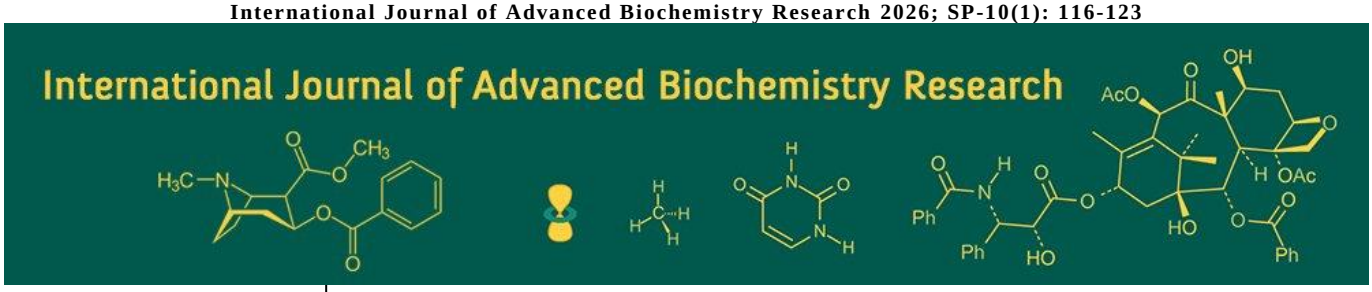

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Medicinal and nutritional values of dragon fruit

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Abstract
In India, another name for dragon fruit (Kamlam) is pitahiya. Large amounts of this American fruit are produced in Thailand, Vietnam, Israel, and Sri Lanka. It belongs to the cactus species. This exotic fruit provides numerous nutritional benefits in addition to doubling growers' profits. This fruit is highly sought after in the market because of its appealing appearance. Its recent cultivation in India serves as an illustration. The pulp that seems pink or yellow on the outside is actually either pink or white on the inside. It has a lot of nutrients and is tasty. Minerals and vitamins abound in it. Dragon fruit consumption is particularly advantageous for those who are immune to a variety of illnesses. What is currently known about dragon fruit production is little. Through research on various aspects of agriculture and the health benefits of dragon fruit, the market for this fruit may rise and the advantages for growers and consumers worldwide may be realised.

Keywords: Dragon fruit, Nutrient value, Medicinal value, Immunity

Introduction
Pitaya, often known as dragon fruit, is a member of the cactus genera *Hylocereus* and *Selenicereus*. Cultivated extensively in tropical and subtropical locations worldwide, it originated in Central and South America. Due to its diverse uses, mild flavour, and appealing appearance (bright-coloured peel, white or red flesh, and many tiny edible seeds), dragon fruit has grown in popularity both as a fresh fruit and in processed forms (juices, powders, extracts). Scientific attention has recently shifted to its nutritional makeup and potential for medical or health benefits. Its distinctive appearance bright pink or red skin with speckled black seeds buried in white or red pulp as well as its soft texture and gently sweet flavour contribute to its appeal as a refreshing fruit (Rahmah *`et al.,* 2024) [48]. In terms of nutrition, dragon fruit is a great provider of vital nutrients. Because it is high in fibre and low in calories, it is a great option for people trying to control their weight or enhance their digestive health (Nishikito *`et al.,* 2023) [35]. The fruit is also a great source of vital vitamins, including vitamin E, which supports healthy skin and guards against oxidative stress, and vitamin C, which strengthens the immune system (Singh and Kumar, 2023) [56].
According to Kumar *`et al.* (2022) [26], dragon fruit is also a good source of minerals including calcium, magnesium, and iron, which are necessary for strong bones, healthy muscles, and healthy blood. The therapeutic potential of dragon fruit is enhanced by a range of bioactive substances that go beyond its nutritional profile. Due of its strong antioxidant content, including According to Zitha *`et al.* (2022) [64], betalains, flavonoids, and phenolic acids have been demonstrated to be essential in lowering oxidative stress in the body. Chronic illnesses including diabetes, cancer, and heart disease are thereby prevented. Due to its high betacyanin concentration, which gives the fruit its vivid red colour and has been connected to anti-inflammatory and anti-cancer properties, dragon fruit is well known for its antioxidant activity (Lee and Lee, 2021). Another area that is gaining attention is the fruit's capacity to control blood sugar levels. Research indicates that the fibre in dragon fruit may help control blood sugar levels, which makes it a potentially advantageous food item for diabetics or individuals seeking to keep their blood sugar levels within a safe range (Poolsup *`et al.,* 2017) [43].

Pansai *`et al.,* (2023) [39] found that the fruit's prebiotic qualities also promote the development of healthy gut flora, which improves digestive health even more. The nutritional profile, bioactive substances, and health advantages of dragon fruit are summarised in this review, which also addresses its limitations, gaps, and future prospects. The data was collected between 2018 and 2025.

Morphology of Dragon fruit plant

Three major species of dragon fruit are found: *(Hylocerous undatus) (Hylocerous megalanthus)* Red fruit with white pulp and colour Yellow-colored fruit with *Hydrocerous polyrhizus,* or white pulp (Hamidah *`et al.,* 2017) [17] Red fruit with red pulp. *Hylocerous undatus:* As they get older, Britton and Rose's long, green stems get a little horny. Green or yellow-green outer perianth segments and pure white interior perianth segments are features of its long (up to 29 cm) flowers. With huge, lengthy scales that are crimson and green at the tips, the fruits have a rectangular shape. They have a rosy-red hue and are between 15 and 22 cm long. Between 300 and 800 g is their weight.

Additionally, very little *Hylocerous megalanthus* is produced in India. Here, the fruits that are growing on the plants have a yellow outside and an inner colour. This fruit has the greatest market price and a very good taste. Robust *Hylocerous polyrhizus* vines are available from Britton & Rose. The stoutest vines in this genus, perhaps. The stems of *H. polyrhizus* are waxy white, but the blooms are similar. The fruits are 10 to 15 cm in diameter and weigh 250 to 600 g. They have the hue crimson. Ovoid in shape, fruits come in a variety of sizes. Its flesh has many tiny black seeds and is a lovely reddish-purple hue. It also tastes great.

Pitaya pulp nutritional composition

The seasonality of harvesting and handling conditions affect the nutritional makeup of pitaya fruits (Liaotrakoon, 2013) [28]. According to Nurul and Asmah (2014) [37], the phytochemical properties and nutritional value of red pitaya fruit vary greatly due to the impact of growing environmental conditions. Pitaya fruit is rich in vitamins, minerals, fibre, fructose, glucose, and antioxidants (Yasmin *`et al.,* 2024) [36]. According to some reports, pitaya fruit has higher concentrations of minerals including potassium, phosphorus, salt, and magnesium than other tropical fruits like pineapple, mango, and mangosteen. Additionally, it has increased vitamin content, with vitamin C being the most prevalent (Choo & Yong, 2011) [9]. 100 g of fresh dragon fruit pulp has a moisture content of about 80%, 8.5-13.0 g of carbohydrates, 6.0 g of total sugar, and 0.4-2.2 g of protein, depending on the species and place of origin (Nurul & Asmah, 2014) [37]. The type of development and maturation stage, as well as the cultivation factors, affect the vitamin C content of pitaya fruit. According to Nurul and Asmah (2014) [37], the number of vitamins and minerals in fruits is dependent on the storage and holding conditions (temperature of approximately 8°C) for improved fruit quality. As a result, vitamin C levels can differ according on the species, crop, origin, stage of fruit development, and extract.

The nutritional makeup of 100 g of pitaya fruits is displayed in Table 1. Pitaya fruit is rich in minerals including calcium, iron, and potassium, high in fibre, and low in fat and carbohydrates. It is also a good source of vitamin C. Furthermore, some researchers looked at the oil that was extracted from pitaya dragon fruit seeds and found that it included a lot of necessary lipids, including linolenic and linoleic acid, along with other fatty acids like palmitic acid, oleic acid, and cis-vaccenic acid (Asghar *`et al.,* 2024) [4].

The health advantages of essential fatty acids are widely recognised. For instance, it has been demonstrated that these acids can help reduce the ratios of low-density lipoproteins (LDL) to very low-density lipoproteins (VLDL), which have been linked to elevated blood cholesterol levels. Additionally, normal brain function, cell membranes, and nerve impulse transmission depend on linoleic and alpha-linolenic acids (Jerônimo *`et al.,* 2015) [24]. About two-thirds of the fruit was made up of pulp, and about one-third was made up of peel. The betacyanin concentration of pitaya peel is 150.46 mg/100 g (Norziah *`et al.,* 2008) [36]. Because betalains can hold their colour throughout a broad pH range of 4-7, they are an attractive pigment for low-acid foods like dairy products. Pitayas get their unique look from the pigmentation process that turns their peel red as they develop (Phebe *`et al.,* 2009) [41]. Compared to apple pomace, which has a higher amount of pectin (10.9%), pitaya peel has a smaller percentage (10.8%). The pitaya peel's overall dietary fibre content was around 69.3% (Table 1). Table 1 shows the percentage and proximate concentration of pitaya peel. Betacyanin is included in pitaya fruit powder along with protein, fat, fibre, and ash, as shown in Table 1. Because polyphenols and colour components have antioxidant properties, natural colourants are thought to offer a number of health advantages (Wybraniec & Mizrahi, 2002) [62]. Additionally, the nutritional makeup of pitaya powder is explained in Table 1.

Table 1: Biochemical composition per 100 g of pitaya fruit (Reyes-García *`et al.,* 2024) [51].

S.N.	Components (Units)	Pitaya pulp	Pitaya peel	Pitaya powder
1.	Moisture (%)	80±0.09	92.65±0.10	4.01±0.12
2.	Protein (g)	0.4-2.2±0.08	0.95±0.15	0.18±0.02
3.	Carbohydrates (g)	8.5-13±0.15	6.20±0.09	ND
4.	Fat (g)	0.4±0.02	0.10±0.04	1.203±0.09
5.	Ash (g)	0.54±0.05	0.10±0.01	0.794±0.28
6.	Vitamin C (mg)	20.5±0.28	ND	ND
7.	Betacyanin (mg)	ND	150.46±2.19	44.72±0.15
8.	Dietary fibers (mg)	30.0±0.17	69.30±0.53	38.051±7.58
9.	Iron (mg)	1.9±0.05	ND	ND
10.	Calcium (mg)	8.5±0.15	ND	ND
11.	Phosphorus (mg)	22.5±0.20	ND	ND

Macronutrients

- **Water content:** The flesh of dragon fruit has a high moisture content (around 82-85%), which keeps its caloric density low while making it hydrating and satisfying. (Arivalagan & colleagues, 2021) [3].
- **Carbs:** The fruit has a moderate amount of carbohydrates, typically 10-13 g per 100 g of fresh weight. Fibre and simple carbohydrates (glucose and fructose) are included in this. (Arivalagan & colleagues, 2021) [3].
- **Suger:** The two main types of simple sugars are glucose and fructose. For instance, in certain white-fleshed types, fructose is about 1-3 g/100 g while glucose is about 5-6 g/100 g. (Arivalagan & colleagues, 2021) [3].
- **Dietary fibre:** This small but important fibre level (often 1 g or more per 100 g) supports gut health. (Arivalagan & colleagues, 2021) [3].
- **Protein and Fat:** The pulp has very little protein (0.9-1.1 g/100 g in many types) and very little fat; the majority of the fat comes from the seeds, which also include healthy fats (Arivalagan *`et al.* 2021) [3].

Minerals and Vitamins

- **Vitamin C:** Dragon fruit contains some vitamin C, but not as much as citrus fruits. 2-6 mg/100 g is reported in several studies (Arivalagan *`et al.,* 2021) [3].
- **Vitamin E**, **Vitamin K**, **B vitamins**: Red-fleshed varieties frequently exhibit higher quantities of certain vitamins and antioxidants; vitamin E, vitamin K, and B vitamins are present but in less amounts. (Arivalagan *`et al.,* 2021) [3].
- **Potassium (K):** significant amounts; in several types, values are around 200-300 mg per 100 g. Cardiovascular health benefits from potassium (e.g. blood pressure management). (Arivalagan *`et al.,* 2021) [3].
- **Magnesium (Mg), Calcium (Ca), Phosphorus (P), Iron (Fe), Zinc (Zn):** Present in modest quantities. For example, *H. polyrhizus* shows ~30-45 mg, Mg, ~20-45 mg Ca, ~20-35 mg P per 100 g. Iron and zinc are lower but contribute to micronutrient intake. (Arivalagan *`et al.,* 2021) [3].

Bioactive Phytochemicals

- **Total phenolic compounds:** Usually expressed in gallic acid equivalents (GAE), research indicates that there are approximately 25-55 mg of GAE per 100 g of flesh, with red flesh types typically having a greater phenolic content. (Arivalagan & colleagues, 2021) [3].
- **Flavonoids:** Variously present; contributes to the antioxidant action. (Arivalagan & colleagues, 2021) [3].
- **Betalains:** betaxanthins and betacyanins Particularly in red-skinned and red-fleshed varieties, these pigments offer anti-inflammatory and antioxidant qualities in addition to adding colour (Spritzler, F. 2023) [57].
- **Other phytochemicals**: have been found in peel or other portions, including alkaloids, carotenoids, saponins, steroids, terpenoids, and tannins; many of them exhibit a variety of biological actions (Chen *`et al.,* 2024) [7].

Medicinal value of dragon fruits

a. Antioxidant properties: Antioxidants, which are abundant in dragon fruit, are essential for defending the body against oxidative stress and lowering inflammation. The main antioxidants that dragon Fruit contains vitamins C and E, phenolic acids, flavonoids, and betacyanins (Al-Mekhlafi *`et al.,* 2021) [1]. The fruit's vivid red hue is caused by betacyanins, which have also been demonstrated to have anti-inflammatory and anticancer effects and to lessen oxidative damage (Choo *`et al.,* 2018) [8]. By enhancing blood circulation and lowering the risk of cardiovascular disorders, flavonoids support heart health. Phenolic acids also help neutralize free radicals, which can damage cells and lead to chronic diseases such as cancer (Rahman *`et al.,* 2021) [49]. The following health benefits have been linked to dragon fruit consumption or extracts based on in vitro, animal, and some human observational or intervention studies: vitamin C strengthens the immune system and supports skin health, while vitamin E shields cells from damage and supports overall well-being. These antioxidants together make dragon fruit a potent superfood that helps prevent disease and support long-term health (Michalak *`et al.,* 2021) [33].

b. Anti-hyperlipidemic: The main causes of dragon fruit's anti-hyperlipidemic qualities include its fibre, antioxidants, and bioactive substances such betacyanins and flavonoids. The elevated fibre helps lower levels of LDL (bad cholesterol) and total cholesterol by reducing the gut's absorption of cholesterol (Prajapati *`et al.,* 2022) [44]. According to Maigoda *`et al.* (2016) [31], antioxidants such as flavonoids guard against lipid peroxidation and oxidative stress, two factors that lead to cardiovascular disorders. By regulating lipid metabolism and promoting fat breakdown, betacyanins also contribute (Safira *`et al.,* 2021) [53]. Consuming dragon fruit has been demonstrated to improve lipid profiles by raising HDL (good cholesterol) and decreasing triglycerides and LDL levels, hence promoting cardiovascular health and averting hyperlipidaemia (Setiawan *`et al.,* 2018) [55].

c. Anti-inflammatory Effects:

- Because of its phenolics, flavonoids, and betalains, dragon fruit exhibits high free radical scavenging action in laboratory tests (DPPH, ABTS, etc.) (Arivalagan *`et al.,* 2021) [3].
- Anti-inflammatory qualities: In animal studies, several extracts lower inflammatory markers. Bioactive substances that inhibit oxidative stress and inflammatory pathways are responsible for these effects (Rathi *`et al.,* 2023) [50].

d. Metabolic Health: Diabetes, Lipid Profile, Obesity

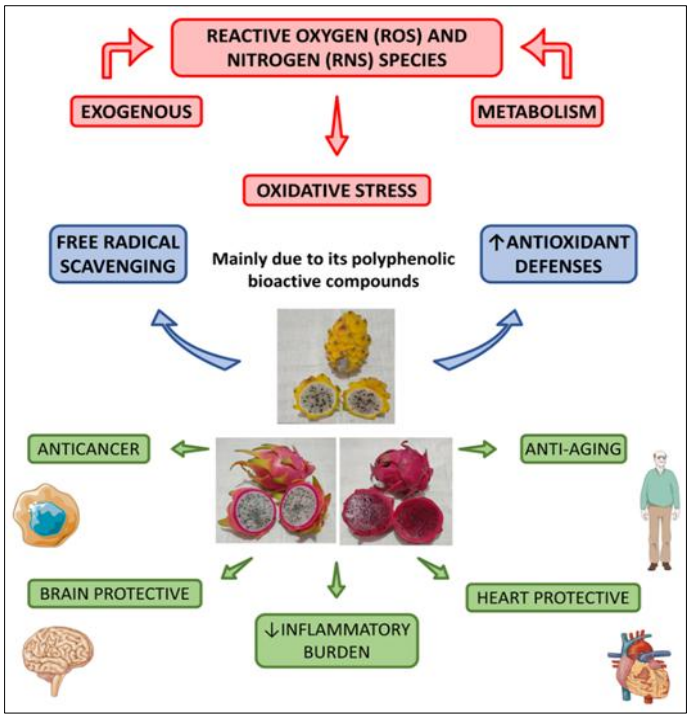
- **Glycaemic control:** Research on animals indicates that dragon fruit can lower fasting glucose and increase insulin sensitivity. Factors include the fibre content, low glycaemic load, and protection from oxidative stress (Spritzler, F. 2023) [57].
- **Improvement of the lipid profile:** According to certain animal research, the ratio of total cholesterol to HDL and LDL (low density lipoprotein) cholesterol have decreased. Antioxidant qualities may help lessen lipid peroxidation (Hossen *`et al.,* 2025) [20].

- **Weight management:** In animal models fed a high-fat diet, dragon fruit may help maintain a healthy weight or prevent weight gain due to its fibre content, low calorie density, and potential to modulate gut microbiota (Spritzler, F. 2023) [57].

e. Gut Health and Prebiotic Effects

- Dragon fruit's dietary fibre and oligosaccharides may function as prebiotics, supporting Lactobacillus and Bifidobacterium, two good gut bacteria. Better barrier function, immunological regulation, and digestion may result from this (Spritzler, F. 2023) [57].

f. Immune System and Antimicrobial Activity: Because of its bioactive components, which include flavonoids, phenolic acids, and betacyanins, dragon fruit has antibacterial qualities. These substances demonstrate the capacity to stop different harmful bacteria and fungi from growing (Hendra *`et al.*, 2019) [18]. According to Tripathi *`et al.* (2024) [60], the mechanism entails breaking down the membranes and cell walls of microorganisms, which causes intracellular components to flow out and eventually results in cell death. The strong antioxidant content of dragon fruit also aids in the neutralisation of free radicals, which erodes microbial defences even more (Seth *`et al.*, 2021) [54]. Research has demonstrated the efficacy of dragon fruit extracts against specific fungus species and bacterial strains such Escherichia coli and Staphylococcus aureus (Lim *`et al.*, 2023) [29]. Because of its antibacterial properties, dragon fruit may be used as a natural remedy for illnesses, which encourages its usage in food preservation. Antioxidant substances, certain bioactives, and vitamin C content all assist the immune system. Rachel, N. (2023) [47] In particular, extracts from peels, seeds, or concentrated bioactive fractions have been shown to possess antibacterial, antifungal, and some antiviral qualities. In vitro, these effects are more documented (Chen *`et al.*, 2024) [7]. According to Chen *`et al.* (2024) [7], dragon fruit exhibits potential for cardiovascular protection through mechanisms like lowering LDL, reducing oxidative stress, supplying potassium (which aids in blood pressure regulation), and potentially enhancing endothelial function.



Chen *`et al.* (2024) [7]

Fig 1: Main antioxidant effects of *Hylocereus* species and their health effects.

g. Antidiabetic properties: The high fibre content and bioactive substances like flavonoids and betacyanins in dragon fruit are the main causes of its antidiabetic qualities. Fibre improves glycaemic management and lessens blood sugar increases after meals by slowing the absorption of carbohydrates (Tarte *`et al.*, 2023) [59]. Furthermore, dragon fruit's low glycaemic index guarantees a steady release of glucose into the blood. Research indicates that its bioactive components might improve insulin sensitivity, which would help cells use glucose more effectively (Erika *`et al.*, 2024) [15]. Flavonoids and other antioxidants shield pancreatic β-cells from oxidative damage, maintaining their ability to produce insulin (Malik *`et al.*, 2023) [32]. Consuming dragon fruit has been found to improve insulin resistance and fasting blood glucose levels, which makes it advantageous for those with type-Pre-diabetes or diabetes type 2. Diabetes can be managed and prevented thanks to its nutritional profile, which promotes glucose regulation (Putri *`et al.*, 2021) [45].

h. Anticancer properties: Dragon fruit's abundance of antioxidants, including flavonoids, phenolic acids, and betacyanins, gives it anticancer properties. These substances fight cancer by eliminating free radicals that have the potential to harm DNA and start the development of cancer (El-Nashar *`et al.*, 2024) [14]. By disrupting important signalling pathways, betacyanins in particular cause cancer cells to undergo apoptosis, or

programmed cell death, and stop proliferating (Chowdhury *`et al.,* 2024) [10]. By lowering inflammation, which is strongly linked to the formation of tumours, flavonoids and phenolic acids play a role (Saenjum *`et al.,* 2021) [52]. Research has demonstrated that extracts from dragon fruit can stop the growth of several cancer cells, including those found in the breast and colon (Padmavathy *`et al.,* 2021) [38]. Dragon fruit is a viable cancer treatment option because of its antioxidant activity, which targets malignant cells while shielding healthy ones treatment and prevention (Al-Radadi, 2022) [22].

i. **Anti-anemia property:** The main factor of dragon fruit's anti-anemia effects is its iron concentration, which promotes the synthesis of haemoglobin, which is necessary for oxygen, and red blood cell creation. bodily transfer (Khuzaimah *`et al.,* 2023) [25]. Dragon fruit's vitamin C content improves iron absorption even more, resulting in increased bioavailability of this essential mineral. Eating dragon fruit lowers the incidence of anaemia by preventing iron deficiency (Damayanti *`et al.,* 2023) [11]. It is a useful dietary supplement for preventing and treating irondeficiency anaemia since studies show that frequent consumption can raise haemoglobin levels and reduce anemia-related symptoms including weakness and exhaustion (Mulyani and Sari, 2020) [34].

j. **Hepatoprotective properties:** Because of its high antioxidant content, which includes phenolic acids, flavonoids, and betacyanins, dragon fruit has hepatoprotective properties. According to Jayaseelan *`et al.* (2023) [23], these antioxidants aid in the neutralisation of free radicals and lower oxidative stress in liver cells, which is a major cause of liver damage. Specifically, betacyanins shield liver tissues from lipid peroxidation, a process that damages cells (Huang *`et al.,* 2021) [21]. Furthermore, the anti-inflammatory qualities of dragon fruit lessen further supporting liver health by reducing inflammation in the liver. According to studies, dragon fruit has the ability to prevent and treat liver diseases by lowering liver fibrosis and raising liver enzyme levels like ALT and AST (Elgazar *`et al.,* 2023) [13].

K. Other Potential Benefits

- **Hepatoprotective effects:** Research on animals has shown that extracts from dragon fruit can lessen liver damage brought on by toxins or a diet heavy in fat. (Chen and others, 2024) [7].
- **Skin health and wound healing:** Antioxidants and vitamin C are known to promote the production of collagen and skin restoration. Healing wounds is one of its traditional applications (Biswas *`et al.,* 2024) [6].

Differences Between Varieties, Flesh vs Peel

- **Red vs. White Flesh:** Compared to white-fleshed types (*H. undatus*), red-fleshed types (*H. polyrhizus*) frequently contain much higher levels of phenolics, betalains, and antioxidant activity (Arivalagan *`et al.,* 2021) [3].
- **Peel vs. meat:** The peel has a stronger antioxidant activity per gramme than the meat and contains a variety of bioactive substances, including as flavonoids, phenolics, and pigments. Peel is more frequently examined in extract form than it is consumed. (Chen and others, 2024) [7].

Limitations, Gaps, and Considerations

- There is currently little clinical data from humans. Animal models, in vitro research, and tiny human observational studies provide a large portion of the evidence. Translation to clinical guidelines is therefore provisional (Spritzler, F. 2023) [57].
- Bioavailability and metabolism: Although some phytochemicals are present in high concentrations, little is known about how well they are absorbed, processed, and stored in the human body. Effects shown in laboratory settings might not be replicated in the physiological environment of humans.
- Variability brought on by cultivar, maturity, growing environment, processing, and storage: These factors have a big impact on the amount of nutrients and phytochemicals. For instance, fresh versus processed, ripe versus underripe, farm versus greenhouse cultivation, and red versus white meat (Arivalagan *`et al.,* 2021) [3].
- Adverse effects, safety, and allergenicity: Rare allergic reactions have been documented, but generally speaking, it is safe. Additionally, others warn that ingesting concentrated extracts or huge amounts of them could have unanticipated consequences (Spritzler, F. 2023) [57].
- Dosage and standardisation: Since many research employ extracts or purified bioactives, it is frequently unclear how much of each should be consumed through food. Additionally, there is now a lack of consistency in the standardisation of extract (which portions are used: peel, flesh, seeds; fresh or dried).

Implications and Practical Applications

- **Nutritional Advice:** Dragon fruit has very few calories and can provide fibre, minerals, and antioxidants. It can be included in fruit varieties that promote digestive, cardiovascular, and metabolic health.
- **Functional Foods/Nutraceuticals:** Supplements, powders, natural colourants (betalains), antioxidant additives, and other products can be made from dragon fruit or its components, particularly peel or seed extracts.
- **Cosmetic and Skin Health Uses:** Due to its antioxidant, vitamin C, and pigment content, it may be used for photoprotection, anti-aging, and skin restoration.
- **Agricultural and Economic Potential:** Increasing economic returns can be achieved by the cultivation of high phytochemical cultivars, especially red-fleshed ones, the utilisation of byproducts (peel) for value addition, and improved post-harvest processing to retain bioactive components.

Technological Applications and Economic Importance

The global fruit industry has grown more competitive and receptive to new products since trade opened, primarily as a result of media revelations about the advantages of eating fruit, emphasising its healthful, balanced, and useful qualities. varied in terms of their hues, forms, scents, and tastes which sparked interest in both domestic and foreign fruits. The pitayas have piqued customers' interest and

belong to the category of exotic fruits. They also piqued fruit growers' interest in planting and cultivating them because of their high commercial value and resistance to water stress (Deshmukh *`et al.*, 2022) [12].

Because of its rusticity and agronomic potential, pitaya has distinguished itself in the exotic fruit industry in Brazil and other countries. Because production, transportation, and distribution expenses necessitate specialised logistics and quality assurance (Pires and others, 2020) [42]. Because of its high nutritional content in the form of antioxidants, fibre, vitamin C, and minerals particularly calcium and phosphorus every part of dragon fruit pulp, rind, seeds, flower buds, and dried flowers has drawn the interest of researchers and can be processed into a variety of goods. In addition to the nutritional advantages of ripe fruit, the fruit peel may also operate as an antioxidant, natural colour, and antibacterial agent. Fresh flower buds and the young stem are also edible and can be used as vegetables. The dried blossoms were thought to provide an antioxidant-rich tea. Juice, wine, jam, and other goods can be made from the fruit pulp. The skin is utilised.

The seeds are primarily used to extract the oil, which contains roughly 50% essential fatty acids, and for the extraction of natural food colouring and pectin. Furthermore, seeds are a component of numerous culinary items, including yoghurt, ice cream, syrups, and chocolates (Pérez-Orozco, and Sosa, 2022) [40]. Betacyanins, which are plentiful in pitaya skins, are a major factor in the fruit's vibrant red hue. Betanin, isobetanine, phyllocatin, isophyllocatin, and hylocerenin are the primary betacyanin compounds. Because there are so many bioactive substances that can be Furthermore, pitaya's overall added value might be increased and its environmental effect could be decreased by using food items as natural colourings or useful ingredients.

Betacyanins have greater antioxidant activity than anthocyanins and can maintain optimum pH stability in the range of 3 to 7, which suggests that they have a lot of promise for use in the food and nutraceutical industries. (Sosa, and Perez-Orozco, 2022) [40]. Specifically, betacyanins are a class of naturally occurring reddish-violet colouring pigments with biological and chemical characteristics that have a wide range of uses in the food, cosmetic, and pharmaceutical sectors. According to a study by Belluci *`et al.*, red pitaya extract is a natural way to enhance the colour and acceptability of meat products.

To enhance colour properties, betacyanins can be used as a natural dye. However, in goods like ice cream, the nutritional fibre in dragon fruit peel can partially replace fat. In one study, the peel of *H. polyrhizus* was added as a fat alternative to create low-calorie, high-fiber ice cream (Filho *`et al.*, 2022) [16]. In order to increase the shelf life of food goods while recovering betacyanins and other phenolic chemicals, dragon fruit is also used in the industry to create edible films and ecologically friendly, active packaging (Qin *`et al.*, 2020) [46]. It is possible to recover betacyanins for use as an edible coating or as active packaging. Microencapsulated pitaya (*H. undatus*) pulp extract is recommended by Tamagno *`et al.* (Tamagno *`et al.*, 2022) [58] as a dietary supplement to reduce the effects of copper poisoning and prevent metal-induced oxidative damage. Hübner (Hübne *`et al.*, 2022) [22] claims that incorporating ginger and dragon fruit pulp into the secondary fermentation process resulted in beers with higher antioxidant capacities than the control beer, indicating a different flavour, aroma, and antioxidant chemicals in this beer style.

The findings of a study conducted by Vijayakumar *`et al.* (2020) [61] showed that the bark extract of *H. polyrhizus* possesses strong antioxidant and photoprotective qualities. Furthermore, the broad-spectrum UVA and UVB photoprotection, high sun protection factor, and general antioxidant qualities were all aided by the flavonoids and phenolic substances. Furthermore, a study that used red pitaya extract revealed that it had significant physiological stability and blood biocompatibility. For biological and medicinal applications, the environmentally friendly synthesis of gold nanoparticles using fruit extract can serve as a substitute for chemical manufacture. (Al-Radadi and colleagues, 2022) [22].

Conclusion

Nutrient-dense dragon fruit, particularly red-fleshed varieties, has several health-promoting qualities. A healthy combination of minerals (potassium, magnesium), vitamins (especially vitamin C), and dietary fibre; Important bioactive substances (phenolics, flavonoids, and betalains) that have anti-inflammatory and antioxidant properties; Possible advantages for cardiovascular protection, gut health, immunological support, and metabolic health (blood sugar management, lipid profiles). Even if the evidence is encouraging, a lot of the claims are still supported by small-scale trials or non-human studies. Before conclusive therapeutic recommendations can be given, more human clinical trials, bioavailability and long-term safety studies, and standardised preparations are required. In the meanwhile, dragon fruit is a beneficial dietary supplement that, when taken as part of a balanced lifestyle, may provide a number of advantages.

References

1. Al-Mekhlafi NA, Mediani A, Ismail NH, Abas F, Dymerski T, Lubinska-Szczygeł M. Metabolomic and antioxidant properties of different varieties and origins of dragon fruit. Microchem J. 2021;160:105687.
2. Al-Radadi NS. Biogenic proficient synthesis of Au-NPs via aqueous extract of red dragon fruit pulp and seed oil: characterization, antioxidant, cytotoxic, antidiabetic, anti-inflammatory, anti-Alzheimer and antiproliferative activities against cancer cell lines. Appl Nanosci. 2022;29(4):2836-2842.
3. Arivalagan M, Karunakaran G, Roy TK, Dinsha M, Sindhu BC, Shilpashree VM, *`et al*. Biochemical and nutritional characterization of dragon fruit (*Hylocereus* spp.). Food Chem. 2021;353:129426.
4. Asghar A, Shahid M, Gang P, Khan NA, Fang Q, Xinzheng L. Nutrition, phytochemical profiling, in vitro biological activities and in silico studies of South Chinese white pitaya (*Hylocereus undatus*). Heliyon. 2024;10:e29491.
5. Bellucci ERB, Munekata PES, Pateiro M, Lorenzo JM, da Silva Barretto AC. Red pitaya extract as natural antioxidant in pork patties with total replacement of animal fat. Meat Sci. 2021;171:108284.
6. Biswas R, Sarkar D, Mishra S, Das S. Dragon fruit: nutritional composition and therapeutic value. J Curr Res Food Sci. 2024;5(2):87-89.
7. Chen SY, Xu CY, Mazhar MS, Naiker M. Nutritional value and therapeutic benefits of dragon fruit: a

comprehensive review with implications for establishing Australian industry standards. Molecules. 2024;29(23):5676.
8. Choo KY, Kho C, Ong YY, Thoo YY, Lim LH, Tan CP, *`et al*. Fermentation of red dragon fruit (*Hylocereus polyrhizus*) for betalain concentration. Int Food Res J. 2018;25(6):2539-2546.
9. Choo WS, Yong WK. Antioxidant properties of two species of *Hylocereus* fruits. Adv Appl Sci Res. 2011;2:418-425.
10. Chowdhury MM, Sikder MI, Islam MR, Barua N, Yeasmin S, Eva TA. A review of ethnomedicinal uses, phytochemistry, nutritional values and pharmacological activities of *Hylocereus polyrhizus*. J Herbmed Pharmacol. 2024;13(3):353-365.
11. Damayanti DF, Bawirza Z, Hidayat T, Wardoyo S. Combination of Fe tablets with dragon fruit on hemoglobin levels in adolescent women with anemia. Curr Issues Pharm Med Sci. 2023;36(2):77-80.
12. Deshmukh RK, Gaikwad KK. Natural antimicrobial and antioxidant compounds for active food packaging applications. Biomass Convers Biorefin. 2022;12:1-22.
13. Elgazar AF, Shalaby MA, Ibrahem ES. Potential effectiveness of flesh-red dragon fruit juice in improving lead acetate-induced neurotoxicity in rats. J Pharm Negative Results. 2023;14:894-906.
14. El-Nashar HA, Al-Azzawi MA, Al-Kazzaz HH, Alghanimi YK, Kocaebli SM, Alhmammi M, *`et al*. HPLC-ESI/MS-MS metabolic profiling of white pitaya fruit and cytotoxic potential against cervical cancer. J Pharm Biomed Anal. 2024;244:116121.
15. Erika Y, Djulim D, Wijaya JF, Napitupulu ODVA. Effects of red and white dragon fruit extracts (*Hylocereus polyrhizus* and *Hylocereus undatus*) on body weight of obese mice. J Ilmu Kesehatan. 2024;17(4):1767-1775.
16. Filho JGDO, Bertolo MRV, Rodrigues MV, Silva GDC, Mendonça GMN, Junior SB, *`et al*. Recent advances in smart biodegradable biopolymer-based films containing betalains. Food Chem. 2022;390:133149.
17. Hamidah H, Tsawab T, Rosmanida R. Analysis of *Hylocereus* spp. diversity based on phenetic methods. AIP Conf Proc. 2017;1854:020012.
18. Hendra R, Masdeatresa L, Abdulah R, Haryani Y. Antibacterial activity of red dragon fruit peel pigment (*Hylocereus polyrhizus*). J Phys Conf Ser. 2019;1351(1):012042.
19. Hossain FM, Numan SMN, Akhtar S. Cultivation, nutritional value and health benefits of dragon fruit (*Hylocereus* spp.): a review. Int J Hortic Sci Technol. 2021;8(3):259-269.
20. Hossen MM, Bose S, Acharyya RN, Barman AK, Rahman S, Ghosh KP, *`et al*. *Hylocereus polyrhizus* peel extract restricts DMBA-croton oil-induced skin carcinogenesis. bioRxiv. 2025:1-28.
21. Huang Y, Brennan MA, Kasapis S, Richardson SJ, Brennan CS. Maturation process, nutritional profile and bioactivities of red pitaya fruits: a review. Foods. 2021;10(11):2862.
22. Hübner DS. Produção de cerveja estilo Catharina Sour com polpa de pitaia (*Hylocereus polyrhizus*) e gengibre (*Zingiber officinale* Roscoe) [dissertation]. Florianópolis: Universidade Federal de Santa Catarina; 2019.
23. Jayaseelan K, Chakraborty A, Mandal SK. Impact of extraction, processing, storage and packaging on antioxidant activity of dragon fruit: a review. Egypt J Chem. 2023;66:1-14.
24. Jerônimo MC, Orsine JVC, Borges KK, Novaes MRCG. Chemical and physicochemical properties and antioxidant activity of red pitaya [*Hylocereus undatus* (Haw.) Britton & Rose]. J Drug Metab Toxicol. 2015;6:1-6.
25. Khuzaimah U, Sulistiarini R, Rija'i HR, Alfiani R. Effect of boiled egg and red dragon fruit (*Hylocereus polyrhizus*) on hemoglobin levels during menstruation. North Afr J Food Nutr Res. 2023;7(16):46-53.
26. Kumar S, Tripathi V, Kumari A, Chaudhary V, Kumawat P. Nutritional and medicinal importance of dragon fruit (*Hylocereus* spp.): a review. Ecol Environ Conserv. 2022;28:247-253.
27. Le TT, Le NL. Antioxidant capacity and betacyanin LC-MS profile of red-fleshed dragon fruit juice (*Hylocereus polyrhizus*). J Food Process Preserv. 2021;45(3):e15217.
28. Liaotrakoon W. Characterization of dragon fruit (*Hylocereus* spp.) components with valorization potential [doctoral dissertation]. Ghent: Ghent University; 2013.
29. Lim TW, Choo KY, Lim RLH, Pui LP, Tan CP, Ho CW. Indigenous microbial diversity in spontaneous fermentation of red dragon fruit (*Hylocereus polyrhizus*). Heliyon. 2023;9(11):e21336.
30. Luo J, Lin X, Bordiga M, Brennan C, Xu B. Manipulating effects of fruits and vegetables on gut microbiota: a critical review. Int J Food Sci Technol. 2021;56(5):2055-2067.
31. Maigoda TC, Sulaeman A, Setiawan B, Wibawan IWT. Effects of red dragon fruit (*Hylocereus polyrhizus*) powder and swimming exercise on inflammation, oxidative stress markers and physical fitness in obese male rats (*Rattus norvegicus*, Sprague Dawley). Int J Sci Basic Appl Res. 2016;25(1):123-141.
32. Malik F, Iqbal A, Zia S, Ranjha MMAN, Khalid W, Nadeem M, *`et al*. Role and mechanism of fruit waste polyphenols in diabetes management. Open Chem. 2023;21(1):2022-2072.
33. Michalak M, Pierzak M, Kręcisz B, Suliga E. Bioactive compounds for skin health: a review. Nutrients. 2021;13(1):203.
34. Mulyani Y, Sari DN. Effect of dragon fruit juice and honey on hemoglobin improvement in pregnant women. J Ilmiah Kesehatan STRADA. 2020;9(2):1409-1414.
35. Nishikito DF, Borges ACA, Laurindo LF, Otoboni AMB, Direito R, Goulart RDA, *`et al*. Anti-inflammatory, antioxidant and other health effects of dragon fruit and potential delivery systems for its bioactive compounds. Pharmaceutics. 2023;15(1):159.
36. Norziah MH, Ruri AS, Tang CS, Fazilah A. Utilization of red pitaya (*Hylocereus polyrhizus*) fruit peels for value-added food ingredients. In: Proceedings of the International Conference on Environmental Research and Technology; 2008; Universiti Sains Malaysia. p. 1-6.
37. Nurul SR, Asmah R. Variability in nutritional composition and phytochemical properties of red pitaya

(*Hylocereus polyrhizus*) from Malaysia and Australia. Int Food Res J. 2014;21:1689-1697.
38. Padmavathy K, Kanakarajan S, Karthika S, Selvaraj R, Kamalanathan A. Phytochemical profiling and anticancer activity of dragon fruit (*Hylocereus undatus*) extracts against human hepatocellular carcinoma (HepG2) cells. Int J Pharm Sci Res. 2021;12(5):2770-2787.
39. Pansai N, Detarun P, Chinnaworn A, Sangsupawanich P, Wichienchot S. Effects of dragon fruit oligosaccharides on immunity, gut microbiome and metabolites in healthy adults: a randomized double-blind placebo-controlled study. Food Res Int. 2023;167:112657.
40. Pérez-Orozco AF, Sosa V. Comparative estimation of betalains and sugars in fruits of five species of *Selenicereus* (Cactaceae). Acta Bot Mex. 2022;129:1-18.
41. Phebe D, Chew MK, Suraini AA, Lai OM, Janna OA. Red-fleshed pitaya (*Hylocereus polyrhizus*) fruit colour and betacyanin content depend on maturity. Int Food Res J. 2009;16:233-242.
42. Pires E, Krauze C. Economic analysis of pitaya production in family farming of southern Santa Catarina. Metodol Aprendizado. 2020;2:181-189.
43. Poolsup N, Suksomboon N, Paw NJ. Effect of dragon fruit on glycemic control in prediabetes and type 2 diabetes: a systematic review and meta-analysis. PLoS One. 2017;12(9):e0184577.
44. Prajapati U, Ksh V, Joshi A. Extraction and utilization of bioactive components from underutilized horticultural crops. In: Bioactive Components: A Sustainable System for Good Health and Well-Being. Singapore: Springer Nature; 2022. p. 535-570.
45. Putri MD, Wiboworini B, Dirgahayu P. Red dragon fruit juice reduces ROS levels and insulin resistance in type 2 diabetes mellitus rat model. J Gizi Indones. 2021;10(1):6-14.
46. Qin Y, Liu Y, Zhang X, Liu J. Development of active and intelligent packaging by incorporating betalains from red pitaya (*Hylocereus polyrhizus*) peel into starch/polyvinyl alcohol films. Food Hydrocoll. 2020;100:105410.
47. Rachel N. Dragon fruit benefits backed by science. Med News Today. 2023 May;1-6.
48. Rahmah L, Ansori AN, Sari NI. Increasing fiber and mineral content in gnocchi by substitution with dragon fruit peels for food quality improvement. Food Syst. 2024;7(1):99-104.
49. Rahman MM, Rahaman MS, Islam MR, Rahman F, Mithi FM, Alqahtani T, *`et al*. Role of phenolic compounds in human disease: current knowledge and future prospects. Molecules. 2021;27(1):233.
50. Rathi KM, Singh SL, Gigi GG, Shekade SV. Nutrition and therapeutic potential of dragon fruit: a qualitative approach. Pharmacogn Res. 2023;16(1):1-9.
51. Reyes-García V, Botella-Martínez C, Juárez-Trujillo N, Muñoz-Tébar N, Viuda-Martos M. Pitahaya (*Hylocereus ocamponis*) peel and flesh flours obtained from fruit co-products: chemical, techno-functional and in vitro antioxidant properties. Molecules. 2024;29:2241.
52. Saenjum C, Pattananandecha T, Nakagawa K. Antioxidative and anti-inflammatory phytochemicals and related stable paramagnetic species in different parts of dragon fruit. Molecules. 2021;26(12):3565-3580.
53. Safira A, Savitri SL, Putri ARB, Hamonangan JM, Safinda B, Solikhah TI, *`et al*. Pharmacological and health aspects of *Hylocereus* (pitaya): an updated review. J Drug Deliv Ther. 2021;11(6):297-303.
54. Seth S, Kaba L, Ahirwar S, Jain P, Pagare M, Sinha R, *`et al*. Characterization of antioxidative components of dragon fruit (*Hylocereus undatus*) for natural food additive applications. Egypt J Food Sci. 2021;49(2):297-304.
55. Setiawan NA, Shintawati R, Priyandoko D. Role of red dragon fruit peel (*Hylocereus polyrhizus*) in improving blood lipid levels in hyperlipidemic male mice. J Phys Conf Ser. 2018;1013(1):012167.
56. Singh S, Kumar S. Nutritional, medicinal and bioactive compounds of dragon fruit (*Hylocereus polyrhizus* (F.A.C. Weber) Britton & Rose): a review. Int J Biochem Res Rev. 2023;32(5):57-67.
57. Spritzler F. Dragon fruit: nutrition, benefits and how to eat it. Healthline. 2023;1-8.
58. Tamagno WA, Santini W, Santos A, Alves C, Bilibio D, Sutorillo NT, *`et al*. Pitaya fruit extract ameliorates copper-induced toxicity in *Caenorhabditis elegans*. J Food Biochem. 2022;46:e14050.
59. Tarte I, Singh A, Dar AH, Sharma A, Altaf A, Sharma P. Unfolding the potential of dragon fruit (*Hylocereus* spp.) for value addition: a review. eFood. 2023;4(2):e76.
60. Tripathi M, Diwan D, Shukla AC, Gaffey J, Pathak N, Dashora K, *`et al*. Valorization of dragon fruit waste to value-added bioproducts and formulations: a review. Crit Rev Biotechnol. 2024;44(6):1061-1079.
61. Vijayakumar R, Abd Gani SS, Zaidan UH, Halmi MIE, Karunakaran T, Hamdan MR. Potential use of *Hylocereus polyrhizus* peels as a cosmeceutical sunscreen agent. Evid Based Complement Alternat Med. 2020;2020:7520736.
62. Wybraniec S, Mizrahi Y. Fruit flesh betacyanin pigments in *Hylocereus* cacti. J Agric Food Chem. 2002;50:6086-6089.
63. Yasmin A, Sumi MJ, Akter K, Rabbi RHM, Almoallim HS, Ansari MJ, *`et al*. Comparative analysis of nutrient composition and antioxidant activity in three dragon fruit cultivars. PeerJ. 2024;12:e17719.
64. Zitha EZM, Magalhães DS, do Lago RC, Carvalho EEN, Pasqual M, Boas EVDBV. Changes in bioactive compounds and antioxidant activity in red-fleshed dragon fruit during development. Sci Hortic. 2022;291:110611.