A Review: New approaches indragon fruit Production,nutraceutical insights and morphological dynamics.

Abstract: Dragon fruit(*Hylocereus spp.*) is recently introduced amazing fruit in India, its cultivation gaining popularity because of its high nutritional value and antioxidant property. Recently, itdrawn the much attention of the Indian consumers owing to itspleasant flavour, colour, with their attractive appearance, tremendous health and nutritional benefits.Dragon fruit extracts from stems, flowers, peels and pulps have beneficial biological properties against pathogenic microbes like bacteria, fungi and viruses as well as diseases like diabetes, obesity, hyperlipidemia and cancer. Nowa days, Indian growers are much interestedin its cultivation due to its promising yield, easy cultivation,great commercial potential, which increases the economical status of the farmers. The area under cultivation is insufficient to fulfill the requirement of peoples hence, there is a need to increase dragon fruit production in India.At present, a very few information is available on production aspects of dragon fruit this review papers is dealt with the knowledge regarding the botany, nutritional composition, uses, health benefits, species, cultivation aspects of dragon fruit based on recent updates of some of the research findings.

Keywords: Dragon fruit, Nutraceutical properties, Botanical description,Cultivation aspects

INTRODUCTION

Dragon fruit is a herbaceous perennial climbing cactus species belongs to the family cactaceae (Jussieu 1789., Patwary*et al.*, 2013). It is originated in tropical and sub-tropical forest regions of Mexico and South America (Mizrahi *et al.*, 1999). In early 1800, French brought dragon fruit from Guana to Vietnam as a ornamental plant but presently in Vietnam this dragon fruit become one of the foremost important commercial fruit crop (Sonawane, 2017).In India it is introduced in the late 90's as garden crop but currentlyin India, thearea under dragon fruit cultivation also increasing gradually as commercial fruit crop.In the world, it is widely distributed in Vietnam, China, Mexico, Coloumbia, Thailand, Malayasia, Indonesia, Australia and United states (Mizrahi and Nerd, 1999; Nobel and D la Barrera, 2002). InIndian states, the ideal fruit cultivation started at Karnataka, Tamil Nadu, Kerala,Maharastra, Gujarat, Orissa, Andra Pradesh,West Bengal and Andaman & Nicobar Island etc. The majority of dragon fruits in Indian markets are imported from Vietnam, Thailand, Malaysia and Sri Lanka(Ahmed *et al.*, 2019).The dragon fruitcultivation 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. The fruits are rich in vitamins, fiber, phosphorus, calcium, magnesium, antioxidan and phytochemicals. Dragon fruits become popular in Asian countries for its nutritional values, attractive feature and color (Harivaindaran et al., 2008; Hoa et al., 2006). Dragon fruit is recently introduced fruit crop in India, it has tremendous scope for its cultivation because of it's high nutritional property and returns per unit area. At present, less information is available on cultivation 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.

Composition and uses

Dragon fruitnutritional composition is varies with species to species of *Hylocerspp,*itis the abundant source of vitamins and mineral nutrients (Nurliyana *et al*. 2010; Perween *et al.* 2018) which includes the vitamin A, vitamin B and richest source of vitamin C, carbohydrates,betacyanin's, antioxidents, flavonoids, carotenes, polyphenols, iron and Phytoalbumins (Moshfeghi*et al.,* 2013).The 100 g fresh fruits biochemical analysiscontain 83-88% moisture, proteins (0.5-0.16 g), fat (0.1-0.61g), calcium (6-8.8mg), phosphorus (19-36.1 mg), iron (0.4-0.6 mg), ascorbic acid (7-25 mg), poly phenols (7.23-1µg) and total flavonoids(26.8-46.29 mg).The fruit's titratable acidity ranged from 0.20 to 0.30 mg lactic acid, making it somewhat acidic (Wakchaure*et al*.,2021).Dragon fruit is recognized as the one of the tropical super fruit because of its abundant nutrients, has lot of various nutrients and less in calories. Reports suggested that it helps in reducing the diabetes and hypertension (Kumar *et al.,* 2018), act as anti-cancerous as it is rich in antioxidant, it fights against free radicals causing cancer (Yusof*et al.,* 2012),anti-inflammatory by reducing the arthritis pain, the seeds are rich in polyunsaturated fats (omega-3 and omega-6 fatty acids), which lower triglycerides and reduce the risk of cardiovascular disorders (Sonawane, 2017).It boosts the immune system by increasing platelet count and lowering cholesterol levels and high in fiber, which aid constipation relief and contains low calories.

Dragon fruit peel has high potential as a natural dye (Harivaindaran et al., 2008). The red layer of the fruit is rich in vitamins like B1, B2, B3, C and minerals(Le Bellec et al., 2006).The higher ascorbic acid content was observed in premature stem than the dragon fruit flesh, which may help to prevent the risk of certain disease such as scurvy, weakness and anaemia(Jaafar*et al.,* 2009). The pulp and peel extract of fruit have phytochemical

compounds, which have antimicrobial activity and can be used as a natural antioxidant (Patel and Ishnava, 2019)

The fruits can be eaten as raw or processed for ice cream, candies, cookies, shake, jam, jelly, wines, for special beverages or as flavor for all kinds of drinks and ingredients of various salad recipes.The dragon fruits flower have been cooked as soups, ingredient of filipino viands andlumpia**.** The pulp of skin is also processed as pickles, jam and be boiled as cleansing drinks. The pulp of skinand skin can also used for beauty soap preparation **(**Pascua *et al*, 2015).Dragon fruit peel has a high potential to be used as a natural dye (Harivaindaran*et al*., 2008)**t**he flesh of the pulp is juicy and contains many small black seeds. It is also regarded as a possible source of antioxidants and micronutrients. (Ariffin*et al*., 2009: Jaafar*et al*., 2009; Lim *et al*., 2010)

Area and Production

According to the recent data, the maximum area and production covered under Vietanm followed by China, Indonesia, Thaiwan, Thailand, Malaysia and Phillipinesetc(Wakchaure*et al*., 2021). The maximum productivity is reported in Vietnamfollowed by Indonesaia, China, Thaiwan, Combodiaand India etc. Vietnam is the largest dragon fruit producer in the world, accounting the highest share in Asia, Europe and sometimes in the United States. The biggest importerand consumer of dragon fruit in this world is China and Vietnam, the main exporter of dragon fruit worldwide due to high global demand (RatnalaThulaja and Abd Rahman, 2017). In India, Gujarat have the highest area and production followed by Karnataka, Maharastra, West Bengal, Andra Pradesh, Tamilnadu and the highest productivity is recorded in Maharastra.

Morphology and Physiology of Dragon fruit

Dragonfruitbelongs to cactus species, it isperennial,herbaceous, climbing vine. It is aCAM (Crassulacean acid metabolism) plant, during day time stomata closed which helps in reducing transpirational loss. It is a terrestrial or epiphytic cactus with succulent three-winged and green stems (Patel and Ishnava, 2019).It has thick, fleshy three angled stem and wax

coating, aerial roots which helps the plant to climb and also helps in absorbing moisture from surrounding, areoles in stem from which spines arises, shallow rooted crop. It has beautiful hermaphrodite flower (length 25-30cm), which is white in colour, large and attractive in nature, flowering occurs in April-May month (Merten, 2003). They are scented and blooms only at night and last only one night. Young flower buds are edible in nature, which used as salad in Malaysian countries.It is cross pollinated crop because, stigma is present over the stamen which hinders self pollination,it is ornithophilous in nature, pollination iscarried out by bats, hawk moths and honey bees.Flower starts open during evening (6:30 to 7 pm)it takes around 20 to 25 days from appearance of flower bud to full blossom(Karunakaran and M. Arivalagan,2019). The fruits are spherical to oval in shape with bright red or yellow skin and green foliaceousscales, spineless with several broad leafy bracts and are larger resembling the skin of a dragon (Hoa*et al.*, 2006). Seeds are black, small, elongate and kidney shaped. (Britton and Rose, 1920).

F**our types of dragon fruits aremainly grown in India are**

Hylocerusundatus: Red skin having white flesh fruits (Britton 19180)

Hyloceruspolyrhizus: Red skin with pink flesh fruits (Britton and Rose 1920)

Hyloceruscostaricencis : Red skin with purple flesh fruits (Britton and Rose 1909)

Selenicereusmegalanthus : Yellow skin with white flesh fruits (Moran, 1953)

Among these species, *Hyloceusspp* are diploid in and *Selenicereus app* is tretraploid in nature, the white and pink flesh fruits are widely cultivated types in India (Fig 1).

Fig 1. Species of dragon fruit grown in India

Dragon fruits fruiting stages

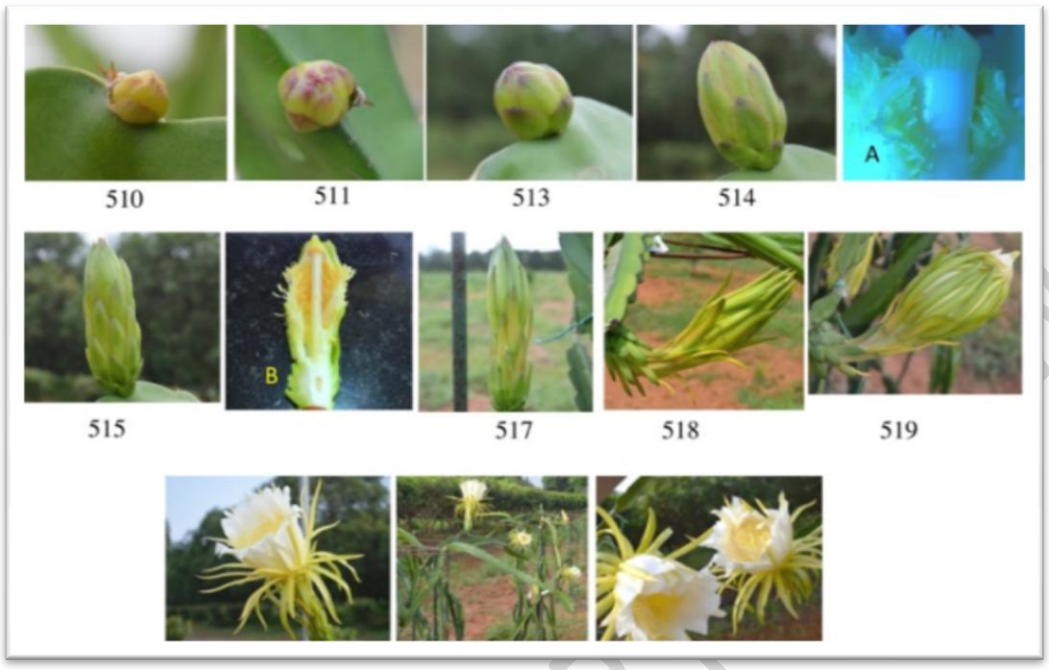

Fig 2: Time taken for flower bud to flower formation (Kundan Kishore, 2016)

Fruiting starts from June to November, it comes in 5-6 flushes, takes around 30 to 40 days for fruit set to maturity. Fruit is botanically known as berry, where endocarp and mascara are edible part and non-climacteric fruit**.**

By using a 3-digit numerical system dragon fruit phenological stages are classified based on the extended BBCH (BiologischeBundesantalt, Bundessortenamt and ChemischeIndustrie) scale, which assists to the standardization of its phenological stages (Fig 2). Bud development (0), shoot development (1), vegetatively propagated organ development (4), reproductive development (5), flowering (6), fruit development (7) and fruit maturation (8) are the seven major growth stages.

Soil and climate

It is a hardy crop, it can be grow in wild range of soils but gives the best results when they growin well drained, sandy loamy soils which is rich in organic matter having pH of 5.5 to 6.5 is good for its cultivation. Water logged condition leads to rotting of root and to avoid this problem, soil may be mixed with tiny stone gravels or sand to provide the good drainage facility (Wakchaure*et al*., 2021).

Dragon fruit is a long day and photosensitive crop (Morton 1987), that requires adequate sunlight and a dry tropical climate, while it is adaptable to humid, semi-arid, tropical and subtropical conditions. Even though sun-loving plant, it prefers temperatures between 20^0 C and 29^0 C. It can tolerate temperatures has high as 38^0 C and low as 0^0 C for short periods of time. Above 40°C temperature will cause stems yellowing in the plants. It requires 500 – 1500 mm annual rainfall and can be grown at an elevation of about 1700 m above MSL. Exessive rain fall causes flower and fruit drop (Karunakaran and Arivalagan, 2019)

Cultivars and propagation

In India, currently there are no officially released varieties or clones. The development of dragon fruit varies and hybrids is currently progresss at ICAR-NIASM in Baramati.Almost all the varieties/clones being propagated and cultivated by farmers and nurseries are introduced from other countries and those remultiplied in India. The mainly grown cultivar of dragon fruits are*Hylocerusundatus*, *Hyloceruspolyrhizus* and *Hyloceruscostaricencis*. Among these types of dragon fruits, red fleshed red skin was popularized and high in area and production because it is particularly rich in betalins, which have the high antioxidental property and used as a natural food colorants and for its wider adoptabiltity. Exotic varieties are Alice, American beauty, Bloody mary, Cosmic charlie, Costarican Sunset, Dark star, Delight, Thompson, Red Jaina , Zomoranoetc are reported in other countries.

Sexual means (seeds) of propagation is very rare in dragon fruit because of the fact that even after a year, seedlings raised from seeds in dragon fruit remain to be smaller and have thin stem and takes long time to yield, less vigorous and are not true to its mother. Stem cuttings are the commercial method of propagation. The cutting should be prepared a couple of days before planting by removing the latex oozing from cutting by drying. The healthy and vigorous cutting are taken from mother plants after the fruiting season and are produce flowers within three years (Rao and Sasanka, 2015). To prevent the diseases the cutting should be treated with fungicides. The better results were observed, when the cuttings were taken from the middle portion of the main stem about 15-25 cm and gives the better shooting

and rooting. Planting the cuttings in 12 x 30 cm size polyethylene bags, which is filled with mixture of soil, farmyard FYM and sand in the ratio of 1:1:2. The bags should be placed in a shady area to encourage better rooting. While too much moisture should be avoided to prevent cuttings from rotting. After 5-6 months, these cuttings develop strong roots and ready for planting (Tripathi*et al*., 2014).Notabaly high survival percentage was observed in Nov, Dec and January (Nandi *et al,* 2019*)*

It is commercially propagated by cuttings, but multiplication rates are extremely low, and obtaining sufficient planting material is difficult due to the large size of the cuttings required. So, *in vitro* propagation was found to yeild more planting material within short period of time. Explants should be selected based on their age and place of origin, whether they are from in vitro germinated seedlings or in vivo mature plants (Garcia-Rubio and Malda-Barrera 2010). The in vitro response was observed using shoot tips 2cm in length supplemented with 2mgL-1 of BAP. MS medium supplemented with 7mg L-1 BAP and 1 mgL-1 Kinetin were recorded the best combination in terms of time taken for multiple shoot induction, shoot length and number of multiple shoots (Arunkumar*et al*., 2022). Stem and leaf explants, regenerated the highest number of shoots on MS medium supplemented with 2.5mg/l BA and 0.01 NAAmg/l compare to that of the other hormone combinations. Rooting was observed in regenerated mature shoots after transferred onto MS basal medium with 0.01mg/l NAA.

Field Preparations and planting

The field should be adequately cleaned by removing any trees, shrubs and their stubbles to allow for unrestricted movement of man and machines. A virgin land needs deep ploughing and harrowing.Plough the field until the soil achieves its fine tilth and is weed-free. After that, you should apply any type of organic compost in a proportionate ratio. Dragon fruit cultivation thrives well in areas with abundant sunlight and open spaces, making them ideal for planting, shaded regions are unsuitable for cultivating dragon fruit. Planting season for dragon fruit cuttings is rainy seasoni.eJune –July. There are different planting systems like single pole system, continuous pyramid system. Generally single pole system consists of concrete pole with ring structure is followed with spacing 3 x 3m or 4 x 4m, the vertical height of the pole ranges from 1.5 to 2 meters, allowing branching and hanging of the viens. By placing the dragon fruit trees next to the poles, facilitates the easy climbing. Per pole four plants are recommended, 300 to 400 poles and 1200 -1600 plants are required to establish 1 acre dragon fruit orchard (Wakchaure*et al*., 2021). To encourage the controlled growth, it is

advised to limit lateral shoots, allowing 2-3 main stem to develop, with lateral removal of shoots as needed. The developed scale act as a useful tool for adoption of effective crop management practices such aspollination, nutrient management, plant propagation, timely harvest of fruits and pest management. (Kundan Kishore, 2016)

Irrigation and nutrient management

Even pithaya can survive with very low rainfall, it requires less amount of water (120 to 150 mm of irrigation/year. For good quality of fruit, there is a need of regular water supply to the plants because, it enables the plant to build sufficient reserves not only to flower at the most favourable time but also to ensure the development of the fruits. Drip irrigation method is adapted to avoids uneven and excess watering that can result in the flowers and the young fruits falling off. Critical stages of irrigation are flowering and fruit enlargement stages.Like other fruit crops dragon fruit also needs judicial application of nutrientsfor 1 to 2 year old plants need 10 to 15 Kg FYM with 300:200:200 g NPK/pillar. More than 3 year old plants need 540:720:300 g NPK/pillar applied in four split applications (April, July, October and January). The application of soluble chemical fertilizers at 500: 750: 300 g NPK/pillar with 4 split applications (in April, July, October and January) through fertigation, improved yield and yield attributing characters of dragon fruit. (Thanki*et al*., 2022)

Intercultural Operations

In the initial stages, plants grow into thick, dense vines that spread quickly. To grow in the direction of the stands, the lateral buds and branches must be pruned. Once the vines have reached the top of the stands, branches are allowed to grow. The tip of the main stem is removed to allow new shoots to grow laterally and climb at the ring that forms an umbrella-like structure of vines. After harvest, the plants are pruned to promote the growth of new, flower-bearing shoots.

Training and Pruning

The Indian institute of horticulture research, Bengaluruhas developed the 4 different trellis system viz., (Wakchaure*et al*., 2021)

- Single pole with cement ring
- Single pole iron ring
- 'T' stands
- 'T' stands continuous pyramid.

Single pole with cement and iron ring

Each trellis is made up of 6 feet tall height by 5- 6 inch thick pole constructed at a depth of 2 feet. For support, single cement poles and rings are used. Rubber tires cut across are placed on top of poles in some regions. Plants can be planted near the poles to allow them to climb easily. 2-4 plants per pole, depending on climate condition. In comparison to others, this approach is less expensive. In India, this is the preferred method.

'T' stands

'T' shape structure of the stand, Plants are planted between the two poles. Initial investment is high, around 6-6.5 lack/acre. After 4th year become clouded and chances of insect pest attack. Usually not prefer by the farmers.

'T' stands Continuous pyramid stands

Continues type G.I. pipe stands and G.I. angles can also be used. This pyramid shape has a length of about 10-15 meters. A greater number of plants could be planted. Adequate aeration was provided to avoid disease and pests attack. Plants should be placed 2-3 feet apart on both sides of the structure. The distance between two structures could be between 5 and 6 meters. Compared to other trellis systems, the single pole system performed better in terms of growth and yield. Although cement poles are expensive, they are long-lasting and can be used.

Fig 3. Different trellis systems namely (a) concrete pole and rings (b) T stand and iron wires (C) Wooden ladder for dragon fruit establishment

Harvesting

Dragon fruits are harvested between 31 and 36 days after flowering and best for ideal maturity and quality. The two species of dragon fruit red and white pulp fruits harvested at 31 day after flowering showed better physicochemical and sensory quality. Harvesting is done when the

fruit epicarp colour changes to red from green colour. Optimum time for harvesting is 7 days after colour transition. 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 non-climacteric and good for consumtion, when it is ripe however, its quality deteriorates gradually after harvest and during storage (Nerd *et al.*, 1999; Chien*et al*., 2007)

Yield and storage

Dragon fruit's stem cuttings starts to yield after 9 months of planting, the economical yield starts after 2 years of planting, fruit starts producing in the month of July till August depends on the species and varieties. It fruits in 3-4 waves during one season. Each pole plants approximately produce 40-100 fruits per wave. Each fruit weight about 300-1000gm and 15-25kg yield was recorded in each pole. It produces the 8-15 ton per acre of plant. The life span of dragon fruit is about 15-20 years.The fruits that are stored at 10°C and 93 percent RH had a longer storage life of 15 to 17 days. In normal room conditions, the post-storage life is 3 to 4 days. The average weight loss is 0.3 percent per day inside the cold room for 17 days storage and 2.6 percent per day in the regular room for 4 days after storage. After 3.5 days, fruits stored under normal room conditions exhibited 100 percent decay incidence and severity (Jadhav, P. B., 2018).

Physiological disorders

Sun burn injury

Sun burn injuries have become prevalent in many places of India. In the month of March and April sun burn symptoms are appeared, when the day and night temperatures varied greatly, particularly in the region where summer temperatures exceeded 40° C**.**

Diseases

In general, dragon fruit is tolerant to the major diseases and pests found in India. Anthracnose, brown spots and stem rots are the major diseases affecting the dragon fruit crop in India. Heavy rains, overwatering, or waterlogged circumstances make the crop prone to certain diseases.

Anthracnose

Causualorganisum: *Colletotrichumsiamense*

Symptoms**:** concentric lesions of reddish or orangish brown with ascervuli begins at the locations where the vine's spines extend from the edge, close to the ribs. It can be controlled by spraing with chlorothalonil2gm per liter,mancozeb at 2gm per liter and carbendazim at 1gm per liter of water.

Stem canker (Neoscytalidiumdimidiatum)

Stem canker, the most destructive disease of dragon fruit, has been observed in several orchards with varying degrees of severity. Unmanaged orchards were severely affected by the disease.

Symptoms: The affected cladodes initially exhibit depressed, chlorotic spots with red flecks. As the disease advances, the spot centers rise and turn red to grey. The centers of spots expand and harden into brown scabs with pycnidia embedded on the surface. As the disease progresses, affected cladodes begin to yellow and then rot. Over time, the necrotic tissues separate from the healthy tissues, leaving shot holes. On fruits, chlorotic depressed spots are followed by rotting of the affected fruit**(**Kakade et., 2022)

Wil: *Fusarium species.*Symptoms: Drying of plant tissues

Conclusion

Dragon fruit has the great nutritional and health benefits, present market trade demand showedthe importance of this fruit is more than the production in India. To meet this demand, there is a need to year round productionof dragon fruit. There is a need to standardize the package of practice for cultivation. It is necessary to develop a training module on the set of methods for successful dragon fruit farming and business ventures. This crop as commercial crop for enhancing income of marginal and small scale farmers in dryland areas. Requirement of post harvest management practices is necessary to avoid the post harvest losses. Lack of information on the species and varieties availability in India there is essentiality of development of variety through conventional and biotechnology tools.

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