

## Unveiling the therapeutic potential of dragon fruit - A functional superfruit

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### Abstract

Dragon fruit (*Hylocereus spp.*), a tropical fruit with vibrant appearance, possesses diverse bioactive compounds and multiple health promoting properties. It exhibits strong antioxidant and anti-inflammatory activities, contributing to the prevention of chronic diseases. Its prebiotic and antimicrobial properties support gut health, while antidiabetic and neuroprotective effects indicate potential in managing metabolic and cognitive disorders. Additionally, dragon fruit shows promising anticancer activity and benefits for skin health. Regular consumption may improve overall wellbeing, enhance immunity, and support metabolic balance. These characteristics highlight dragon fruit as a functional food with multifaceted health benefits and potential applications in nutrition and therapeutics. Continued research is warranted to further explore its therapeutic potential and establish effective dietary recommendations.

**Keywords:** Dragon fruit, therapeutic potential, prebiotic, antidiabetic, antioxidant

### Introduction

Dragon fruit (*Hylocereus spp.*), also known as *Pitaya* or *Pitahaya*, is a tropical fruit belonging to the Cactaceae family. Native to Mexico, Central America, and South America, its cultivation has expanded worldwide because of its rich nutritional composition and potential health benefits. The plant is an epiphytic climbing cactus that uses aerial roots for anchorage as it grows along tree trunks. Its fruit is easily recognisable by its brightly coloured outer skin covered with scale like bracts, giving it a dragon like appearance. Internally, the pulp ranges in colour from white to deep magenta and is embedded with numerous small, edible seeds (Hossain *et al.*, 2021) [1]. Fruit weight typically ranges between 350 and 900 g, influenced by genetic factors and pollination efficiency (Nizamlioglu *et al.*, 2021).

Several species of *Hylocereus* are cultivated commercially. *Hylocereus undatus* has white pulp and pink peel, whereas *Hylocereus polyrhizus* features red pulp with pink peel. *Hylocereus guatemalensis* is distinguished by its magenta pulp and notably high antioxidant content. Another related species, *Selenicereus megalanthus*, commonly known as yellow dragon fruit, is characterised by its yellow peel, white pulp, and higher sugar content.

Dragon fruit is valued for its impressive nutritional profile. It is rich in micronutrients, dietary fibre, and essential minerals such as calcium, magnesium, and potassium, which are vital for various physiological processes. The seeds also contribute additional minerals. Furthermore, the fruit contains an abundance of bioactive compounds including polyphenols, flavonoids, betacyanins, and carotenoids that are responsible for its strong antioxidant and anti-inflammatory properties (Zainoldin and Baba, 2009).

Beyond its nutritional qualities, dragon fruit has gained attention for its health promoting and therapeutic potential (Zang *et al.*, 2019). Traditionally consumed for its refreshing taste and perceived health benefits, recent studies have revealed its functional food properties. Its bioactive compounds exhibit antioxidant, anti-inflammatory,

antidiabetic, and antimicrobial effects, positioning dragon fruit as a promising dietary component for disease prevention and health support (Neraj *et al.*, 2020).

In addition to its nutritional and medicinal value, dragon fruit is increasingly being explored for industrial and emerging applications. It is incorporated into functional food formulations, evaluated for pharmaceutical innovations such as nutraceuticals and drug delivery systems, and used in cosmetic products for its anti-aging and hydrating effects. These diverse uses highlight the need for continued research to fully uncover the potential of dragon fruit in food, medicine, and biotechnology.

Given its rich composition of bioactive compounds and essential nutrients, dragon fruit exhibits a wide spectrum of biological activities that contribute to human health. Recent studies have highlighted its multifunctional properties, including antioxidant, anti-inflammatory, antidiabetic, prebiotic, anticancer, antimicrobial, neuroprotective, and skin health benefits. However, like many functional foods, it may also produce certain adverse effects in susceptible individuals. The following sections provide a detailed overview of these health promoting properties and safety considerations, emphasizing the therapeutic potential of dragon fruit as a functional food.

### Antioxidant properties

Dragon fruit is rich in bioactive compounds that contribute its antioxidant capacity.  $\beta$ -carotene in the pulp scavenges free radicals, while gallic acid (peel, pulp, seeds) and anthocyanins (peel, pulp) provide pigmentation and potent antioxidant effects (Singh and Kumar, 2013). Vanillic acid and *p*-hydroxybenzoic acid inhibit lipid peroxidation and DNA damage (Tarte *et al.*, 2023). Phenolics such as flavonoids, phenolic acids, and stilbenes regulate oxidative stress pathways, upregulate antioxidant enzymes (SOD, CAT, GPx), inhibit NF- $\kappa$ B, and modulate miRNAs, thereby lowering oxidative stress (Luu *et al.*, 2021). Betalains in the peel (101.04 mg betanin eq./100 g) and the 80 phenolic compounds identified by Chen *et al.* (2021) highlight the

fruit's diverse antioxidant profile, with the pulp richer in total phenolics and the peel higher in flavonoids and tannins.

Additional constituents like  $\alpha$ -amyrin,  $\beta$ -amyrin, stigmast-4-en-3-one, and  $\beta$ -sitosterol show cytotoxic or antioxidant properties (Luo *et al.*, 2014). White dragon fruit peel exhibited the strongest anti-proliferative effects on AGS, HeLa, and MCF-7 cell lines, correlating with its 3–5 times higher flavonoid and polyphenol content (Kim *et al.*, 2010). Ethyl acetate peel extract of *Hylocereus costaricensis* had the highest total phenolic (4.56 g GAE/100 g) and flavonoid content (12.63 g QE/100 g) (Fidrianny *et al.*, 2017). Vitamin C and quercetin further enhance antioxidant and anti-inflammatory effects, while *H. undatus* and *H. polyrhizus* peels show superior phenolic content and radical scavenging activity (MR *et al.*, 2010). Overall, dragon fruit's rich mix of phenolics, vitamins, and other bioactive compounds underscores its strong antioxidant profile and health promoting potential.

### Anti-inflammatory properties

Dragon fruit (*Hylocereus* spp.) exhibits notable anti-inflammatory activity due to bioactive compounds such as squalene, flavonoids, phenolic acids, and betalains, which modulate inflammatory pathways, reduce oxidative stress, and prevent chronic inflammatory diseases (Saenjum *et al.*, 2021). Betalains, responsible for the fruit's red and pink hues, inhibit lipid peroxidation and inflammatory signaling by downregulating iNOS and COX-2, though they are highly sensitive to heat, pH, oxygen, and light (Acarin *et al.*, 2002). Flavonoids like quercetin and kaempferol (in peel and pulp) suppress NF- $\kappa$ B and COX-2, decreasing IL-6 and TNF- $\alpha$ . Phenolic acids such as gallic and ferulic acids enhance SOD and GPx activity, mitigating ROS-driven inflammation. Squalene, reported at 13.2% concentration in dragon fruit flesh (Eldeen *et al.*, 2020), inhibited acetylcholinesterase, COX-2, and 5-lipoxygenase (EC<sub>50</sub>: 46–47  $\mu$ g/mL). Ethanol extract of *H. polyrhizus* (EH) protected against TNBS induced colitis by reducing weight loss, histological damage, MPO activity, pro-inflammatory gene expression, and NF- $\kappa$ B activation. Additionally, dragon fruit's polysaccharides and dietary fibre may indirectly reduce inflammation by supporting gut microbiota and SCFA production (Nishikito *et al.*, 2023) [24].

Red dragon fruit peel extract, rich in flavonoids, alkaloids, saponins, and tannins, inhibited protein denaturation and reduced leukocyte counts in inflammatory exudates (Macias-Ceja *et al.*, 2016; Yuna *et al.*, 2023). *Hylocereus undatus* flower treatment in ulcerative colitis mice lowered IL-1 $\beta$ , TNF- $\alpha$ , and IL-6, restored VIP and SP-A, upregulated IL-10 and SIRT1, and suppressed p-p38MAPK signaling. Other studies indicate dragon fruit extracts may enhance epithelial barrier function and reduce macrophage oxidative bursts, suggesting broader immunomodulatory effects. While its anti-inflammatory potential especially for gut health is promising, prebiotic and oligosaccharide related effects remain underexplored, and well-designed clinical trials are needed to confirm efficacy and optimal dosages (Ceja *et al.*, 2016).

### Anti-diabetic properties

The bioactive rich composition of dragon fruit including flavonoids, phenolic acids, betacyanins, dietary fibre, and antioxidants makes it a promising natural intervention for

diabetes management. These compounds enhance insulin sensitivity, modulate glucose metabolism, reduce oxidative stress, and protect pancreatic  $\beta$ -cells. Both pulp and peel contribute to glucose homeostasis, with *H. costaricensis* (0.28  $\pm$  0.016 mg/g FW) and *H. megalanthus* (0.27  $\pm$  0.014 mg/g FW) showing the highest flavonoid levels, while *H. undatus* has the lowest (0.26  $\pm$  0.025 mg/g FW) (Yasmin *et al.*, 2024). Flavonoids such as quercetin, anthocyanins, and kaempferol improve insulin signaling by upregulating GLUT4, scavenging ROS, and protecting  $\beta$ -cells from inflammation induced apoptosis (Ghorbani *et al.*, 2019). Phenolic acids like ferulic, chlorogenic, and caffeic acids inhibit  $\alpha$ -amylase and  $\alpha$ -glucosidase, slowing glucose absorption (Chen *et al.*, 2019). Flavonoids also reduce inflammatory cytokines (TNF- $\alpha$ , IL-6), improving insulin sensitivity (Ruzlan *et al.*, 2010).

The peel is particularly rich in phenolic antioxidants (up to 6013 mg GAE/100 g dry matter), dietary fibre (14 g/1000 kcal), and betacyanins betanin, phyllocactin, isobetanin, and isophyllocactin that synergize with flavonoids to boost adiponectin levels, enhancing insulin sensitivity and fatty acid oxidation (Zhang *et al.*, 2008). Lira *et al.* (2021) demonstrated hypoglycemic and antioxidative effects of *H. polyrhizus* peel in diabetic mice, while Lodi *et al.* (2023) showed that *H. lemairei* peel and pulp extracts reduced hyperglycemia, oxidative stress, and inflammation, and inhibited  $\alpha$ -glucosidase and pancreatic lipase. Al-Ezzi *et al.* (2024) reported that high methoxyl pectin from pitaya peel exhibited excellent bile acid binding and emulsifying properties, supporting its use in cholesterol lowering and diabetes management. Furthermore, betacyanins lower fibroblast growth factor 21 (FGF21) levels elevated in insulin resistance further improving glycemic control (Zhuang & Sun, 2012). Collectively, these findings highlight dragon fruit as a promising functional food for supporting glucose regulation, protecting pancreatic  $\beta$ -cells, and managing diabetes.

### Prebiotic potential

Prebiotics are nondigestible food ingredients that improve host health by selectively stimulating the growth and activity of beneficial gut bacteria. Dragon fruit contains prebiotic compounds primarily in the form of oligosaccharides (DFO), which are fermented by gut microbiota to produce short chain fatty acids (SCFAs) such as acetate, propionate, and butyrate. Acetate is utilized by muscles, propionate supports liver ATP synthesis, and butyrate promotes colonocyte health and exhibits anti-colon cancer properties (Venegas *et al.*, 2019). *In vitro* studies have demonstrated that DFO resists digestion by  $\alpha$ -amylase in the mouth, stomach, and small intestine and selectively stimulates beneficial microorganisms, particularly *Lactobacillus* spp., while modulating SCFA production (Dasaesamoh *et al.*, 2016) [1].

Animal studies further support DFO's functional benefits. Panasi *et al.* (2019) reported that oral supplementation of 4 g/kg/day in rats increased IgG and IgA levels and enhanced beneficial bacteria populations while reducing harmful bacteria. Khuituan *et al.* (2019) showed that DFO accelerates gut transit and increases fecal mass without causing diarrhea or affecting body weight, demonstrating its safety and functional prebiotic effect. A human trial by Pansai *et al.* (2023) with 107 healthy adults confirmed that 4 g/day of DFO significantly raised IgA levels (10.95%),

while 8 g/day promoted growth of *Bifidobacterium spp.* (8.41%) and *Faecalibacterium* (1.99%) and reduced *Escherichia coli* (8.44%). These findings establish dragon fruit oligosaccharides as a functional prebiotic fibre with immunomodulatory effects and gut microbiome enhancing properties.

### Anti-cancer properties

Dragon fruit has been extensively investigated for its promising anti-cancer potential. Several studies attribute these effects to its rich bioactive compounds, including phenolic acids, flavonoids, betacyanin,  $\beta$ -sitosterol,  $\beta$ -amyrin,  $\alpha$ -amyrin,  $\beta$ -carotene, and lycopene. Divakaran *et al.* (2019) [7] reported that dragon fruit derived nanoparticles significantly inhibited MCF-7 breast cancer cells, while Padmavathy *et al.* (2021) [25] demonstrated that methanol extracts of *H. undatus* effectively suppressed HepG-2 liver cancer cells.

Wu *et al.* (2006) [32] found that red pitaya peel exhibited stronger inhibitory effects on B16F10 melanoma cells compared to the flesh, although both parts are rich in polyphenols and antioxidants. Additionally, faecal fermentation of pitaya oligosaccharides enhanced beneficial gut bacteria (*Lactobacillus*) and increased the production of short-chain fatty acids (acetic, propionic, lactic, and butyric acids), which inhibited Caco-2 colon cancer cells and may reduce colon cancer risk (Dasaesamoh *et al.*, 2016) [1]. Collectively, these findings indicate that *H. undatus* and *H. polyrhizus* possess significant anti-cancer properties through multiple mechanisms

### Antimicrobial properties

Dragon fruit has strong antimicrobial potential. Kumar *et al.* (2019) reported that red pitaya peel extract exhibited efficient *in vivo* and *in vitro* effects against *Escherichia coli* and *Pseudomonas aeruginosa*. Rusip *et al.* (2020) found a minimum inhibitory concentration of 50  $\mu$ L for *Staphylococcus aureus* and *E. coli*, while Tenore *et al.* (2020) demonstrated that hexane, chloroform, and ethanol extracts of *H. undatus* peel inhibited both Gram-positive and Gram-negative bacteria. Peel and fruit extracts also displayed antifungal activity against *Rhizoctonia solani*, *Candida albicans*, *Aspergillus flavus*, *Botrytis cinerea*, *Fusarium oxysporum*, and *Cladosporium herbarum*. Betacyanin and other bioactive compounds contribute to these effects through mechanisms such as cell wall lysis, reactive oxygen species generation, and synergistic inhibition with antibiotics. Broth microdilution and disc diffusion assays revealed refrigerated fruits, with higher betacyanin content, were more effective against multiple bacterial strains, and silver nanoparticles from dragon fruit peel further enhanced antibacterial activity (Kylanel *et al.*, 2020) [18].

### Neuroprotective effects

Dragon fruit has gained attention for its notable neuroprotective properties. Bioactive components in its seeds, particularly essential fatty acids, are linked to the prevention of neurodegenerative disorders such as Alzheimer's, Parkinson's, and amyotrophic lateral sclerosis (Kyereh and Otewey, 2024) [17]. Additionally, the flesh contains flavonoids, phenols, and anthocyanins that contribute to protecting neural tissues, though their effects may vary with environmental and demographic factors *H.*

*polyrhizus* has also demonstrated protective effects against lead induced brain toxicity (Chu *et al.*, 2021) [6].

In an *in vivo* study on cerebellar aging, red dragon fruit (RDF) extract significantly reduced neuronal degeneration by increasing Purkinje cell numbers and granular layer thickness, decreasing oxidative stress markers (MDA, 3-NT), inflammatory mediators (TNF- $\alpha$ , iNOS), and apoptotic activity (active caspase-3), while restoring antioxidant defenses (SOD, GSH) compared to aged controls. These results indicate that RDF supports neuroprotection through antioxidant, anti-inflammatory, and anti-apoptotic pathways (Gomez *et al.*, 2024).

### Skin health effects

Dragon fruit promotes skin health due to its rich content of vitamin C, antioxidants, and bioactive compounds like betalains and flavonoids (Khan, 2016) [15]. These nutrients help combat free radicals, reduce oxidative stress, and slow premature aging, while vitamin C supports collagen production for skin elasticity and firmness (Mohiuddin, 2019) [23]. Its high-water content aids in hydration, and its anti-inflammatory properties can help reduce redness and acne. Regular consumption or topical use of dragon fruit can contribute to healthier, more radiant skin (Formella, 2016).

In addition to its antioxidant and hydrating benefits, dragon fruit may also protect the skin from environmental damage. The bioactive compounds in the fruit help shield skin cells from harmful UV rays and pollution, reducing the risk of sun damage and dark spots (Mahadi, 2019). Its gentle, natural properties make it suitable for both consumption and topical application, supporting overall skin repair, soothing irritation, and enhancing the skin's natural glow over time.

### Anti-viral properties

Dragon fruit exhibits notable antiviral activity, largely attributed to its high content of betacyanins, a class of bioactive pigments with potent biological effects. These compounds have been shown to interact directly with viral receptors, thereby preventing viruses from entering host cells and inhibiting subsequent viral replication. The antiviral potential of betacyanins has been demonstrated in preclinical studies, where they exhibited dose dependent activity against significant human pathogens such as dengue virus (DENV-2) and SARS-CoV-2 (Chatterjee *et al.*, 2024). By blocking the initial stages of viral infection, betacyanins reduce viral load and limit the severity of infection, highlighting their importance as a natural antiviral agent.

The mechanism underlying this activity involves interference with viral surface proteins that are essential for host cell attachment, as well as modulation of host cellular pathways that may enhance viral replication (Mateo *et al.*, 2015) [22]. In addition to their direct antiviral effects, betacyanins possess antioxidant properties, which help mitigate virus induced oxidative stress and inflammation, further supporting host defenses (Foo *et al.*, 2022) [8]. These multifaceted activities position dragon fruit as a promising functional food with potential applications in both preventive and therapeutic strategies against viral infections. Continued research is warranted to explore optimal dosages, bioavailability, and clinical efficacy in human populations.

### Gastroprotective effects

Dragon fruit demonstrates notable anti-ulcer activity, primarily attributed to its flavonoid content, particularly

quercetin. Quercetin exhibits strong antioxidant and anti-inflammatory properties, which help reduce oxidative stress and inhibit the cyclooxygenase (COX-1 and COX-2) pathways that play a central role in ulcer formation. Experimental studies have demonstrated that quercetin protects against indomethacin induced ulcers by stabilizing gastric mucosal cells and reducing inflammation, effectively alleviating ulcer symptoms (Harimurti *et al.*, 2021).

The gastroprotective effect of dragon fruit is also enhanced by its phenolic compounds, which scavenge free radicals and prevent lipid peroxidation in the gastric lining. This dual mechanism reducing oxidative stress and suppressing inflammatory mediators supports mucosal integrity and accelerates ulcer healing (Jiang *et al.*, 2023) <sup>[14]</sup>. Additionally, the synergistic action of flavonoids and other bioactive compounds in the peel and pulp strengthens the antioxidant defense system, further protecting the gastric mucosa from chemical or stress-induced (Chauhan *et al.*, 2013) <sup>[4]</sup>. These findings highlight the potential of dragon fruit as a natural therapeutic agent for ulcer prevention and management, suggesting that regular consumption could serve as a dietary strategy to support gastrointestinal health and reduce reliance on synthetic anti-ulcer medications.

### Wound healing properties

Dragon fruit facilitates wound healing through its rich composition of bioactive compounds, particularly betacyanins and polyphenols. These compounds exert potent anti-inflammatory and antioxidant effects at the site of injury, which helps reduce oxidative stress and cellular damage during the healing process. By mitigating inflammation, betacyanins and polyphenols accelerate tissue repair, decrease healing time, and improve recovery outcomes in both acute and chronic wounds (Chang *et al.*, 2020).

The mechanism underlying dragon fruit's wound healing potential involves modulation of inflammatory cytokines, reduction of reactive oxygen species (ROS), and stimulation of fibroblast proliferation. These actions promote collagen synthesis and enhance angiogenesis, ensuring more efficient tissue regeneration (Nishikito *et al.*, 2013). Additionally, the bioactive compounds in dragon fruit improve epithelial cell migration and strengthen the structural integrity of repaired tissue. Collectively, these properties demonstrate that dragon fruit can be an effective natural adjunct for wound management. Its incorporation into topical formulations or dietary interventions could provide a safe, plant-based approach to enhance recovery from injuries and support overall skin health (Holanda *et al.*, 2019) <sup>[10]</sup>.

### Anti-anaemic properties

Dragon fruit exhibits significant anti-anaemic potential due to its high content of iron and vitamin C. Iron is essential for hemoglobin synthesis, while vitamin C enhances its absorption and utilization in erythropoiesis. Studies have reported that consumption of red dragon fruit juice for seven days significantly increases hemoglobin levels and erythrocyte counts, improving oxygen carrying capacity and reducing anaemia related fatigue (Widyaningsih *et al.*, 2017).

In addition to supporting haematological health, the bioactive compounds in dragon fruit, including flavonoids and polyphenols, protect erythrocytes from oxidative stress and prevent premature red blood cell destruction (Chen *et*

*al.*, 2024). By reducing oxidative damage to hemoglobin and cellular membranes, these compounds contribute to sustained improvements in blood quality. The combined presence of iron, vitamin C, and antioxidants makes dragon fruit a multifunctional dietary intervention for managing iron deficiency anaemia (Azhar *et al.*, 2024) <sup>[3]</sup>. Its regular inclusion in the diet can help prevent hematological deficiencies, improve overall energy levels, and enhance general physiological well being, offering a natural, plant-based alternative to conventional iron supplements.

### Anxiolytic effects

Dragon fruit demonstrates anxiolytic-like effects through its bioactive compounds, including maltotriose, quercetin-3-O-hexoside, and betalains. Experimental studies using zebrafish models revealed that these compounds modulate anxiety related behaviors, reducing stress indicators without observable toxicity (Lira *et al.*, 2020) <sup>[20]</sup>. These compounds influence neurotransmitter systems and signaling pathways associated with stress and anxiety, contributing to improved behavioural responses.

The underlying mechanisms involve the modulation of the hypothalamic pituitary adrenal (HPA) axis and antioxidant mediated neuroprotection. By reducing oxidative stress in neuronal cells, the bioactive compounds help stabilize neurotransmission, promoting relaxation and reducing anxiety related physiological responses (Lew *et al.*, 2020) <sup>[19]</sup>. Additionally, the natural flavonoids and betalains may enhance serotonin and dopamine activity, which are critical for mood regulation. These findings suggest that dragon fruit could serve as a safe, natural functional food for managing anxiety and stress related disorders. Its inclusion in the diet may complement conventional anxiolytic therapies while providing additional antioxidant and health promoting benefits (Rusip *et al.*, 2020).

### Hepatoprotective effects

Dragon fruit, particularly its betacyanin rich peel extract, exhibits hepatoprotective effects through modulation of lipid metabolism and anti-inflammatory pathways. Betacyanins downregulate SREBP-1 and CYP2E1 while activating AMPK and PPAR- $\alpha$ , which are critical regulators of hepatic lipid homeostasis. This dual action reduces fat accumulation and mitigates oxidative stress in liver cells. Additionally, inflammatory markers such as TNF- $\alpha$ , IL-1 $\beta$ , and TLR4 are suppressed, further protecting against liver injury (Yeh *et al.*, 2020) <sup>[33]</sup>.

Experimental studies in models of alcoholic progressive liver disease demonstrated decreased histological liver damage, improved lipid metabolism, and reduced inflammatory responses following dragon fruit peel extract administration. These findings suggest that regular intake of dragon fruit, especially the peel, may provide functional support for liver health, offering a natural strategy to prevent or attenuate liver related disorders (Sarkar *et al.*, 2020).

### Anti-hyperlipidemic properties

Dragon fruit pulp with seeds demonstrates anti-hyperlipidemic activity by modulating serum lipid profiles. The fruit enhances high density lipoprotein cholesterol (HDL-c) while reducing low density lipoprotein (LDL), triglycerides, and total cholesterol levels. These effects are attributed to the synergistic action of flavonoids,

polyphenols, and dietary fibre present in the pulp and seeds (Anand *et al.*, 2010) [2].

Preclinical studies in hyperlipidemic mice showed significant improvements in lipid metabolism after dragon fruit consumption, including reductions in fat accumulation and improved cardiovascular markers (Stewart *et al.*, 2020) [30]. These results indicate that dragon fruit can serve as a natural dietary intervention for managing hyperlipidemia, reducing cardiovascular risk, and promoting overall metabolic health.

### Conclusion

Dragon fruit is a nutrient dense functional food with diverse therapeutic potential, including antioxidant, anti-inflammatory, prebiotic potential, antiviral, anti-ulcer, anti-wound, anti-anaemic, anxiolytic, hepatoprotective, anti-hyperlipidemic, and gastrointestinal protective effects. Its rich composition of bioactive compounds such as flavonoids, phenolic acids, betacyanins, squalene, and dietary fibre underlies these health promoting activities. While generally safe for consumption, mild adverse effects may occur in sensitive individuals. Overall, the multifaceted bioactivities of dragon fruit highlight its promise as a natural intervention for supporting health, preventing disease, and complementing conventional therapeutic strategies

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