions, diabetes, and digestive disorders, cacti have been utilized for centuries. For instance, the anti-inflammatory and antioxidant effects of the prickly pear cactus (*Opuntia ficus-indica*) have traditionally been employed in medicine (Paredes-López et al., 2012).

Extracts derived from this plant can improve the lipid profile and blood glucose levels of individuals with diabetes (Gomaa et al., 2012). The mucilage that cactus possesses, coupled with its high fiber content, promotes digestive health by stimulating regular bowel movements and preventing constipation (Gómez-López et al., 2010). Additionally, cactus saponins have been examined for their potential as clinically useful drugs for treating infections and supporting immune function (Feugang et al., 2006).

Another recent study suggested that extracts from prickly pear cactus possess antihyperglycemic activity, which may be significant in managing type 2 diabetes by regulating blood sugar levels (Gomaa et al., 2012; Mena et al., 2019). The anti-inflammatory and antioxidant properties of other cactus compounds are also being examined concerning their therapeutic potential for conditions such as arthritis and cardiovascular disease (Feugang et al., 2006). All these findings indicate that more clinical studies are necessary to confirm the safety and efficacy of cactus-based treatments in modern medicine.

Clinical trials have shown that cacti may be useful in the treatment of type II (adult-onset) diabetes, as they reduce blood sugar levels (Alarcon-Aguilar et al., 2003). Cacti may also help mitigate the adverse consequences of alcohol overdosing; their application prior to consuming alcoholic beverages reduces these negative effects (Wiese et al., 2004). Cactus fruit extracts are utilized in Chinese medicine for treating pain, inflammation, and detoxifying snakebite wounds, as they have traditionally been regarded as harmless poisons (Matos et al., 2024). The wound healing properties and anticancer activity of prickly pear cacti are well known (Zou et al., 2005). For many years, fruit juice from cactus pears has been used as a health beverage. Saenz and Seplveda (2001) reported on the technological challenges and characteristics involved in producing high-quality cactus pear juice. Additionally, the fermentation microorganism *Saccharomyces cerevisiae* has been successfully employed in the fermentation of cactus pear juice (Turker et al., 2001).

Extracts of cacti (particularly from the pads and fruits) have been reported to have antimicrobial activity against diverse pathogens, which may provide potential applications for food preservation and medicine (Rodrguez-Félix & Cantwell, 1993). Cactus extracts have also shown anti-inflammatory activity in laboratory tests, which could prove useful in treating conditions such as arthritis, skin inflammations, and other inflammatory disorders (Feugang et al., 2006). Cacti may help neutralize oxidative stress, which plays an important role in aging and a wide range of chronic diseases. Antioxidant activities of cacti seem to be due mainly to their high concentration of phenolic compounds and flavonoids (Moussa-Ayoub et al., 2020).

Lakshminarayana et al. (1979), Hernandez (1980), and Joubert (1993) report that the fruit of the cactus pear contains > 85% water, 11–14% fermentable sugar, 1.8% crude fiber, 0.1% lipids, 0.21–1.5% protein, and 0.4–1.6% (w/w) ash. In addition, it has 50 IU vitamin A, calcium, and up to 60 and 30 mg/100 g of vitamins C and C. They were supported by Salim et al. (2009). Turker et al. (2001) used the fruit juice of cactus pear plants as a feedstock for yeast fermentation.

Edible cactus

Edible cactus refers to the species of cactus whose pads (*cladodes*) and fruits are safe for human consumption and are commonly used as food. The most widely consumed and economically important edible cactus is *Opuntia ficus-indica*, also known as prickly pear or cactus pear. Its tender pads, called nopales, and its sweet fruits, known as tunas, provide dietary fiber, vitamins, minerals, and antioxidant-rich phenolic compounds beneficial to human health (Sáenz, 2006). Edible cacti are divided into two species: the prickly pear (*Opuntia ficus-indica*) and the nopal cactus (*Opuntia spp*.). It is harvested for the pads (nopales) and the fruits (tunas), which are eaten in various forms of cuisine. The prickly pear (the sabra) produces colorful fruit in different colors, from green to red or purple, which are sweet-flavored. The nopal cactus produces flat, oval pads that can be collected and eaten either as a fresh product or cooked (Paredes-López et al., 2012). The prickly pear (along with other, more traditionally known names like "sabra") is one of the most common food plants in Mexico, where its leaves and fruits are used in many forms of meal preparations, including salad, stew, and tacos (Paredes-López et al., 2012). The cultivation of edible cacti has grown beyond areas considered traditional in Mexican cuisine, due to their adaptability and nutritional values. Although it can be grown in areas of natural habitat, they have been increasingly used in other regions of the globe (Gibson & Nobel, 2003).

Opuntia ficus-indica (also called "prickly pears" or "nopales") is a multifunctional plant that has several medicinal properties, including anti-inflammatory and antioxidant properties. Some biological components of the plant, polyphenols and flavonoids, have been detected in pharmaceutical products, as well as cosmetic products and animal feed. More clinical trials are needed to fully develop its therapeutic potential (Ha et al., 2024).

For many centuries, Native Americans have eaten cacti (Opuntia) as both common vegetables and medicines to treat many types of diseases and illnesses (Knishinsky, 1971; Kay, 1996; Cornett, 2000; Tesoriere et al., 2004). It has long been known that fresh cladodes have nutritional value (Frati et al., 1990; Fernandez et al., 1992). The cactus pear is one of the major crops of the 21st century. It is drought-tolerant and succulent and produces over 20 tons of dry matter per hectare annually, as well as 180 tons of water in each hectare annually contained in its cladodes. As such, it is a cost-effective approach for irrigating livestock (Dubeux et al., 2015).

In Mexico, the US, Italy, and Argentina, cactus pear fruits are used to make jam, a concentrated product. Jam of cactus pear fruits has also more recently started to be produced in Chile. Commercial cladodes are also used to make jams, and fruit is used in Mexico, Italy, and the US to make jelly. Although jam is also made from other Opuntia species, 'Opuntia streptacantha' is used to make the traditional Mexican 'melcocha'. Mexican domestic markets offer a wide range of pickles made from cactus nopales. There are over twenty-five brands available, each with a different mix of spices and in jars, cans, and plastic bags. Pickled nopales are also known as "sweet and hot cactus" or "kosher dill cactus" in Texas. Nopales, following blanching and preservation in vinegar (not exceeding 2% acetic acid content), are seasoned and can be served with or without vegetables and condiments. The liquid is put into jars, sterilized in an autoclave or water bath, cooled, drained, and dried prior to labeling (Corrales & Flores, 2000).

Chopped mature cladodes and/or fruits can be used to make candies or glazed products, which is a particular type of dehydration. Whole cactus pear fruits are eaten as dessert in France after being glazed. Fresh, raw cactus pear juice is requested in Chile, especially at home and in ecological restaurants (FAO, 2013). The cactus pads' tender young segments, or nopales, are eaten raw or prepared in salad dressings, soups, stews, and marmalades in Mexico and other southwestern countries. Strips are cut and cooked with eggs and jalapeños and served as a breakfast delicacy. Nopales are generally marketed fresh in Mexico, with a slice being given to each client as required. They are also exported in bottled or canned form, and less commonly in dried form (Kauthale et al., 2017).

Nutritional benefits and functional foods

In addition to their pharmaceutical potential, cacti contain high nutritional content and are a functional food ingredient with significant nutritional contributions (Table 1). Cacti, and in particular the prickly pear and nopal cactus, are a source of significant nutrients, including vitamins (A, C, and E), minerals (calcium, magnesium, and potassium), and dietary fiber. These substances have been accountable for various health benefits, such as immune system function, bone health, and cardiovascular well-being (Gomaa et al., 2012). High fiber content in cacti maintains healthy digestion and prevents metabolic disorders (Gómez-López et al., 2010). Additionally, cactus compounds' antioxidant activity counteracts free radicals and reduces oxidative stress, which is the cause of chronic diseases such as cancer and cardiovascular disease (Gomaa et al., 2012). Their antioxidant activity, which results from phytochemicals such as flavonoids and phenolic acids, contributes to their nutritional quality in that they combat oxidative stress and reduce the risk of chronic illness.

Cactus extracts have also shown anti-inflammatory activity in laboratory tests, which could prove useful in treating conditions such as arthritis, skin inflammation, and other inflammatory disorders (Feugang et al., 2006). Cacti may help neutralize oxidative stress, which plays an important role in aging and a wide range of chronic diseases. Antioxidant activities of cacti seem to be due mainly to their high concentration of phenolic compounds and flavonoids (Moussa-Ayoub et al., 2020).

Table 1
Nutritional benefits and functional foods of cacti

Component/property	*Nutritional benefits*	*Functional food value*	*Supporting citations*
Dietary fiber	Improves digestion, regulates bowel movement	Helps in glycemic control; suitable for diabetes-friendly foods	Feugang et al. (2006); Sáenz et al. (2004)
Vitamins (vitamin C, A, B-complex)	Boosts immunity and antioxidant capacity	Used for immune-enhancing beverages and supplements	Stintzing & Carle (2005)
Minerals (calcium, magnesium, potassium)	Supports bone health, electrolyte balance	Mineral-rich functional drinks and nutraceutical formulations	Sáenz et al. (2004)
Phenolic compounds and flavonoids	Strong antioxidant and anti-inflammatory properties	Functional foods for chronic disease prevention (anti-diabetic, anti-hypertensive)	Butera et al., (2002); Stintzing & Carle, (2005)
Betalains	Natural pigments with antioxidant capacity	Used as natural colorants in food industry	Stintzing & Carle (2007)
Polysaccharides (mucilage)	Enhance gastrointestinal health, acts as soluble fiber	Applications in food thickening, stabilizers, and prebiotic formulations	Sáenz et al. (2004)
Essential amino acids	Supports metabolic processes and muscle maintenance	Incorporated into plant-based protein foods	Feugang et al. (2006)
Low calorie and low-fat content	Aids in weight management	Suitable for low-calorie dietary foods	Feugang et al. (2006)
Anti-ulcer and anti-inflammatory properties	Helps protect gastric mucosa and reduce inflammation	Medicinal foods and herbal formulations	Khémiri et al. (2019)
Hypoglycemic effects (especially Opuntia ficus-indica)	Helps reduce blood glucose	Functional foods targeted for diabetes control	Frati et al. (1990)

Culinary uses and preparation

The culinary uses of edible cacti are diverse and culturally significant. Nopales are often cooked and added to Mexican foods like "nopalitos" (stir-fried cactus pads) or "tacos de nopal" (cactus tacos). They may be grilled, boiled, or stir-fried and are generally served with other ingredients such as tomatoes, onions, and cilantro (Paredes-López et al., 2012). Prickly pear fruits are eaten fresh, juiced, or processed into jams and preserves. They are also used in beverages such as "agua de tuna" (prickly pear water) and "tequila de tuna" (prickly pear tequila). The fruits are notably flavored from mildly sweet to sour depending on the ripeness stage and variety (Gomaa et al., 2012). Cactus processing requires gentle handling to remove the spines and also to properly clean them. In the case of nopales, the pads are normally peeled and de-spined before preparation, whereas prickly pears need to be peeled to get rid of the tough outer shell and the tiny spines.

The antioxidant-rich fruits, particularly phenolic acids and vitamin C, have been integrated into items like juices and jams. The betalain pigments in the fruit not only contribute to the distinctive bright color of the fruits but also possess potential applications in natural food colorants with high potential for use in sustainable food packaging (Jaramillo et al., 2003; Saenz et al., 2004). Seeds, which are primarily composed of unsaturated fatty acids and vitamin E, also add to the value of the plant as a functional food ingredient (Kuti, 2004).

Cacti are a traditional food crop in dry and semi-dry areas, especially in Mexico, dating back centuries. Their future as a sustainable food crop has been brought into focus by recent research based on their ability to thrive in extreme climates, low water needs, and nutritional value (Moussa-Ayoub et al., 2020). Dietary fiber, vitamins (particularly vitamin C), and trace elements like calcium and magnesium are high in fruits (tunas) and cactus pads (termed as nopales) (Piga et al., 2020). Cacti are being widely sought as a food crop around the world because of global climate change related increases in food insecurity. Their ability to yield well in desert conditions makes them a viable option to yield food where other produce might not be so successful (Mena et al., 2019). In addition, the use of cacti in such food products as jams, jellies, beverages, and flour is gaining popularity due to their health benefits and unique taste (Feugang et al., 2006).

Processing effects on phytochemicals in cacti

Processing methods substantially influence the phytochemical integrity and functional quality of cactus cladodes, particularly *Opuntia ficus-indica*. Moderate thermal treatments such as microwaving, steaming, and griddling generally enhance the extractability and bioaccessibility of phenolics and flavonoids, with microwaving increasing total (poly) phenols up to 3.2-fold and improving phenolic bioaccessibility from ~44% in raw cladodes to 55–64% (De Santiago et al., 2018). In contrast, wet-heat processes like boiling cause marked reductions in water-soluble phytochemicals-including phenolics and vitamin C due to leaching into the cooking medium, which significantly lowers antioxidant potential despite improved tissue softening (Ramírez-Moreno et al., 2013). Drying techniques also affect phytochemical stability; low-temperature convective drying (~45°C) better preserves phenolics, flavonoids, β-carotene, and ascorbic acid compared with high-temperature drying, while excessive heat accelerates oxidative degradation of pigments and phenolic structures (Medina-Torres et al., 2011). Intensive industrial processing, such as extrusion, leads to substantial losses of phenolics, flavonoids, chlorophyll, and antioxidant activity, with degradation largely dependent on extrusion temperature and moisture conditions; nevertheless, cactus flour produced via extrusion can still enhance antioxidant levels in composite foods compared with untreated controls (Pérez-Viveros et al., 2024). Overall, gentle thermal processing and low-temperature drying best preserve functional phytochemicals, whereas boiling and extrusion require optimization to minimize nutrient loss, underscoring the need for standardized processing approaches to maximize the cactus's potential as an alternative food source.

Cacti, particularly those in the genus Opuntia, are getting attention as potential alternative food due to their ability to tolerate extreme environments and being highly nutritious. *Opuntia ficus-indica*, or prickly pear, is one of the most researched species for food uses, with its fruits, cladodes (pads), and seeds having various applications. The cladodes are rich in dietary fiber and bioactive phenolics like kaempferol and quercetin and thus are best to incorporate into foods like pastries and food in the deserts (Saenz, 2006; Fernández-López et al., 2022).

The phytochemical composition of cacti reveals the presence of diverse bioactive compounds such as betalains, flavonoids, phenolic acids, vitamins (particularly vitamin C), minerals, dietary fiber, and mucilage, which are responsible for their significant therapeutic and nutritional properties. These compounds contribute to antioxidant, anti-inflammatory, antidiabetic, antimicrobial, hepatoprotective, and cholesterol-lowering activities. Different plant parts, including cladodes, fruits, seeds, and flowers, are traditionally used for managing various health conditions and are increasingly incorporated into modern functional foods. Moreover, cacti are widely utilized in food applications such as fresh fruits, juices, jams, salads, and nutraceutical formulations, demonstrating their dual role as medicinal and nutritional resources (Table 2).

Table 2
Phytochemistry, medicinal uses, and food applications of cacti

Focus Area	Authors
Phytochemical and functional food applications of *Opuntia ficus-indica*	Ahmed et al. (2024)
Nutritional profile and diverse applications of *Opuntia ficus-indica*	Shoukat et al. (2023)
Comprehensive review on chemical composition and bio-pharmacological properties of cacti	Das et al. (2020)
Nutritional and medicinal applications of *Opuntia* species	Alshaikhi et al. (2023)
Health-promoting properties of *Opuntia* cladodes	Koufan et al. (2024)
Anticancer properties and phytochemicals of *Opuntia ficus-indica*	Wang et al. (2023)
Ethnomedical uses and phytochemistry of *Cereus hildmannianus*	Santos et al. (2021)
Phytochemical screening and bioactivities of Mexican cacti	Rodríguez-Mendoza et al. (2022)
Physicochemical, nutritional, and medicinal properties of *Opuntia ficus-indica*	Martins et al. (2023)
Medicinal uses and phytochemicals of *Caralluma tuberculata*	Ishaq et al. (2023)

Health benefits and medicinal applications

Edible cacti have been employed in traditional medicine for a variety of purposes and possess several health benefits. Prickly pears and nopales are appropriate for diabetic patients because they contain high fiber, which also helps in the digestion and regulation of blood sugar levels (Gómez-López et al., 2010). Tunç et al. (2025) report that the antioxidant activity of cactus-derived compounds such as flavonoids and phenolic acids is associated with a decrease in oxidative stress and inflammation, which can reduce the incidence of cancer and cardiovascular disease. Moreover, there has been a study on the possible prebiotic health effects of cactus mucilage that can improve gut health by stimulating healthy gut flora (Feugang et al., 2006). Anti-inflammatory and antihyperglycemic activities of cactus extracts have been identified by a multitude of research, indicating the prospective application of these compounds in the treatment of metabolic syndrome as well as other chronic conditions (Gomaa et al., 2012). Overall, the therapeutic applications of consumable cacti align with conventional uses and continue to be explored in modern studies.

Environmental and economic impact

The cultivation of edible cacti has both environmental and economic implications. Cacti are suited for hot and semi-arid conditions, where other plants would not readily thrive. That they have low water requirements and can thrive on poor soils makes them an environmentally friendly option for agriculture in areas with low water availability (Gibson & Nobel, 2003). The cultivation of edible cacti can assist in preserving the soil and reducing the environmental impact of traditional crop cultivation.

Soil organic carbon impacts, erosion metrics and value chains

The cultivation of edible cacti contributes positively to environmental sustainability by enhancing soil organic carbon (SOC), reducing erosion, and supporting climate-resilient agricultural value chains. Cacti such as *Opuntia ficus-indica* improve SOC through their high biomass production and continuous deposition of organic residues, which enhance soil structure and microbial activity, particularly in arid and semi-arid soils (De Santiago et al., 2018; Bierer et al., 2021). Their extensive shallow root systems stabilize the soil surface and significantly reduce erosion rates, making them effective in degraded landscapes and sloping terrains prone to runoff (Nefzaoui et al., 2014). Economically, cactus value chains are expanding due to their multifunctional uses: fresh fruits, pads as vegetables, forage, natural dyes, nutraceutical extracts, and cosmetic ingredients, which generate income opportunities for smallholder farmers and dryland communities (FAO, 2017; Sáenz, 2002). The low input requirements, climate resilience, and diverse market applications position cactus production as a sustainable agro-economic strategy in regions facing water scarcity and land degradation, strengthening both environmental conservation and rural livelihoods.

Economically, the production of cactus-based products can provide an income source for rural farmers and assist in stimulating local economies. The new global demand for exotic and health-promoting foods has also opened up new markets for cactus products, which makes them increasingly economically feasible (Paredes-López et al., 2012). However, good management and sustainable agricultural practices are required to maximize the benefits of cactus cultivation and minimize any potential negative impacts on the environment.

Challenges and future directions

Despite the promising potential of cacti, several challenges must be addressed to fully realize their benefits. One of the challenges is the need for more extensive scientific research to validate traditional uses and explore new uses. While there is ample anecdotal evidence of the medicinal properties of cacti, further clinical trials and research are needed to establish their efficacy and safety for use in various therapeutic indications (Tunç et al., 2025). Additionally, standardization of cactus products is required to ensure efficacy and quality consistency. Advances in biotechnology and phytochemical analysis can help in developing standardized extracts and products (Feugang et al., 2006). The research examines the potential use of cacti in the food industry from the perspective of their sustainability in cultivation and commercial use. Cacti-derived ingredients find use in food applications like probiotics and postbiotics. Additional studies need to be directed toward processing technology and probiotic-raw material interactions (Monteiro et al., 2023). Resolution of such issues through concerted research efforts, technological innovation, and sustainable approaches will be paramount to advance the use of cacti in medicine, nutrition, and other fields.

Cactus in agriculture and environmental management

Apart from their medicinal and dietary uses, cacti have significant roles in agriculture and land management. Their ability to thrive in dry conditions makes them valuable in preventing soil erosion and land rehabilitation in desertification risk areas (Nobel, 2003). Cacti can stabilize soil and improve the quality of soil by virtue of their extensive root systems and addition of organic matter. Moreover, cacti are employed as livestock fodder in dry environments, creating a renewable animal feed source (Gibson & Nobel, 2003). Cacti production for sale as ornamental plants and food crops also equates to local economic contribution and sustainable farming. Overall versatility of cacti in various environments and farming also emphasizes their value for nutrition and medicine.

Sustainability and ethical issues

Increased market demand for products from cacti requires sustainability and ethical considerations in their use and production. Sustainable farming ensures that habitat loss and natural resource depletion are prevented during cactus farming. Organic farming, such as the minimization of the use of chemicals and promotion of biodiversity, can aid in maintaining soil quality and ecological equilibrium (Nobel, 2003). In addition, ethical concerns in the production sourcing of cactus products, and especially those relating to indigenous knowledge and traditional practices, are significant. Collaboration with indigenous communities and fair respect for their intellectual property can create more equitable and respectful exploitation of cactus resources (Paredes-López et al., 2012). Ensuring sustainability and ethics in the cultivation and use of cactus will make them remain significant to their ecological and cultural context while their benefit is marketed in modern applications.

The heightened need for cacti as an alternative food source has necessitated increased research on commercializing them. Italy and Mexico are some of the nations that have already included cacti in their agricultural activities, selling them as a functional food due to their health-giving qualities (Moussa-Ayoub et al., 2020). Additionally, cacti are also studied for their ability to produce natural pigments, biodegradable containers, and even biofuels due to their abundant polysaccharide and mucilage content (Piga et al., 2020). Food items that are obtained from cacti are increasingly being added to various health foods and supplements, particularly weight-loss foods, due to their high fiber value and capacity for increasing satiety (Feugang et al., 2006). Cacti are also being used to produce gluten-free food products, which are increasing their application in modern diets (Rodríguez-Félix & Cantwell, 1993).

Conclusion

In general, the study of cacti as a new food source is an optimistic and multifaceted opportunity, depending on their unique phytochemical profile and pharmaceutical uses. Cacti harbor bioactive compounds such as alkaloids, flavonoids, and polysaccharides that are responsible for their extensive therapeutic activities. Their blood glucose-lowering, gastrointestinal-facilitating, and antioxidant and anti-inflammatory properties make them good candidates for traditional and complementary medicine. The reality of today is a greater awareness of the opportunity that cactus plays in addressing food security and sustainable agriculture challenges. Better cultivation technologies and processing methods are rendering them ever more suitable as a secure food source, particularly in dry and semi-dry regions where they naturally abound. Moreover, their consumption in contemporary diets is in harmony with global currents towards plant-based diets and ecological sustainability. However, the full potential of cacti remains limited by gaps such as insufficient long-term clinical evaluations, variability in nutrient composition across environments, limited standardization of phytochemical extracts, and challenges in commercial-scale processing. To overcome these constraints, a clear research roadmap is needed that prioritizes comprehensive clinical and toxicological studies, the development of standardized phytochemical profiling methods, agronomic and nutritional characterization across diverse climates, innovations in food processing and value-added product development, economic and ecological assessments of cactus-based farming systems, and sociocultural research on market acceptance and indigenous knowledge. Strengthening these research areas will enable the integration of cacti into modern food systems and maximize their contribution to global nutrition, health, and sustainable agriculture.

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Conflicts of interest

The authors declare that they have no conflicts of interest regarding the publication of this review article.

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