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## Dragon fruit: A health potential and remunerative fruit crop for Chhattisgarh

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### Abstract

The dragon fruit [*Hylocereus undatus* (Haworth) Britton & Rose] is an exotic, perennial, xerophytes climbing cactus which belongs to family Cactaceae. Dragon fruit is a nutritious has abundant in vital nutritional ingredients viz. carotene, calcium, fiber, vitamin B, vitamin C, and phosphorous. It has an extremely low amount of cholesterol, which reduces the chance of heart attack and other diseases caused by accumulation of cholesterol. It contains protein as well as omega-3 and omega-6 fatty acids that can help prevent cardiovascular diseases. It is an excellent source of monounsaturated fats, helping the heart stay in great condition. It helps to clean up digestive system. It has high fiber content, which can assist with poor digestion and constipation. Eating the flesh and seeds, which contain good protein, will keep body fortified. It is the perfect fruit to maintain weight. It is a long day plant. Being a crassulacean acid metabolism (CAM) plant with xerophytes' characters, it has got ability to grow in a wide range of agro-climates including areas of high temperature and water scarcity regions. The dragon fruit can be cultivated commercially up to altitude of 1700 m with rainfall ranging from 500-1500 mm. Chhattisgarh has a tropical climate where summer temperatures can reach up to 49 °C. It is hot and humid in the summer because of its proximity to the tropic of cancer and its dependence on the monsoons for rains. The state receives an average annual rainfall of 1,292 millimeters (50.9 in). Thus there is a tremendous potential and remunerative benefit to cultivate the crop with good agriculture practices (GAP) in diverse climatic regions of Chhattisgarh.

**Keywords:** Dragon fruit, nutraceutical, xerophytes, exotic, GAP

### Introduction

Dragon fruit [*Hylocereus undatus* (Haworth) Britton & Rose] is a super food to the farmers and consumers in order to remunerative and wholesomeness, is obtaining rapid popularity amongst farmers. The *Hylocereus* Spp. are botanically diploid ( $2n = 22$ ) and is characterized by climbing plants with aerial roots that bear a glabrous berry with large scales [6]. Its genus name, *Hylocereus*, refers to both its habitat (hulos means "forest" in Greek) and the way in which it resists drought due to the wax or cereus covering the stems [6]. It is known by several names in different countries, such as pitaya (France, Israel, and Spain), dragon fruit, queen of the night and strawberry pear (USA, European and Asian countries). Fruit is named as pitaya because of the bracts or scales on the fruit skin and hence the name of pitaya means "the scaly fruit". Dragon fruit received worldwide recognition, first as an ornamental plant and then as a fruit crop. Most of *Hylocereus* species are principally originated from Mexico and Central and South America [30]. Dragon fruit was first introduced in India during the late 1990S as a garden crop [29]. Farmers in the Indian states of Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh and Andaman & Nicobar Islands have already taken up its cultivation, and the estimated total area under dragon fruit cultivation in these regions may be less than 400 ha [29]. Presently, the total area under cultivation of dragon fruit in India is more than 3,000 hectares which is not able to meet the domestic demand; hence majority of the dragon fruits available in Indian market is imported from Thailand, Malaysia, Vietnam and Sri Lanka [7]. This fruit is considered as an important economic fruit species worldwide due to its nutritional values [30]. The fruits are consumed either as fresh fruits or in salads, for production of jam, jelly, ice-cream, juice, wine, face-packs etc. Dragon fruit is mainly available in three variants viz., red skin with white pulp (*Hylocereus undatus*), red skin with red pulp (*Hylocereus monacanthus*) and yellow skin with white pulp (*Hylocereus megalanthus*). The red fleshed varieties of pitaya are relatively rich in antioxidants. It is well known for medicinal values to prevent colon cancer, reducing hypertension and diabetes,

neutralizes toxic substances such as heavy metals; reduce cholesterol and high blood pressure. It is rich in vitamin C, phosphorus and calcium [29, 7]. It has many advantages including low water and nutrient requirements, relatively less requirement of resources for establishing the orchard and maintenance; multiple harvests of fruit in a year; potential to sustain high yield up to 20 years; high benefit to cost ratio; and high nutraceuticals and functional properties (e.g. rich in antioxidants and fibres). All these qualities are attracting the growers worldwide to establish and expand dragon fruit farming, provide opportunity for global export and encourage for high quality produce to meet the market demand [32]. It has the tremendous ability to grown in a wide range of agro-climates including areas of high temperature and water scarcity regions due to xerophytes characters and CAM [32]. Dragon fruit is introduced in 125 droughts prone villages of Sangli district in Maharashtra; small, marginalized farmers, women and disabled farmers have successively adopted the crop as an alternative livelihood source for income augmentation [7]. Although at present, little information is available on production aspects of strawberry pear (*Hylocereus undatus*) but the Chhattisgarh state has also posses the diverse climatic and soil conditions that can be made it possible to grow at different regions of Chhattisgarh. 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 [32]. Beside of these, it was concluded by researchers that complete feed with the addition of dragon

fruit peel flour at a level of 10% produced optimal values for rumen fermentation characteristics based on pH values and ammonia levels (NNH3) in goats [48].

**Taxonomy and botanical description**

The dicotyledonous family Cactaceae (Caryophyllales) of *Hylocereus* Spp. comprises between 120 and 200 genera consisting of between 1500 and 2000 species found especially in the semi-desert, hot tropical regions of Latin America [6]. Cactaceae are mainly appreciated for their ornamental qualities, but they also include nearly 250 cultivated species [6]. The nomenclature of dragon fruit [54] is as follows:

Kingdom	Plantae (Plants)
Sub kingdom	Tracheobionta (vascular plants)
Super division	Spermatophyta (seed plants)
Division	Magnoliophyta (flowering plants)
Class	Magnoliopsida (dicotyledons)
Order	Caryophyllales
Family	Cactaceae (cactus family)
Subfamily	Cactoideae
Tribe	Hylocereeae
Genus	<i>Hylocereus</i> (Berger) Britt and Rose.
Species	<i>Hylocereus undatus</i> (Haw.) Britt and Rose.

Gunsena *et al.* (2006) have classified different edible cacti species based on nature of stem habit, fruit skin and pulp color [30]. Dragon fruit is mainly available in three variants which are discussed as in table 1.

**Table 1:** Major species of dragon fruit based on colour

S.N.	Species	Fruit peel color	Pulp color
1.	<i>Hylocereus undatus</i>	Red	White
2.	<i>H. monacanthus</i> (previously known as <i>H. polyrhizus</i> ), <i>H. costaricensis</i>	Red	Red
3.	<i>Hylocereus megalanthus</i> (previously known as <i>Selenicereus megalanthus</i> or <i>Hylocereus megalanthus</i> )	Yellow	White
4.	<i>H. ocamponis</i>	Yellow	Red

**Health and nutritional value**

The red fleshed varieties of dragon fruit are relatively rich in antioxidants. It is well known for medicinal values to prevent colon cancer, reducing hypertension and diabetes, neutralizes toxic substances such as heavy metals; reduce cholesterol and high blood pressure. It contains protein as well as omega-3 and omega-6 fatty acids that can help prevent cardiovascular diseases. It is a good natural source of anti-oxidants, which help to prevent the dangers of free radicals, which can cause cancer and other undesirable health detriments. People who suffer from the vector-borne diseases like malaria, dengue, and their platelet count become low and can be fatal if not treated timely. A healthy person normally has 150,000 to 450,000 platelets every micro liter of blood. And platelets' function is to stop bleeding by clumping and clotting blood vessel injuries. Dragon fruit helps in improving platelet count in dengue patients because of its antioxidant properties. Hence, doctors recommend dragon fruit for dengue patients. Eating a dragon fruit especially red flesh one with its rich antioxidants can keep the skin tight and young. Anti-aging face-masks can be prepared by using fruit combined with honey. It can be good alternative for face-masks [7]. It is rich in vitamin C, phosphorus and calcium [29, 7]. Red dragon fruit enriched with iron (1.9 mg/100g) which increases haemoglobin and erythrocyte levels in pregnant women [29]. The flavour of the fruit resembles to kiwi fruit. Fruits are low in fat and rich in minerals with the optimum Brix value of 15-

18 °B. It is widely used as fruit salad in star hotels and restaurants. It can be processed to range of industrial products such as juice, jam, syrup, ice cream, yogurt, jelly, preserve, candy and pastries [7].

**Table 2:** Nutritional value of ripen dragon fruit

Nutrient	Nutrient Amount (per 100 g)	Daily value (%)
Water	87 g	-
Protein	1.1 g	2.1
Fat	0.4 g	-
Carbohydrates	11.0 g	3.4
Fiber	3 g	12
Vitamin B1 (Thiamine)	0.04 mg	2.7
Vitamin B2 (Riboflavin)	0.05 mg	2.9
Vitamin B3 (Niacin)	0.16 mg	0.8
Vitamin C (Ascorbic Acid)	20.5 mg	34.2
Calcium (Ca)	8.5 mg	0.9
Iron (Fe)	1.9 mg	10.6
Phosphorus (P)	22.5 mg	2.3

Sources: FAO (2002) and <https://www.healwithfood.org>

**Production technology**

**Climate**

Dragon fruit requires warm climate thus it grows well in semi-arid regions [6, 7]. *Hylocereus undatus* grows as a climbing cactus in shaded or semi-shaded positions under large canopies, it may be injured by extreme sunlight and can

tolerate some shade; however, it is considered to be a full sunlight (Heliophyte) crop in Central and South American countries. The dragon fruit can be cultivated up to altitude of 1700m. About 500-1500 mm rainfall with proper distribution is good for its growth. Excess water leads to abscission of flowers and young fruits. The average Rainfall requirement is 1145–2540 mm per year. Since the cladodes (shoots) of pitaya are sensitive to high temperature and strong sunlight in summer, they are prone to sunburn, which may reduce yield. Dragon fruit plant prefers a dry tropical climate with an average temperature of 20-29 °C, but can withstand temperatures of 38-40 °C, and as low as 0 °C for short periods [30, 29]. Optimum temperatures for growth are 18-25 °C, with good relative humidity levels.

### Soil

Dragon Fruit could be grown in a wide range of soil types provided it is well drained. However, the most ideal soil type is rich in organic matter and slightly acidic [29]. The sandy loam soil, rich in organic matter is good for its commercial cultivation. The soil pH of 5.5-6.5 is optimum. It is very shallow rooted crop; mostly roots are confined up to 40 cm, therefore, depth of soil may not be problem for cultivation [31]. Recent research revealed that the growing of dragon fruit in trench mixed soil (native and black soils) could be most economic viable options and can be recommended to boost productivity of fruits. Moreover, dragon fruit cultivation is a one of potential step towards the diversification and commercialization of agriculture in degraded land regions of India [47]. It has reported the catalase gene of dragon fruit (HuCAT3) and proteins involved in chloroplast and mitochondria metabolism were documented to play a crucial role in abiotic stresses such as cold, drought and salt stresses [55, 56].

### Propagation

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 plant produces flower within three years [30]. The seeds germinate in 3-4 days and Seedlings are ready for transplanting after 9-10 months. Seedlings remain smaller with thin stem even after one year of planting. Further the plants produced from seeds are not true to type and there is there lot of variability among the plants. Thus seed are generally not used for commercial multiplication of dragon fruit [29, 7].

Fruit plants can easily multiply through stem cutting. The cutting should be taken from elite mother plants after the fruiting season. Before planting of cuttings in nursery bags, cuttings should be dipped in fungicide (e.g. Tebuconazole) @ 0.1% v/v and also drenched in second week from date of planting in bags to avoid fungal damages to stem cuttings. After Generally 20-25 cm long stem cuttings are used for planting. The cutting should be prepared one–two days prior to planting and the latex oozing out of cut is allowed to dry. These cuttings are planted in polybags of size around 30 × 12 cm should be preferred for planting of dragon fruit cuttings, filled with either soil + sand medium (3:1) or soil + sand + FYM medium (3:1:1) or soil, farmyard manure and sand (1:1:1). The bags are kept at a shady place for rooting. Excess moisture should be avoided for prevention of rotting of cutting. These cutting produce roots profusely and become ready for planting with 5-6 months [29, 7, 32]. For hormonal treatment, IBA @ 6000 ppm is found effective for

enhancement of adventitious rooting in dragon fruit [32]. It has been found that IBA @ 7000 ppm and media Soil: Sand: Cocopeat: Vermicompost (2:1:1:1) gave better results with respect to shooting of cuttings in dragon fruit [30].

### Cropping system

A fruit-based multi-storey system (mango + dragon fruit + pineapple) has been developed at CHES, Bhubaneswar, to enhance per unit productivity by growing CAM fruits with mango considering their light preferences. Dragon fruit and pineapple have been selected for intercropping in low density mango orchard. The LER (land equivalent ratio) of the system is estimated at 1.4. The cost benefit ratio of the system was 2.85 [7]. The intercropping of cereals like wheat, rice, green manuring and also vegetables crops is possible under irrigated conditions [35].

### Planting

The study revealed that IBA @ 7000 ppm and media containing Soil: Sand: Cocopeat: Vermicompost (2:1:1:1) had significant effect on improving shooting of dragon fruit cuttings viz., minimum days to sprout (35 days) and survival percentage was 98.34 [30]. The rooted cuttings are ready to transplant in the main field within 30-40 days in the nursery [7]. Generally in single post system planting is done at 3x3 m distance. Planting is usually done during rainy season (June to August), is the best time for planting but it can be planted in other seasons too with the provision of irrigation followed by making proper ridges of 50 cm height to give support to the plants. Single post vertical height of pole of 1.5 m to 2 m at which point they are allowed to branch and hang down. The dragon fruit may be planted near the poles to enable them to climb easily. Around the pole, 3-4 plants should be planted in 0.5 m<sup>3</sup> sized pits depending on the climatic condition which are filled with top soil along with FYM and other fertilizers [30]. Planting at a distance of 2.5 m each to row and between the plants with 4 cutting/ support can accommodate 6400 plants / ha and also gives good yields and quality of fruits [30]. Lateral shoots must be limited and 2-3 main stems are allowed to grow. Because lateral shoots must be removed time to time. It is important to arrange round metal/concrete frame to maintain balanced shrub. Because it spread the hanging shoots balance way [29].

### Manure and fertilizer

Dragon fruit is a shallow rooted fruit crop and it requires judicious application of manure and fertilizer for higher yield [30, 29]. In initial stage, more nitrogen should be applied for good vegetative growth whereas more amounts of phosphorus and potash should be applied in the later stages. A combination of organic manure with neem cake and 100 g of complete fertilizer (19-19-19) applied every three to four months were also found beneficial [30]. In India, ICAR-NIASM, Pune (MH) has recommended dose for dragon fruit grown in rocky degraded lands in which for first two years, 500 g urea and 500 g P and 300 g K is applied to each pole per year in four splits at three months interval. After two years each pole/year should be fertilized with 800 g N, 900 g P and 550 g K, which should be well distributed in six splits [7]. A good vegetative growth is responsible for getting good yield and quality fruits. Thus, it had revealed that the application of fertilizer dose N<sub>450g</sub> P<sub>350g</sub> K<sub>300g</sub> g/ pillar with 10 kg of FYM and adoption of spacing 2.5 x 2.5 m<sup>2</sup> is good to enhance the vegetative growth characters of dragon fruit under Tamil



Nadu conditions <sup>[29]</sup>. The experiment conducted in BCKV, Kolkatta, India for different combination of N, P, and K fertilizer doses revealed the dose of N 450: P<sub>2</sub>O<sub>5</sub> 350: K<sub>2</sub>O 300 performs best result for yield and quality <sup>[30]</sup>. In recent study, it had revealed that the application of nitrogen fertilizer at 50 g-1pillar and phosphorus at 75 g-1pillar produced maximum yield, respectively, and thus, it should be recommended as optimum doses <sup>[30]</sup>. A study suggested that nano urea was beneficial and resulted very close to the recommended dose of fertilizers and the nano urea @ 6 ml/l may be recommended for dragon fruit growth. Since, it produced maximum vegetative growth in terms of stem length, stem thickness and higher plant branches. <sup>[28]</sup> It has been reported that foliar application of mono-potassium phosphate (1% w/w), Folar-K® (0.1% v/v), potassium nitrate (1% w/w), and Box-Flower® (1% v/v) on a weekly basis for three months induces pitaya flowering by 18.7, 27.7, 33.2, and 38.0%, respectively <sup>[53, 54]</sup>.

### Training

A dragon fruit is an epiphytic plant climbs on the trees or supporting structures viz., concrete, wooden posts <sup>[7]</sup>. An economic life span of dragon fruit is nearly 20 years and during full bearing period, plants are laden with fruits, and thus the support system should be enough strong and durable. For commercial cultivation in tropics the plant can be trained to cement/concrete poles and tied with coier fibre rope. The IHR Bengaluru, India evaluated four different trellis system of Single pole with cement and iron ring, continuous pyramid stands and 'T' stands with two different cultivars. For our analysis, each trellis consisted of one 6 feet height by 5 or 6 inch thickness of poles erected 2 feet depth. Single pole system showed better performance in growth and yield when comparatively other trellis system. Single pole with ring type of trellis that can support the weight of the plants and allow easy access to flower and fruit will work for commercial production. Continuous type stands made of G.I. pipe and G.I. angles can also be used for dragon fruit training. The wooden poles are hard but their durability is least compare to cement poles. It is not possible to change the poles in between because of the growth and entangled branches. Therefore it is better to go with concrete poles its cost may be high for cement pole but they are durable and can be used <sup>[29]</sup>. About 700 poles are required, each pole of 6.5 feet length.

### Irrigation

Dragon fruit has shallow root system and distributed in the top 15 to 30 cm depth of the soil. Hence irrigation should be insured to provide sufficient water during dry season. Excessive irrigation is not desirable as it may promote bacterial and fungal disease; therefore, proper drainage should be provided in rainy season <sup>[30, 29]</sup>. Flowering and fruit enlargement are the critical stages <sup>[31]</sup>. The dry period before flowering is required for production of more fruits. Frequent dry period without irrigation reduces the yield and quality of fruits. Approximately 2-4 liters of water weekly twice per plant is sufficient during the summer/dry days. Water requirement may increase or decrease depending upon soil, climate and plant health. Irrigation by flooding is not recommended as it wastes water and increases work of weeding <sup>[29]</sup>. Micro-irrigation is recommended to avoid uneven and excess watering that can result in flowers and early fruit drop <sup>[31]</sup>.

### Flowering and fruiting

It is a long day plant usually flowering begins from April to November sometimes extending till December and occurs in four to six flushes and sometimes to seven <sup>[30]</sup>. Due to poor genetic diversity and sometimes there is absence of pollinating agents in certain production areas is reported. To overcome the problem manual cross-pollination is needed to ensure fruit set and development. Manual pollination may be begun before anthesis of the flower from 4:30 P.M. to 11:00 A.M. The pollen of two flowers will be enough for around 100 pollinations with a brush. The pollen can be stored for 3 to 9 months at -18 °C to -196 °C without any risk <sup>[30]</sup>. This manual pollination helps to obtain excellent quality fruit <sup>[32]</sup>. Flowering and fruit setting in Dragon fruit are affected by environmental factors such as photoperiod, temperature, rainfall, light intensity, and relative humidity <sup>[32]</sup>. It is a nocturnal plant. The flowers (white colour inside and greenish yellow with purple dyes on the outside) of hermaphrodite nature blooms during night and pollination complete on the same night. Bud formation takes place at aureoles from bud formation to flower opening requires 20 days. For the purpose of floral buds induction in pitaya, a 29-32 °C day and 19-22 °C night temperature is required during long days <sup>[6]</sup>. Flowering begins usually from April and fruiting season extends up to November <sup>[35]</sup>. From flower opening to fruit ripening requires about 40-45 days after fruits set <sup>[30]</sup>. In two year old dragon fruit plants, the number of fruits per pole (73.6) and TSS (12.87 °B) was higher in pink pulped than white pulped cultivar (40.5 and 9.25 °B) <sup>[7]</sup>. There is considerable variation in fruit size and shape between the varieties. At present, very little knowledge is available on varietal and production aspects <sup>[29]</sup>. The peel and pulp colours of the fruits were governed by the betalain pigments, which contributes to the nutritional and visual appeal of the fruit <sup>[27]</sup>.

### Harvesting

Dragon fruit provides fast return with economic production in the first year after planting and full production is attained in 3-4 years. The life expectancy of the crop is about 20 years <sup>[7]</sup>. The harvesting time varies depending on the country where the crop is cultivated. Harvesting of fruit is to be done after the attainment of physiological maturity and completion of developmental stages <sup>[29]</sup>. From flower opening to fruit ripening requires about 40-45 days after fruits set. Change of fruit peel colour from green (Carotenoid biosynthesis and betalain biosynthesis pathway gene such as ZEP and CYP76Ad are involved, respectively) to pink (Betalain biosynthesis pathway and carotenoid gene such as CYP76Ad and PSY, PLIS are involved, respectively) colour may be used as fruit maturity index. Usually, a 40:1 ratio of soluble solids content (SSC) with titratable acidity (TA) was recommended as an optimum harvest index instead of considering them alone as a measure of maturity. The optimum harvest maturity is obtained at 35-38 days after anthesis and 32-34 days after anthesis for domestic and international markets, respectively <sup>[43]</sup>. Early harvested fruits 25 days from flowering are more sensitive to chilling injury compared to fruits harvested 30 to 35 days from flowering <sup>[28]</sup>. The quality of the fruit varies with varieties, although harvest timing has a considerably higher impact on quality than varietal differences <sup>[29]</sup>. The eating quality of fruit can be determined using a hedonic scale. The highest score (8.5) was recorded when the mature fruit are 28 to 31 days old. This coincides with the preferred TSS/acidity ratio of 40. The fruit

matures only on the mother (because it is non climacteric fruit) plant<sup>[30]</sup>. The most common practice followed for harvesting is, twisting the fruit manually which often damages the skin. To overcome this, knife/secateurs can be used which is carried out with two cut operation and can be speeded up by one cut with a pair of shears<sup>[32]</sup>. The plants yield the fruits in the months between June to September or June to December, and harvest could be done three to four times in a month<sup>[54, 29]</sup>.

### Yield

Dragon fruit starts fruiting (Average economic yield) from second year onwards while the potential average yield of 1215 t ha<sup>-1</sup> can be expected from third year onwards with the recommended package and practices<sup>[7]</sup>. The average yield can be 10 to 12 tons/ha. But in well managed commercial orchards the yield of 16-27 tons/ha can be possible from 3rd year onwards under favorable climatic and properly managed conditions. Average weight of fruit is 300- 800 g.<sup>[31]</sup> In India, at present the market rate is Rs 100 per kg fruit and it varies with place to place, so the revenue generated by selling fruits per year is Rs 1000000. Benefit Cost Ratio (BCR) is: 2.58<sup>[7]</sup>.

### Insect-pests and diseases

In general, the dragon fruit experiences less pest and diseases compared to other commercial fruit crops like pomegranate, grapes etc. but few pests have been recorded on *Hylocereus*. Ants belonging to the genera *Atta* and *Solenopsis* are very notorious pest and can cause major damage to the plants as well as to the flowers and fruits. *Cotinus mutabilis* perforates the stem and *Leptoglossus zonatus* sucks the sap, leaving stains and some deformation<sup>[30]</sup>. Different species of aphids and scales have also been observed on fruits and flowers. Rats and birds can cause serious damage, mainly to flowers and fruits (N'Guyen, 1996)<sup>[54]</sup> as well as ripe fruits<sup>[30, 32]</sup>. The study reported that the use of 16 mesh net house has considerable potential for commercial production of white-fleshed pitaya, is also blocked major pests, such as melon flies, beetles and bugs, without exacerbating sunburn. As a protected facility, net house helps prevent diseases and pests and can substitute fruit bagging<sup>[55]</sup>.

Diseases like stem rot caused by *Xanthomonas campestris* and canker caused by *Neoscytalidium dimidiatum* and anthracnose (*Colletotrichum truncatum*) occur in some production areas. Viral (Cactus virus X), and bacterial (*Xanthomonas* sp. and *Erwinia* sp.) diseases are reported in the literature and can have major consequences<sup>[30, 36, 37, 32]</sup>.

### Post-harvest management

**Sorting and grading:** Systematic sorting and grading of freshly harvested dragon fruit is basic necessity for effective marketing. In India, it is usually done in a backyard or a shady area or tree shadow nearby farmer's resident as of limited numbers of growers cultivating dragon fruit. Farm labours sort fruit by inspecting them and grading based on weight, size and colour to meet the quality standards. Diseased, insect-infested, cracked and damaged fruits are rejected and kept in separate container for disposal. Then graded fruit is cleaned to eliminate adhering dirt and improve its appearance<sup>[43]</sup>. Fruit is typically classified by unit weight or size basis, and accordingly each country has different classes. Larger fruits will attract greater pricing than smaller ones. Especially,

Vietnam, the world's leading producer, frequently exports dragon fruit in two sizes: small (300-450 g) and large (460 g and more). Whereas, in Philippine fruit has been categorized into Jumbo (> 700 g), Extra Large (XL, 531-700 g), Large (L, 431-530 g), Medium (M, 331-430 g) and small (S, 230-330 g) as mentioned by Rodeo *et al.* (2018)<sup>[35]</sup>. There is no official classification for domestic produce yet in India, although it is classed into three grades i.e. A (>400 g), B (200-400 g), and C (200 g) for marketing<sup>[43]</sup>. In addition to the above classification, the fruits are also graded on the basis of the weight. Red/white dragon fruits are graded in nine different size codes and yellow fruit is graded in five different size codes as mentioned in Table 3.

**Table 3:** Codex Alimentarius grading of dragon fruit based on unit weight

Size code	Unit weight of Dragon fruit (g)	
	Red/White	Yellow
A	110-150	110-150
B	151-200	151-200
C	201-250	201-260
D	251-300	261-360
E	301-400	>361
F	401-500	
G	501-600	
H	601-700	
I	>700	

**Source:** Codex Alimentarius<sup>[7]</sup>

**Pre-cooling:** Pre-cooling is a most essential process for removal of 'field heat' just after harvesting of the commodity. In dragon fruit, it can be performed either initially or immediately after preliminary farm level sorting and grading. Particularly in commercial farms freshly harvested dragon fruit are immediately transported to pre-cooling to meet the storage and export need. It is vital to note that pre-cooling works best for dragon fruit when the temperature stays between 5-8 °C for 24 hours. In dragon fruit, there is primarily room and forced air cooling methods are being commonly used<sup>[29]</sup>.

**Packaging and storage:** Packaging of fruit in different packaging materials is a promising approach to reduce rapid shriveling and water loss during storage. Particularly in India, after successful sorting and cleaning, the dragon fruit is placed into plastic crates or packed into fiberboard boxes or cartons which completely solved the purpose of local market delivery<sup>[43]</sup>. Most of Indian farmers usually pack dragon fruit in 10 kg cartons as it is preferred in domestic market and export including Gulf countries. Packing is often done in the afternoon. The fruit are stacked in two to three layers, separated by a cardboard barrier. One carton of 10 kg carries 18-28 fruit depending on weight (350-500 g). According to Zee *et al.*<sup>[55]</sup> the fruit quality was acceptable for 25–30 days when stored in perforated plastic bags at 4.5 °C, however, when stored at room temperature the shelf life was less than 10 days. Garcia and Robayo<sup>[46]</sup> found that wrapping of green pitahaya in non-perforated PE wrap with storage at 10 °C resulted in the shelf life of 18 days and 21 days with a less than 5% and 10% rate of deterioration, respectively. Chandran<sup>[7]</sup> reported that dragon fruit (*Hylocereus polyrhizus* and *Hylocereus undatus*) wrapped using cling packaging (0.8µm) were stored upto 15 days at 6 °C compared to 9 days at 24±1

°C. Sutrisno and Purwanto <sup>[46]</sup> recommended that storing dragon fruit in MA containing 2–4% of O<sub>2</sub> and 6–8% CO<sub>2</sub> at 10 °C enhanced the storage duration to 25 days with stretch film and styrofoam plate of dimensions 120 × 180 mm <sup>[39]</sup>. Recommended storage temperature for dragon fruit (*Hylocereus undatus* and *Hylocereus polyrhizus*) is 10 °C and for yellow pitaya (*Selenicereus megalanthus*) it is 6 °C with 85–90% RH <sup>[28]</sup>.

### Conclusion

This is review paper, aimed to propagate the production huge possibilities of dragon fruit among the growers for adopting in a new area considering the food and economic values. It is a nutritious has abundant in vital nutritional ingredients whereas, an extremely low amount of cholesterol, which reduces the chance of heart attack and other diseases caused by accumulation of cholesterol. It contains protein as well as omega-3 and omega-6 fatty acids that can help prevent cardiovascular diseases. These nutritional, medicinal properties and health benefits are enhancing its worldwide popularity for the consumption as well as cultivation. Moreover, dragon fruit has the tremendous ability to grown in a wide range of agro-climates including areas of high temperature and water scarcity regions due to its physiology and has wide adaptability. Thus dragon fruit may be ensured as remunerative fruit crop for Chhattisgarh growers because the state has wider climatic and edaphic conditions for its cultivation and pave a way for a very promising industry as well.

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