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Dragon fruit: A review of health benefits and nutritional importance

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Abstract

The dragon fruit, also known as pitaya, is an exotic tropical plant with numerous health benefits due to its high nutritional value and bioactive components, which include powerful natural antioxidants. Extracts from dragon fruit stems, blooms, peels, and pulps have a variety of therapeutic biological effects against pathogenic microbes such as bacteria, fungus, and viruses, as well as disorders such as diabetes, obesity, hyperlipidemia, and cancer. Dragon fruit extracts also exhibit cardiovascular and hepatoprotective benefits, as well as potential prebiotic characteristics. Its cultivation is suited to tropical climates with favourable climate conditions for the development of pitaya plantations, which are very adaptable and tolerable to a wide range of environmental conditions (e.g. salinity adaptation, favour light intensity, drought resistance, etc.).

Keywords: Tropical fruit, nutrition, medicinal value, antioxidant properties

Introduction

Because of its health and therapeutic properties, dragon fruit, pitaya, or strawberry pear (*Hylocereus* spp. and *Selenicereus* spp.) is developing as a super crop even for marginal soil. It is a climbing cactus vine native to Central and South America, tolerant to abiotic conditions and pests, and disease resistant. It has a number of benefits, including low water and nutrient requirements, relatively less resources for orchard establishment and maintenance, multiple fruit harvests per year, the ability to sustain high yield for up to 20 years, a high benefit to cost ratio, and high nutraceuticals and functional properties (e.g. rich in antioxidants and fibres). All of these characteristics entice growers around the world to start and develop dragon fruit cultivation, allowing for global export and encouraging high-quality output to fulfil market demand. It can grow in a wide range of agro–climates, including locations of high temperature and water scarcity, because it is a crassulacean acid metabolism (CAM) plant with xerophytes' characteristics. Commercial cultivation of the dragon fruit is possible up to 1700 metres above sea level, with rainfall ranging from 500 to 1500 mm. Its shallow roots (40 cm) make it less picky in terms of soil requirements, and it may be grown in a wide range of soils without excessive wetness. However, slightly acidic (pH 5.5–6.0) loamy soil with high organic matter content and an ambient temperature of 20–30 °C are suitable for commercial dragon fruit orchard development. Dragon fruit, which is native to southern Mexico, Guatemala, and Costa Rica, was brought to south Asian tropical areas for commercial cultivation in 1990. Many countries, including Vietnam, China, Mexico, Colombia, Nicaragua, Ecuador, Thailand, Malaysia, Indonesia, Australia, and the United States, are currently producing and expanding fruit. Apart from its spontaneous expansion over the world, however, its manufacturing and marketing data is rarely available. Based on market availability, output, planted areas, and economic considerations, dragon fruit is classified as a minor tropical fruit. As a result, dragon fruit has gained widespread popularity in tropical Asian countries in recent decades, prompting commercial production around the world.

Climate change-induced abiotic and biotic stresses, such as episodic and frequent droughts, floods, widespread land degradation, salinity/alkalinity, extreme temperatures, pests, and diseases, pose significant challenges to agriculture in India, particularly in less fertile barren land and semi-arid drought-prone regions. In compared to neighbouring fertile areas, the agriculture sector in these resource-poor areas is significantly impacted by abiotic pressures and lags behind in crop production, diversification, and yields, as well as agricultural market economization. With a focus on crop and fruit diversity, an intensified farming system could address issues such as water scarcity/floods, low fertility, and poor soil for the region's long-term growth. As a result, identifying varied native and exotic crops/fruits, species, and genotypes that may be grown as an alternative and profitable crop in a harsh habitat is critical. However, facts linked to its adaptation, shelf–life, consumer acceptance, and market opportunity must be rigorously analysed for socio–economic development of debt–ridden farming communities in barren, flood, and drought prone regions when selecting such crops and fruits for introduction. Dragon fruit is one such prospective crop that may be grown readily in degraded terrain and drought-prone places around the country. Because of its colourful bracts, dark red meat, and delicious microscopic black seeds imbedded in white flesh, it has gained worldwide fame as a decorative plant and later as a fruit crop, and has become a favourite salad fruit. Dragon fruit pulp can be used to make value-added goods such as juice, jam, jelly, candy, syrup, and wine. It is one of the fastest-returning perennial fruit crops, with production beginning in the second year and reaching full production after five years of planting. With all of these factors in mind, this fruit is becoming increasingly popular with Indian farmers, businesses, and consumers in both rural and urban locations. Some Indian producers have taken steps in the last 3–5 years to adopt new technologies. Because the crop is new to India's different agro-climatic conditions, optimising region-specific cultivation, harvesting, and postharvest management procedures for maximum yield and quality performance is a big problem. Furthermore, proper awareness of the global and national scenario of cultivation, as well as marketing and consumption patterns, is critical for success in the production of dragon fruit, particularly in drought-affected degraded and barren land areas of India. In Asian nations, where traditional practitioners utilise herbal medicines to prevent and cure ailments, dragon fruit is also regarded a medicinal plant (Sofowora *et al*. 2013) [28]. Perween *et al*. (2018) [21] found that the pulp and peels contain a lot of water, are high in fibre, and include a lot of nutrients like vitamins, minerals, and antioxidants. Dragon fruit's biological activity has been examined and proved in various studies in recent years (Zain *et al*. 2019; Juliastuti *et al*. 2020) [36, 12].

Fig 1: Four different types of dragon fruit in world market

Nutritional Values

Hylocereus undatus, *Hylocereus polyrhizus*, and Hylocereus costaricensis are among the species in the genus Hylocereus, but only a few are cultivated for their commercial and nutritional value (Muniz *et al*. 2019) [15]. The nutritional qualities of dragon fruit juice derived from various species and crops demonstrate that they are significantly variable (Jeronimo *et al*. 2015) [11]. Depending on the species and provenance, 100 g of fresh dragon fruit pulp includes above 80% moisture, 0.4 to 2.2 g of protein, 8.5 to 13.0 g of carbs, and 6.0 g of total sugar. The authors attributed the lower vitamin C concentrations in the Jeronimo *et al*. (2015) [11] studies to several factors: ascorbic acid is susceptible to air and light and undergoes oxidative degradation with relative ease during juice preparation; the concentration of ascorbic acid in fruit varies depending on the type of cultivation, the stage of maturity, and other factors; and the concentration of ascorbic acid in fruit varies depending on the type of cultivation, the stage of maturity, and other factors. *H. costaricensis* (super red pulp), *H. polyrhizus* (red pulp), and *H. undatus* (white pulp) were obtained from four separate locations: Pasuruan (East Java), Sukoharjo and Klaten (Central Java), and Bantul districts (Yogyakarta). Vitamin C concentrations ranged from 3.3 to 6.0 mg 100 g–1 depending on the species and locality; for example, the maximum vitamin C content was discovered in Pasuruan super red pitaya (6.0 mg 100 g–1), while the lowest value was reported in Bantul white pitaya (3.4 mg 100 g–1). Choo and Jong (2011) discovered that ascorbic acid contents in two species, *H. polyrhizus* and *H. undatus*, were 36.65 mg 100 g–1 fresh pulp and 31.05 mg 100 g–1 fresh pulp, respectively. Another study found 55.8 mg 100 g–1 of ascorbic acid in Hylocereus sp., cv. Red Jaina (red skin with red pulp) and 13.0 mg 100 g–1 in Hylocereus sp., cv. David Bowie (red skin with white pulp) (Mahattanatawee, *et al*. 2006). As a result, vitamin C content varies by species, crop, origin, fruit maturity level, and extraction method (Rahmawati and Mahajoeno, 2009; Ramli and Rahmat, 2014) [25, 26]. The young stem of the pitaya includes substantial nutritional contents, including raw protein (10.0–12.1 g 100 g–1), raw fibre (7.8–8.1 g 100 g–1), and various minerals, including P, K, Ca, Mg, Na, Fe, and Zn, with Fe ranging from 7.5–28.8 mg kg–1 of dry mass (Ortiz-Hernández and Carrillo-Salazar, 2012). Jeronimo *et al*. (2015) [11] analysed the flesh of the species *H. undatus* and found that the most predominant fatty acids were linoleic, oleic and palmitic acid, accounting for 50.8%, 21.5% and 12.6% of the total fatty acid content, respectively. Linoleic, oleic, and palmitic acids were discovered to be the most prevalent fatty acids in the meat of the species H. undatus, accounting for 50.8 percent, 21.5 percent, and 12.6 percent of the total fatty acid content, respectively, according to Jeronimo *et al*. (2015) [11]. Similarly, Ariffin *et al*. (2009) [4] examined the oil extracted from red and white pitaya dragon fruit seeds and discovered a high content of essential fatty acids, such as linoleic (50%) and linolenic (1%), as well as other fatty acids such as cis-vaccenic acid (3%), palmitic acid (17.5%), and oleic acid (22.7 percent). Mono and polyunsaturated fatty acids have been shown to be beneficial to human health. These acids, for example, have been shown to aid in the reduction of low-density and very low-density lipoprotein fractions linked to elevated serum cholesterol (Jenkins *et al*. 2002) [10]. In addition, linoleic and alpha-linolenic acids are necessary to maintain cell membranes, brain function and the transmission of nerve impulses under normal conditions (Jeronimo *et al*. 2015) [11].

Phytochemistry and medicinal properties of dragon fruit phytochemical compositions

Phytochemicals are non-nutrient plant substances that are bioactive. Nyamai *et al*. (2016) [17] found that these chemicals are secondary plant metabolites that have health advantages.

In recent years, there has been a surge of interest in not just identifying the phytochemical substances found in dragon fruit, but also in harnessing their potential medical benefits. Bioactive chemicals extracted from all portions of the pitaya include betalains, flavonoids, polyphenols, terpenoids, steroids, saponins, alkaloids, tannins, and carotenoids (Jeronimo *et al*. 2015; Mahdi *et al*. 2018) [11, 13]. As a result, not only the edible sections of the dragon fruit, such as the pulp, but also the waste parts, such as the peels, are high in phytochemicals and could be used as herbal medicine or natural dyes. The phenolic chemicals studied were quinic acid, cinnamic acid, quinic acid isomer, 3,4-dihydroxyvinylbenzene, isorhamnetin 3-O-rutinoside, myricetin rhamnohexoside, 3,30-di-O-methyl ellagic acid, isorhamnetin aglycone monomer, apigenin, jasmonic acid, oxooct.

Antioxidant activities

Exploitation of natural antioxidant substrates in medicinal plants with preventative effects on cellular damage induced by free radicals, which are implicated in a variety of diseases such as cancer, is on the rise (Young and Woodside, 2001). The antioxidant (radical-scavenging) qualities of component phenolic compounds (such as flavonoids, phenolic acids, stilbenes, lignans, and tannins), alkaloids, and vitamin C may explain the appeal of many plants in disease prevention (Nyamai *et al*. 2016; Gan *et al*. 2017) [17, 7]. Several studies have linked antioxidant scavenging activity to total phenolic compound concentration (Wu and Ng, 2008) [34]. Phenolic substances, such as phenolic acid (e.g. gallic acid) and polyphenol (e.g. flavonoids), have been shown to be more effective antioxidants in vitro than vitamin C and vitamin E (-tocopherol) (Nurliyana *et al*. 2010) [16]. The antioxidant activity of different species, as well as the antioxidant content of different parts of the plant (e.g. pulp, peel, stem, and foliage), have been studied extensively (Wu *et al*. 2008; Nurliyana *et al*. 2010; Ramli *et al*. 2014; Jeronimo *et al*. 2015; Moo-Huchin *et al*. 2017; Mahdi *et al*. 2018; Zain *et al*. 2019) [34, 16, 26, 11, 13, 36]. The majority of research has concentrated on two Hylocereus species that stand out in cultivation and distribution: H. polyrhizus and H. undatus. 2, 2'-diphenyl—picrylhydrazyl (DPPH) (Brand-Williams *et al*. 1995) [5] and 2, 2'-azinobis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) (Re *et al*. 1999) are two of the most extensively used methods for evaluating antioxidant properties. Both are spectrophotometric assays that measure the radical scavenging activity of antioxidants even when present in complex biological mixtures (e.g. plant or food extracts) by quenching stable coloured radicals (DPPH or ABTS+). Nurliyana *et al*. (2010) [16] employed DPPH assays to compare the radical scavenging activity of H. polyrhizus and H. undatus pulps and peels, finding that the peels had stronger radical scavenging activity than the pulps in both species. Furthermore, at sample concentrations ranging from 0.8 to 1.0 mg mL–1, the antiradical activity of both species' peels was higher than that of the positive control, a powerful synthetic antioxidant known as butylated hydroxyanisole (BHA). The peels of *H. polyrhizus* and *H. undatus* have higher IC_{50} values than BHA (0.15 mg mL–1). In the case of pulps of both species, they showed low percentage of radical scavenging activities over the measured extract concentrations, suggesting that their IC_{50} values could be higher than 1.0 mg mL^{-1}. Interestingly, the total phenolic content (TPC) assay demonstrated that peels of both Hylocereus species contained higher phenolic content than the pulps. In a further study with red pitaya *(H. undatus*), Jeronimo *et al*. (2015) [11] obtained similar results like Nurliyana *et al*. (2010) [16] regarding the higher antioxidant activity of the peel compared to the pulp. Thus, the antioxidant activity of the pitaya peel (445.2 mg mL^{-1}) was greater than in the pitaya pulp (1 266.3 mg mL^{-1}). The highest concentration of compounds with antioxidant activity in the fruit peels, usually discarded, supports its value as leftovers rich in fibre, nutrients, and bioactive compounds.

Antidiabetic properties

Diabetes mellitus is one of the most common systemic disorders in the world, characterised by hyperglucemia caused by a pancreatic defect in the generation of insulin and/or insufficient sensitivity of cells to insulin action. Diabetic therapies have traditionally included herbs such as neem (*Azadirachta indica*), ivy gourd (*Coccinia indica*), bitter gourd (*Momordica charantia*), jamblon (*Syzygium cumini*), aloe vera (*Aloe barbadensis* Miller), and chicory (*Cichorium intybus*) in folk medicine in various countries (Adinortey *et al*. 2019) [2]. In general, medicinal plants show antidiabetic effects through biochemical mechanisms such as recovery of pancreatic β-cell function, improvement of insulin sensitivity by receptors, stimulation of insulin secretion, inhibition of liver gluconeogenesis, enhanced glucose absorption, and inhibition of glucose-6-phosphatase, β-amylase, and β-glucosidase activities (Adinortey *et al*. 2019) [2]. Several research have looked into the anti-diabetic properties of dragon fruit. In insulin resistance rats caused by fructose supplementation, Omidizadeh *et al*. (2014) [18] studied the anti-insulin resistant activity of red pitaya (*Hylocereus polyrhizus*). The findings of this study revealed that pitaya reduced insulin resistance, implying that the antioxidant and soluble dietary fibre content of red pulp pitaya is to blame for its anti-insulin resistance properties. In streptozotocin-induced diabetic rats, Swarup *et al*. (2010) [32] found that an aqueous extract of the fruit pulp of H. undatus at doses of 250 and 500 mg kg–1 body weight reduced fasting blood glucose levels, but not to normal levels. The reducing effect was limited, and greater doses of pulp extract had no effect. Abd Hadi *et al*. investigated the effect of red pitaya (*H. polyrhizus*) consumption on blood glucose levels and lipid profiles in type 2 diabetes individuals (2012). The investigation lasted seven weeks and was divided into three phases: one week before therapy, four weeks of treatment (phase 2), and two weeks after treatment. Patients were given 400 g and 600 g of pitaya per day throughout phase two, without halting their medication. Throughout the trial, fasting blood samples and anthropometric measurements were taken to see how pitaya affected blood glucose, triglyceride, and cholesterol levels. The findings revealed that while eating 400 grammes of fruit was more helpful in lowering triglyceride levels, eating 600 grammes was more effective in lowering blood glucose, total and LDL cholesterol levels, and increasing HDL cholesterol levels. There were no significant variations in body weight or total body fat between the two regimens. Poolsup *et al*. (2017) [24] investigated the beneficial effects of red and white dragon fruit in diabetes prevention through a systematic review and meta analysis of more than 401 studies, including both published and unpublished academic research, that compared the effect of dragon fruit with placebo or no treatment in prediabetes or type 2 diabetes subjects. There is a general trend to observe a greater reduction of blood glucose with higher doses of pitaya, but Poolsup *et al*. (2017) [24] concluded that due to restricted available data and poor quality of clinical evidence, further well-controlled clinical trials are yet required to further evaluate the clinical benefits of this fruit in prediabetes and type 2 diabetes patients.

Antiviral and antimicrobial activity

The physiological and biochemical foundation of plant resistance to pathogen attacks (i.e. virus, fungus, or bacteria) is linked to secondary metabolites produced by plants during microbial infection (Mickymaray, 2019) [14]. Secondary metabolites implicated in plant immunity can be classified using a variety of criteria, including core structure, common precursors, and modes of action. Defensive metabolites produced and stored constitutively in plant tissue are called phytoanticipins (e.g. saponins, glucosinolates, cyanogenic glucosides, and benzoxazinone glucosides), whereas those synthesised de novo in response to infection are called phytoalexins (e.g. camalexin, phenylalanine-derived phytoalexins like resveratrol, isoflavonoids like glyceollins, or terpenoids). The benefits of the consumption of plants against a wide range of pathogenic microorganisms are associated with different bioactive compounds, including secondary metabolites with greater antimicrobial properties like flavonoids (flavones, flavonols, flavanols, isoflavones, anthocyanidins), terpenoids (sesquiterpene lactones, diterpenes, triterpenes, polyterpenes), steroids, phenolic acids (hydroxybenzoic, hydroxycinnamic acids), stilbenes, lignans, quinones, tannins, coumarins (simple coumarins, furanocoumarins, pyranocoumarins), alkaloids, glycosides, saponins, lectins, and polypeptides, which exhibit a great antimicrobial potential (Tahera *et al*. 2014, Mickymaray, 2019) [33, 14]. The antimicrobial activity of the plant extracts and their bioactive compounds involves different mechanisms such as to promote microbial cell wall disruption and lysis, induce generation of oxygen species production to kill microbes, prevent biofilinhibit cell wall construction, inhibit several enzymes related to the replication of microbial DNA, inhibit energy synthesis of microbes, and inhibit bacterial toxins to the host (Mickymaray, 2019) [14].

Anticancer activity

The antiproliferative potential of dragon fruit is related to its content of strong antioxidants such as polyphenol, anthocyanin, betalains, steroids and triterpenoids (Wu *et al*. 2008) [34]. Among these compounds, aside from antimicrobial and antiviral properties, betalains can also inhibit the lipid peroxidation, cyclooxygenase (COX-1 and COX-2) enzymes and proliferation of human tumour cells (Strack *et al*. 2003; Afandi *et al*. 2017) [29, 3]. Supercritical carbon dioxide extracts of pitaya peels from H. polyrhizus and H. undatus possess antioxidant and cytotoxic activities, as demonstrated by Luo *et al*. (2014) [37]. The extracts of both pitaya species showed cytotoxic activity against three types of cells, i.e. PC3 (human prostate cancer cell line), Bcap-37 (human breast cancer cell line), and MGC-803 (human gastric cancer cell line) with IC_{50} values ranging from 0.61 to 0.73 mg mL–1. Luo *et al*. (2014) [37] also identified β-amyrin, β-sitosterol, and stigmast-4-en-3-one as the compounds responsible for the cytotoxic activities. The cell cycle analysis showed that the pulp extract caused an increase in G0 /G1 phase followed by a decrease in G2 /M phase. Moreover, the extract induced apoptosis in MCF-7 cells and suppression of BRCA1, BRCA2, PRAB (progesterone receptor isoform A and B), and Erα (estrogenic receptor α) gene expressions. Wu *et al*. (2008) [34] also proved the antiproliferative activity of pitaya extract against B16F10 melanoma cell line. This study revealed that the antiproliferative activity of the peel extract on B16F10 melanoma cancer cells was stronger than that of the pulp extract Anti-hyperlipidaemic and anti-obesity activities. Dyslipidaemia is a complex disease and major risk factor for adverse cardiovascular events, as it is known to promote atherosclerosis. With the aim of evaluating the effect of red dragon fruit peel powder (*H. polyrhizus*) on the blood lipid levels, Hernawati *et al*. (2018) [9] fed different groups of hyperlipidaemic Balb-C male mice with different doses of pitaya peel powder, ranging from 50 to 200 mg kg–1 body weight (BW) during 30 days. After the treatment, blood samples of each group were analysed for total cholesterol levels, triglycerides, and low-density lipoprotein cholesterol (LDL-c) and the results showed that all these parameters decreased along with increasing doses of red dragon fruit peel powder. The study of Suastuti *et al*. (2018) [30] on the anti-obesity and hypolipidaemic activity of methanol flesh extract of H. costaricensis showed that obese rats fed the flesh extract at a dose of 100 mg kg–1 BW decreased significantly their body weight, Lee obesity index, organ weight, visceral fat weight, total cholesterol, low-density lipoprotein, triglycerides, very low-density lipoprotein, and total cholesterol/high-density lipoprotein (HDL) ratio. In contrast, the concentration of HDL-cholesterol, faecal fat and cholesterol increased in these rats. Sudha *et al*. (2017) [31] evaluated in vitro the antioxidant, antidiabetic, and anti-lipase activities of white pitaya (*H. undatus*) juice extract. The phytochemical screening of the white dragon fruit revealed the presence of bioactive compounds with antioxidant, antidiabetic, and antilipase activities, such as triterpenoid, alkaloid, flavonoid, and saponin, with great value and potential uses. In short, bioactive compounds in dragon fruit extracts, including crude fibre, phenolic, polyphenol, and flavonoid content, contribute to the decrease of serum lipid profile, since these antioxidants are able to inhibit the absorption of cholesterol in the intestine, facilitating its excretion through the faeces. Rodriguez *et al*. (2016) [27] reported anti-inflammatory activity of maltodextrin encapsulated and non-encapsulated betalains from *H. polyrhizus* peel extract. Betalains are unstable and sensitive to degradative factors such as temperature, pH, oxygen, or light, but their bioactivity can be extended by encapsulation through the addition of a protective and impermeable layer (Rodriguez *et al*. 2016) [27]. Betalains inhibited sodium dodecyl sulphate (SDS)-induced vascular irritation of duck embryo chorioallantoic membrane (CAM). Free radicals may be main pro-inflammatory mediators; thus, removal of the mediators leads to alleviation of the inflammatory response (Rodriguez *et al*. 2016) [27]. Eldeen *et al*. (2020) [6] investigated the anti-inflammatory properties of flesh and peel of H. undatus and identified its main bioactive compounds. They found betalains, which are known to have high radical scavenging activity, and they reported for the first time the presence of squalene (a polyunsaturated hydrocarbon with a formula of $C_{30}H_{50}$ and formed by six isoprene units) in the flesh of the fruit as the dominant constituent (13.2%). According to Rahmawati *et al*. (2019) [25], the high content of vitamin C in the dragon fruit is responsible for its anti-anaemia activity, as it facilitates the absorption of iron needed in the production of blood and non-heme iron. Prebiotic potential. Prebiotics are non-digestible oligosaccharides that stimulate the growth of normal flora in the colon and provide protective effects against intestinal diseases, such as colon cancer (Gibson *et al*. 2004) [8]

Conclusion

The dragon fruit has several health benefits due to its nutritional and medicinal qualities, most notably in the regulation and management of oxidative stress. Bioactive chemicals found in all sections of the pitaya (stems, flowers, peels, and pulps) are involved in a wide range of biological activities, including antioxidant, antibacterial, and anticancer properties. These include betalains, flavonoids, polyphenols, terpenoids and steroids, saponins, alkaloids, tannins, and carotenoids, which have been shown to be effective, healthier, safer, and longer-lasting alternatives to synthetic drugs for the treatment and prevention of diseases like diabetes, cancer, obesity, hyperlipidemia, and pathogenic agents like viruses, bacteria, and fungi.

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