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Cultivation, Nutritional Value and Health Benefits of Dragon Fruit (*Hylocereus* spp.): A Review

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ABSTRACT

This review is planned to discuss the cultivation technology, nutritional values and health benefits of Dragon fruit. Dragon fruit plant has wide adaptability and grown well in slightly heavy texture soils. Plants are commonly propagated by stem cuttings. Flower buds are emerging after 15-18 months of planting and required 28-30 days for blooming. This fruit is popular due to its nutritional value, which is a good source of minerals, glucose, fructose, dietary fiber and vitamins. It strengthens the immune system of the human body and is also used in the treatment of diabetes, heart diseases and in maintaining healthy body weight. The yield and nutritional value of Dragon fruit vary depending on the species, cultivation practices, growing area and harvesting time. Dragon fruit peel has a high potential to be used as a natural dye. Numbers of commercial growers are gradually increasing in different countries due to getting a lucrative price of their product in the markets. At present, little information is available on production aspects of Dragon fruit. Research on different aspects of cultivation and health benefits of this fruit can help to maximize the benefits to worldwide growers and consumers and to expand the market of Dragon fruit.

Introduction

Dragon fruit is a vine cactus species belonging to the family Cactaceae (Patwary et al., 2013). Its plant is attractive due to its exotic appearance (Liaotrakoon, 2013). Dragon fruits are gaining popularity for their nutritional and medicinal properties (Sonawane, 2017). This fruit is considered as an important economic fruit species worldwide due to its nutritional values (Rifat et al., 2019). The cultivar, season, climate, cultural practices, water availability, transport, handling and storage may affect the bioactive compounds of Dragon fruit (Franke et al., 2004; Wall, 2006). Dragon fruit has great potential as a new crop for Mediterranean growers due to the requirement of little water and well adaption to the high temperatures (Trivellini et al., 2020). The color of red-fleshed Dragon fruits became pigmented during the ripening process (Rahim et al., 2009). The fruit is rich in sugars and antioxidants having good taste and crispy

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properties (Rao and Sasanka 2015). Dragon fruit is an edible fruit with water-soluble fiber and contains high level of vitamin C and antioxidants like Betalains, Hydroxycinnamates and Flavonoids (Moshfeghi et al., 2013). It has several health benefits including its ability to aid in weight loss, improve digestion, reduce LDL cholesterol in the blood and strengthen the immune system. Hydroxycinnamates helps to prevent cancer and Flavonoidsis acts on brain cells and blood vessels to reduce the risk of heart diseases. It also guards against bacteria and fungi and helps in the overall functioning of the body (Verma et al., 2017). The origin of Dragon fruit is the tropical and sub-tropical forest regions of Mexico and Central and South America (Mizrahi et al., 1997). This fruit spread to tropical and sub-tropical America, Asia, Australia and the Middle East from the center of its origin. It is well cultivated in Australia, Cambodia, China, Israel, Japan, Nicaragua, Peru, Philippines, Spain, Sri Lanka, Taiwan, Thailand, South-Western USA and Vietnam (Mizrahi and Nerd, 1999; Nobel and D la Barrera, 2002). Dragon fruit is also popular in South East Asia (Patwary et al., 2013). The cultivation of Dragon fruit is expanding in recent years due to its health and economic importance leading to its utilization as a source of functional materials to provide phytochemicals with strong antioxidant capability (Parmar et al., 2019). The *Hylocereus undatus* fruits are rich in fiber, vitamins, calcium, phosphorus, magnesium, phytochemicals and antioxidants (Mahdi et al., 2018; Luo et al., 2014; Sushmitha and Sathyamurthy, 2018). Dragon fruits become popular in Asian countries for its nutritional values, attractive feature and color (Harivaindaran et al., 2008; Hoa et al., 2006). Cultivation of Dragon fruit has been started in different districts of Bangladesh due to suitable tropical climate and seasonal rainfall, light intensity and soil type. Mass media have drawn public attention regarding cultivation and various health benefits and nutritional effect of Dragon fruit. Research on Dragon fruit has already been started at Bangladesh Agricultural Research Institute (BARI), Gazipur and the Germplasm Center of Bangladesh Agricultural University (BAU), Mymensingh (Patwary et al., 2013). There are tremendous prospects of growing Dragon fruit in different countries for its environmental suitability. At present, very few information is available on production aspects of Dragon fruit (Karunakaran and Arivalagan, 2019). This review papers is dealt with the knowledge regarding the cultivation, nutritional values and health benefits of Dragon fruit based on recent updates of philanthropist works and some of the research findings.

Morphology of Dragon fruit plant

The Dragon fruit plant (*Hylocereus* spp.) is a fast-growing evergreen cactus, which reaches up to 1.5 to 2.5 meters height with leafless thin vine-like branches. It is a terrestrial or epiphytic cactus with succulent three-winged and green stems (Patel and Ishnava, 2019). The stem is fleshy and vine-like with many-branched segments. Each segment has three wavy wings and 1-3 spines or sometimes spineless (Crane and Balerdi, 2005). Aerial roots of the plant absorb water and grow on the underside of stems and keep the stems on vertical surfaces. Dragon flowers are usually white in color and fruits are 25 to 30 cm long and 15-17 cm wide with bell-shaped (Merten, 2003).

The fruit is beautiful with bright red skin studded with green scales and white or red flesh with numerous tiny black seeds (Patwary et al., 2013). It needs support to hold the vine upward.

Fig. 1. Dragon fruits plant with flower and fruit.

Fig. 2. Dragon fruits of three different colors.

Generally, three types of Dragon fruits are cultivated in different countries (Fig. 2). All are leathery and slightly leafy skin. These are *Hylocereus ubdatus* (red-skinned fruit with white flesh), *Hylocereus costaricensis* (red-skinned fruit with red flesh) and *Hylocereus megalanthus* (yellow-skinned fruit with white flesh) (Hunt, 2006; Hamidah et al., 2017). Suitable plant variety for every given country and the proper cultivation process and management are hot topic for investigation on Dragon fruit plant.

Cultivation Technology

Dragon fruit is a semi-epiphytic plant that prefers a dry tropical or subtropical climate with an average temperature of 21-29 ˚C but can withstand temperatures of 38-40˚C and freezing temperature for short periods. This crop requires sunshine and rainfall of 600-1300 mm with alternating wet and dry seasons (McMahon, 2003). The fruit crop is grown around the year in subtropical and tropical countries. Dragon fruit plants require suitable environmental factors especially tropical and sub-tropical photoperiodic climate, sufficient rainfall, humid sandy soil, etc. All these factors are also required for flowering and fruit setting (Nerd and Mizrahi, 1995; Yen and Chang, 1997, Feng-Ru and Chung-Ruey, 1997). Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures and humidity. This climatic

condition is favorable to grow this nutritious Dragon fruit plant. Moderate temperatures are suitable for better fruit growth and scorching sunlight and full shade hamper the flowering and fruit setting thus influences the growth and development of fruits (Mallik et al., 2018). Fruit splitting, flower dropping, yellowing of the plant are occurred due to over-irrigation. The plant is adapted to tropical or arid climates with rainfall of 30-40 inches and any kind of soil with organic matter. Dragon fruit propagated through seeds and stem cuttings. The seedling from seed needs 4-5 years to produce flowers and fruit; whereas the vegetatively propagated plants produce flowers within three years (Rao and Sasanka, 2015). The plant blooms only at night, which can affect the process of pollination. Manual cross-pollination is needed to ensure fruit set and development due to a lack of genetic diversity and the absence of pollinating agents in certain production areas (Weiss et al., 1994). Flowering and fruit setting in Dragon fruit are affected by environmental factors such as photoperiod, temperature, rainfall, light intensity, and relative humidity (Mallik et al., 2018). Recommended cow dung 40 kg, 50 g urea, 100 g TSP, 100 g MoP, 100 g gypsum and 10 g borax per plant pit for Dragon fruit is needed for more fruit production (Rahim et al., 2009). The fruit is normally planted with vertical support of pillar and its stem must be attached to the support with a clip. Pillar with a frame attached on the top to allow the plant to hang down. Regular irrigation is important for the plant to build sufficient reserves to ensure the development of the fruits (Perween et al., 2018). Under tree sprinklers with a 1-1.5 m diameter wetting area to concentrate water into the root zone are suitable. Dragon fruit takes 28-30 days to mature after flowering (To et al., 2002). The variety and flowering time have a great influence on the physio-morphological traits of Dragon fruit (Mallik et al., 2018). Flower bud emergence after 15-17 months of planting and 28 d is required for blooming. Ripened fruits could be harvested between 30-50 days after pollination (Nerd et al., 1999; Pushpakumara et al., 2005). A Dragon fruit plant can bear fruit for up to 25-30 years. The plant starts yielding fruit between May and November each year in Bangladesh and the fruit can also be preserved for at least two months. Best quality fruits with a big size of more than 400 g even up to 500 g by weight. BAU Dragon fruit-2 variety exhibited superior performances on some physio-morphological and chemical characters than BAU Dragon fruit-1 (Mallik et al., 2018). No special change in color, flavor, odor, total soluble solids (TSS) and pH during the first 4 months of storage at ambient temperature (27-34 ˚C) and a little change of pH was observed after 4th month (Islam et al., 2012). The fruit changes its peel color from green to red at the mature stage. Fruit pulp color was red in HUP-002 variety whereas white in HUP-001 variety (Patwary et al., 2013). It is an easy income generation crop due to its early and yielding ability (Thokchom et al., 2019). Dragon fruit growers can obtain more benefits following latest farming management practices.

Nutritional Values of Dragon fruit

The nutritional value of Dragon fruit varies depending on the species, origin and harvesting time (Liaotrakoon, 2013). Nutritional composition and the phytochemical properties of red Dragon fruit significantly differ due to the influence of the growing environmental conditions (Nurul and Asmah, 2014). Dragon fruit contains significant amounts of minerals such as potassium, phosphorus, sodium and magnesium; higher than those of mangosteen, mango and pineapple (Gunasena et al., 2007; Stintzing et al., 2003; To et al., 1999) and all sources of vitamins (Choo and Yong, 2011). Flowering and fruit setting time significantly affect the quality of fruits, especially on total soluble solids contents (Mallik et al., 2018). Mature Dragon fruits have higher TSS, which is mainly higher in autumn fruits than in summer fruits (Nomura and Yonemoto, 2005). Dragon fruit is a good source of minerals, glucose, fructose, dietary fiber and vitamins (Rao and

Sasanka, 2015). It is well-known for its rich vitamin C, phosphorus, calcium as well as antioxidant contents (Morton, 1987). The fresh fruit contains 82.5-83.0% moisture, 0.16-0.23% protein, 0.21-0.61% fat, 0.7-0.9% fiber. 100 g of fresh fruit pulp contains 6.3-8.8 mg calcium, 30.2-36.1 mg phosphorous, 0.5-0.61 mg iron and 8-9 mg vitamin C (TFIDRA, 2005). The red flesh is additionally rich in Betalains, meeting the increasing trade interest in antioxidant products and natural food colorant (Perween et al., 2018). Table 1 shows the components and minerals contain in 100 g edible Dragon fruits.

Table 1. Nutrient content of 100 g edible portion of Dragon fruits (Thokchom et al., 2019).

Component	Amount	Component	Amount
Water	87 g	Vitamin B_1	0.04 mg
Protein	1.1 g	Vitamin B_2	0.05 mg
Fat	0.4 g	Vitamin B_3	0.16 mg
Fiber	3.0 g	Vitamin C	20.5 mg
Carbohydrate	11.0 g	Calcium	8.5 mg
Iron	1.9 mg	Phosphorus	22.5 mg

The red layer of the fruit has rich sources of vitamins including B_1, B_2, B_3, C and minerals (Le Bellec et al., 2006). Moreover, this fruit has a relatively high antioxidant activity in comparison with other subtropical fruits (Davis, 2007). Dragon fruit is rich in nutrients like vitamin B_1, B_2, B_3, C, high fiber content, minerals like Ca, Fe, P, with low amount of carbohydrates and no fats. Whereas, seeds contain 50% of essential fatty acids namely, linoleic acid and linolenic acid (Sonawane, 2017). The premature stem of Dragon fruit has higher in ascorbic acid content compared to Dragon fruit flesh, which may help to prevent the risk factors of certain disease like scurvy, anaemia, weakness (Jaafar et al., 2009). Dragon fruit could be a substantial source of pectin in fruit production (Tang et al., 2011). Nur Izalin et al. (2016) recommended using Dragon fruit peel pectin as a thickener in food products such as low viscous food and beverages. Dragon fruits are accepted globally for its high sources of polyphenolic components and antioxidant properties. Numerous tiny black seeds of these fruits contained high-quality essential fatty acids (Ortiz-Hernandez and Carrillo-Salazar, 2012). Dragon fruit pulp and peel extract have phytochemical compounds, which have antimicrobial activity and can be used as a natural antioxidant (Patel and Ishnava, 2019). All the mentioned research findings have been stated that Dragon fruit contains several vitamins and minerals that are important for a healthy body.

Consumption of Dragon Fruits

Fruits popularity increases worldwide due to its attractive colors, sweet, juicy pleasant taste (Minh et al., 2019). Dragon fruit is best eaten as raw fresh or dried fruit and sometimes used as a natural coloring agent in various drinks and beverages (Sonawane, 2017). Fruit and its young stems of *H. undatus* and fresh flower buds have been eaten as vegetables, while dried ones are used for local medicine. In Taiwan, dried flowers are consumed as vegetables. It also is taken as fresh table fruit in the form of juice, jam, or preserves according to the taste needed (Perween et al., 2018). Fresh and dried skins of Dragon fruit are rich in pectins and Betalains, making it natural food thickener and the natural coloring agent (Sonawane, 2017). The fruits can be eaten as raw or processed for ice cream, cookies, candies, jam, wines, shake, for special beverages or as flavor for all kinds of drinks and ingredients of various recipes. The flowers of Dragon fruits have been cooked as soups, lumpia and ingredient of Filipino viands. The skin pulps also been processed as embotido, pickles, jam and be boiled as cleansing drinks.

The stems and skin pulps can also be processed to beauty soap (Pascua et al, 2015). It may be summarized that Dragon fruit has multipurpose uses.

Health benefits of Dragon fruit

As indicated before, Dragon fruit is healthy and nutritious for human health due to its essential nutrients such as vitamins, minerals, complex carbohydrates, dietary fibers and antioxidants (Table 2). Studies show that Dragon fruit promoted the growth of healthy gut bacteria and Betacyanin which serves as a red or purple pigment with anti-oxidative properties (Liaotrakoon, 2013). It is low in calories, zero cholesterol and full of antioxidants; it minimizes cardio-vascular heart problems and maintains blood pressure (Patel and Ishnava, 2019). Dragon fruit flesh is rich in polysaccharides (Xu et al., 2016) and mixed oligosaccharides (Wichienchot et al., 2010); these are acting as stimulating factors for the growth of Lactobacilli and Bifidobacteria. These gastrointestinal microflora are called probiotics and suppress the growth of gastrointestinal pathogens. Dragon fruit is also used as a natural probiotic (Sonawane, 2017). The pulp is juicy and contains numerous small black seeds. It is also considered as a potential source of micronutrients and antioxidants (To et al., 1999; Mahattanatawee et al., 2006; Lim et al., 2007; Ariffin et al., 2009: Jaafar et al., 2009; Lim et al., 2010).

Table 2. Functions of some of the main antioxidants compounds and minerals contained in Dragon fruit.

Components	Amount	Functions
Flavonoids	Red fleshed 46.29 ± 2.47 mg RE/100 g FW & white fleshed 26.71 ± 4.46 mg RE/100 g FW (Senadheera and Abeysinghe, 2015).	Flavonoids are acts on brain cells and blood vessels to reduce the risk of heart diseases (Verma et al., 2017). It minimizes heart diseases and maintains blood pressure (Patel and Ishnava, 2019).
Betalains	42.71 ± 2.48 mg/100 g fresh pulp (Rodriguez et al., 2015).	Betalains can combat oxidative stress and may have the ability to suppress cancer cells. It has the ability to aid in weight loss, improves digestion, reduce LDL cholesterol in the blood and strengthen the immune system (Verma et al., 2017).
Hydroxycinnamates	Minor amounts of hydroxycinnamic acids (Mahattanatawee et al., 2006).	Hydroxycinnamates helps to prevent cancer (Verma et al., 2017).
Carotenoids (Beta-carotene)	1.4 mg/100 g (Charoensiri et al., 2009).	Reduced risk of cancer and cardio-vascular diseases (Aghajanpour et al., 2017).
Lycopene	3.4 mg/100 g (Charoensiri et al., 2009).	Lycopene inhibiting the cell growth of various human cancer cell lines (Levy et al., 1995).
Linoleic acid and linolenic acid	Seeds rich with 50% of essential fatty acids (Sonawane, 2017).	The seeds of Dragon fruits are high in polyunsaturated fats (omega-3 and omega-6 fatty acids) that reduce triglycerides and lower the risk of cardiovascular disorders (Sonawane, 2017).
Vitamin C	White-fleshed 31.11 ± 3.85 mg / 100g FW & Red fleshed 20.00 ± 1.33 mg / 100g FW (Senadheera and Abeysinghe, 2015).	Regular consumption of Dragon fruit that contains a high amount of Vitamin C would help in fighting against cough and asthma; increases the wound healing properties and quickly heals the cuts areas; moreover, enhances the immune system and also stimulate the activity of other antioxidants in the body (Cheah et al., 2016, Duarte and Lunec, 2005).
Phosphorus (P) and calcium (Ca)	P 22.5 mg/100g and Ca 8.5 mg/100g (Thokchom et al., 2019).	Dragon fruit contains high levels of phosphorus and calcium; which helps to reinforce bones and plays an important role in tissue formation and forms healthy teeth (Choo and Yong, 2011).
Iron	1.9 mg/100g (Thokchom et al., 2019).	Red Dragon fruit having so much iron, which increases haemoglobin and erythrocyte levels in pregnant women (Nurliyana et al., 2010).

Dragon fruit promotes the healing of wounds and cuts. Moreover, this fruit improves appetite, eyesight and memory of human being (Rao and Sasanka 2015). It has old-age retarding properties (Lim et al., 2012; Zhuang et al., 2012), cancer-preventing effects (Yusof et al., 2012), positive effects on metabolism, digestion, immune system, clear vision, oxidative stress, diabetes and cardiovascular diseases (Nurmahani et al., 2012). It strengthens the immune system and is used in the treatment of diabetes. Medicine made from its flower and stem improves blood circulation. The fruit offers numerous nutrients, including Vitamin C, phosphorus, calcium, fiber and antioxidants. The nutrients of Dragon fruits help to control diabetes and lower cholesterol level and prevent asthma and arthritis. Red Dragon fruit having much iron to increase haemoglobin and erythrocyte levels in pregnant women (Nurliyana et al., 2010). It also reduces aortic stiffness (Kumar et al., 2018). Dragon fruit peel has a high potential to be used as a natural dye (Harivaindaran et al., 2008). Fresh and dried Dragon fruit skins both are rich in pectins and Betalains making it natural food thickener and natural coloring agent. One of the natural food additive derived from the disposable part (peel) of the fruit named 'Dragon Fruit Coloring Powder' (DFCP) is using namely as 'albedo'. So, it does not affect the natural benefit of Dragon fruit (Moshfeghi et al., 2013). The 'albedo' of Dragon fruit is used as a conventional method to color rice, milk, yoghurt, juice, and pastry (Moshfeghi et al., 2013). It has medicinal values like reducing hypertension and diabetes (Kumar et al., 2018). The seeds of Dragon fruits are high in polyunsaturated fats (omega-3 and omega-6 fatty acids) that reduce triglycerides and lower the risk of cardiovascular disorders (Sonawane, 2017). Dragon fruit contains a high level of phosphorus and calcium; it helps to reinforce bones and play an important role in tissue formation and forms healthy teeth (Choo and Yong, 2011). Regular consumption of Dragon fruit that contains a high amount of Vitamin C would help in fighting against cough and asthma; increase the wound healing properties and quickly heals the cuts areas, enhance the immune system and also stimulate the activity of other antioxidants in the body (Cheah et al., 2016, Duarte and Lunec, 2005). Polyphenolic compounds are an excellent antioxidant and bioactive free radical scavengers, playing an important role in protecting human health (Barros et al., 2015). Dragon fruit boosts immunity in individuals due to the presence of bioactive compounds. Thus, improves physical and mental health (Jeronimo et al., 2017). Therefore, it can be concluded that Dragon Fruit has a lot of health benefits. It can limit cholesterol level, maintain blood sugar concentration, prevent colon cancer, improve kidney function and bone formation, strengthen the brain workings, increase the sharpness of the eyes and can be used in cosmetic ingredients (Sonawane, 2017). Due to its complex disease-prevention capabilities and medicinal properties, as well as the abundance of vitamins and nutrients, the cultivation of this fruit is rapidly increasing worldwide. The red Dragon fruit peel powder has potential to reduce total cholesterol, triglyceride, and LDL-c and to increase HDL-c levels. Red Dragon fruit peel powders can be consumed as a supplement in foods that are expected to maintain a healthy body and prevent hyperlipidemia (Hernawati et al., 2018). It presented more environmental benign antioxidant and act as antibacterial agents that are significant in the fields of healthcare, food processing, nutraceutical and cosmeceutical industries. These effects draw the attention of medical studies toward using this fruit in controlling various diseases and vital health-promoting factors.

Conclusion

This review paper is aimed to introduce the production of Dragon fruit in a new area considering the food and economic values. Dragon fruit has wide adaptability and become

popular worldwide due to its nutritional value and health benefits. This fruit crop is grown around the year in the subtropical and tropical countries under well-drained media to slightly heavy texture soils. This fruit is a good source of minerals, glucose, fructose, dietary fiber and vitamins. All the components of Dragon fruits worked all together to strengthen the immune system of the human body. Environmental factors have been directly involved in the flowering and fruit set of Dragon fruit. The nutritional value of Dragon fruit varies depending on the species, cultivation area and harvesting time. Dragon fruit peel has a high potential to be used as a natural dye. The prospect of the fruit is bright in the global market due to the increasing trend of its consumption. The research of Dragon fruit should be intensified and extended by emphasizing its value chain and production aspects for long term perspective.

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