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Review Article

A Comprehensive Review of Phytochemistry and Pharmacological Activities on *Selenicereus undatus* (Dragon Fruit)

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ABSTRACT

Dragon fruit (*Selenicereus undatus*, syn. *Hylocereus undatus*) is an economically important tropical fruit belonging to the family Cactaceae, increasingly recognized as a rich source of bioactive compounds. Although pulp and peel have received considerable scientific attention, seeds are often discarded as agricultural by-products despite containing valuable phytochemicals including fatty acids, phenolic acids, flavonoids, betalains, tocopherols and phytosterols. Recently, dragon fruit has drawn significant attention among Indian consumers owing to its pleasant flavor, attractive color, and tremendous health and nutritional benefits. Extracts from stems, flowers, peels, pulps and seeds have demonstrated beneficial biological properties against pathogenic microbes and chronic disorders such as diabetes, obesity, hyperlipidemia and cancer. In India, growers are showing increasing interest in its cultivation due to its promising yield, easy cultivation practices, and great commercial potential. However, the area under cultivation is insufficient to meet growing demand, and limited information is available on its production aspects. This review comprehensively discusses the botany, taxonomical classification, nutritional composition, phytochemistry, pharmacological activities, traditional uses, species diversity and cultivation aspects of *Selenicereus undatus* based on recent research findings.

INTRODUCTION

Dragon fruit, commonly known as pitaya or pitahaya, has been traditionally used as a nutritious food in many Asian and tropical regions. The ripe fruit is eaten fresh or processed as juice, desserts, jams, and salads. Traditionally, it has also been

valued for supporting digestion and hydration because of its high water content and dietary fiber. In some cultures, the flowers and young stems are cooked and consumed as vegetables¹. Dragon fruit belongs to the cactus family Cactaceae. Species commonly associated with dragon fruit include

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Selenicereus undatus (white-fleshed), *S. costaricensis* syn. *Hylocereus polyrhizus* (red-fleshed), and *S. megalanthus* (yellow-skinned)^{2,5}. The fruit contains pulp, peel, and numerous small black seeds. Research has traditionally focused on the nutritional and antioxidant properties of the pulp and peel, whereas seeds have received comparatively less attention^{3,6}. The increasing prevalence of antimicrobial resistance has stimulated interest in naturally occurring substances that may provide alternative or complementary sources of antibacterial agents. Medicinal and edible plants contain numerous secondary metabolites capable of interfering with bacterial growth and survival. Consequently, plant-derived extracts are being investigated for pharmaceutical, food-preservation, and nutraceutical applications^{4,11,13}. Dragon fruit has attracted scientific interest because it combines relatively simple cultivation with considerable nutritional and economic potential. Recent reviews have emphasized improvements in agronomic practices, propagation, flowering and pollination management, post-harvest technology and utilization of bioactive compounds^{5,19}. Modern taxonomic treatments place several traditionally recognized *Hylocereus* species within the genus *Selenicereus*. However, the name *Hylocereus* remains widely used in agricultural literature^{2,5}.

PLANT DESCRIPTION

Dragon fruit, commonly known as Pitaya, is a climbing or scrambling hemi-epiphytic cactus belonging to the family Cactaceae. The commercially important dragon fruits are mainly species of the genus *Selenicereus* (formerly *Hylocereus*). The plant is adapted to tropical and subtropical climates and is cultivated for its edible fruits^{1,2}.

Botanical Description

1. Root: Dragon fruit has an exceptionally shallow fibrous root apparatus. In addition to underground roots, the plant produces plane/adventitious roots from stems¹.

2. Stems: Stems are inexperienced, succulent and photosynthetic. It is generally triangular or triangular, with margins of 1,five prominent ribs.

3. Leaves: Dragon fruit does not have the traditional large leaves. The leaves are beautifully reduced, and photosynthesis is carried out by the stem¹.

4. Flowers: Dragon fruit plants have many unique functions for this plant. They are very large, white or creamy white, fragrant, usually produced from stems, mostly nocturnal, and nectar-bearing The flowers are open especially through the night, which is associated with pollination through nocturnal pollinators which include bats and moths¹,

5. Fruit: The fruit is a fleshy berry, generally oval, ovoid or oblong in shape. The outer surface is covered by characteristic scale-like bracts. Depending on species or cultivar, the fruit may have:

a) Red/pink skin with white flesh [*Selenicereus undatus*],

b) Red/pink skin with red or purple flesh [*S. costaricensis*],

c) Yellow skin with white flesh [*S. megalanthus*]^{1,2}.

6. Seeds: The seeds are small, black, oval to slightly elongated and embedded throughout the pulp. They are edible and generally consumed together with the fruit^{6,7}.

Taxonomical Classification



Taxonomic Rank	Classification
Kingdom	Plantae
Clade	Angiosperms
Clade	Eudicots
Order	Caryophyllales
Family	Cactaceae
Sub-family	Cactoideae
Genus	Selenicereus
Species	Selenicereus undatus (Haw.) D.R. Hunt
Synonyms	Hylocereus undatus, Cereus undatus
Common Names	Dragon fruit, Pitaya, Strawberry pear

Taxonomical classification as per Plants of the World Online (Kew) and recent reviews^{2,5}.

PHYTOCHEMISTRY

Phytochemical investigations reveal that different parts of *Selenicereus undatus* are rich in diverse bioactive compounds^{17,18}.

Plant Part	Major Reported Constituents (References)
Pulp	Phenolics, flavonoids, betalains, vitamins C, B-complex, sugars, minerals, dietary fiber [7-10]
Peel	Phenolics, flavonoids, betalains, terpenoids, polysaccharides, higher antioxidant activity than pulp [8,16]
Seeds	Fatty acids (linoleic 45-55%, oleic 20-25%), tocopherols, phenolics, phytosterols [6,18]
Seed Oil	Essential fatty acids, gamma-tocopherol, squalene [6]
Flowers	Phenolic acids, flavonoids, terpenes [5,16]
Stems	Phenolics, polysaccharides, triterpenoids, alkaloids [5]

Seed oil of pitaya is notable for its high content of essential fatty acids. Ariffin et al. reported linoleic acid as the dominant fatty acid followed by oleic and palmitic acids⁶. Betalains are the characteristic pigments responsible for red-violet color and possess strong antioxidant and anti-inflammatory potential^{9,10}. Extraction methods significantly

influence phytochemical yield and biological activity²⁰.

PHARMACOLOGICAL ACTIVITIES

1. Antioxidant Activity

Pulps and peels of *S. undatus* exhibit significant free radical scavenging activity evaluated by DPPH, ABTS, FRAP assays. White and red-fleshed varieties show dose-dependent antioxidant properties due to betalains, phenolics and flavonoids^{7,8,9}. Nurliyana et al. reported higher antioxidant activity in peel compared to pulp⁸.

2. Antimicrobial activity

Stem, plant, bark, pulp extracts have proven interests against pathogenic microorganisms (*Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*), fungi (*Candida albicans*, *Aspergillus* spp.) and viruses with Phenolic flavonoids inhibit pathogens and microorganisms make^{4,11,12,thirteen}. In silico research has identified phytochemicals from *S. undatus* that are able to bind to bacterial target proteins¹⁴. Pharmaceutical antibiotics based on food mainly from dragon fruit appear as preservatives¹⁹.

3. Antidiabetic Activity

Red pitaya fruit consumption has demonstrated hypoglycemic effects in animal models. The soluble fiber, polyphenols and betalains help regulate blood glucose, improve insulin sensitivity and inhibit alpha-amylase and alpha-glucosidase^{15,17}.

4. Anticancer Activity

Betalains, polyphenols and triterpenoids have shown anti-proliferative activity against various cancer cell lines. Wu et al. demonstrated anti-



proliferative activity of red pitaya extracts⁹. South Chinese white pitaya profiling also supported anticancer potential¹⁷.

5. Anti-inflammatory Activity

Dragon fruit bioactive compounds modulate NF- κ B pathway and reduce pro-inflammatory cytokines. Franceschi et al. reviewed delivery systems for dragon fruit bioactives to enhance anti-inflammatory potential¹⁶.

6. Antilipidemic and Anti-obesity Activity

High fiber and betacyanins reduce cholesterol absorption and improve lipid profile. Seed oil rich in unsaturated fatty acids contributes to cardioprotective effects^{6,15}.

7. Wound Healing and Cosmeceutical Applications

Fatty acids, tocopherols and phenolics from seeds offer opportunities for developing cost-effective cosmetic, food and nutraceutical products. Polysaccharides from peel exhibit moisturizing and skin-barrier functions^{6,16,18}.

NUTRITIONAL COMPOSITION AND HEALTH BENEFITS

Dragon fruit is low in calories and rich in vitamin C, dietary fiber, iron and magnesium. Regular consumption supports digestion, immunity, hydration, and cardiovascular health. It is increasingly promoted as a functional food and superfood in Indian markets^{3,5,17}.

CULTIVATION ASPECTS IN INDIA

Indian growers are increasingly interested in dragon fruit cultivation due to its promising yield, adaptability to arid and semi-arid regions, low water requirement, and great commercial

potential^{1,5}. Propagation is mainly through stem cuttings. Flowering is seasonal and requires pollination support. Post-harvest handling, cold storage and value-addition are key areas for expansion⁵.

CONCLUSION

Selenicereus undatus represents a promising cactus fruit with tremendous potential for health promotion, sustainable use of agricultural by-products, and economic upliftment of farmers. While pulp and peel have been extensively studied, seeds remain underutilized despite being rich in essential fatty acids and antioxidants. Future research should focus on detailed pharmacokinetic studies, clinical validation, standardization of extracts, and development of novel food, pharmaceutical and cosmeceutical formulations from all parts of the fruit including seeds and peel^{5,6,14,18}.

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