



ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(6): 613-622
© 2022 TPI
www.thepharmajournal.com
Received: 19-05-2022
Accepted: 27-06-2022

Maddela Kiranmai
School of Agriculture, Lovely
Faculty of Technology and
Sciences, Lovely Professional
University, Phagwara, Punjab
India

Review of exotic fruit: Nutritional composition, nutraceutical properties and food application of Dragon fruit (*Hylocereus* spp.)

Maddela Kiranmai

Abstract

Dragon fruit is scientifically known as *Hylocereus* spp, belongs to the Cactaceae family and has 18 more species. It is originated from Central and South America and has been grown all- over India from past few decays. Besides its attractive colour, dragon fruit is prevailed globally for its nutrients and the health-promoting and used in food processing industry, cosmetic and pharmaceutical industries. A wide ranging of phytochemicals of antioxidants like betalains, polyphenolic compounds and carotenoids are discovered which have chemo-protective properties against oxidant stress in the body as well as maintain optimum equilibrium between antioxidants and oxidants for the enhancing of human health. The findings of this review are important to deliver an overview of *Hylocereus undatus* and its functional nutritional composition, nutraceutical activities and the food application with relation to its potential health benefit in providing perspectives of research and application the consumer's daily life.

Keywords: Dragon fruit, nutritional composition, nutraceutical activities, food applications of dragon fruit

Introduction

Dragon fruit is also called as pitaya, which is scientifically known as *Hylocereus* spp. The genus is *Hylocereus* which belongs to Cactaceae family (Md. Farid Hossain *et al.*, 2021) ^[21] and there are 18 species within the *Hylocereus* spp (Edmundo M. Mercado-Silva 2018). It is a non-climacteric fruit originated in Central and South America and now being cultivated in all Asian countries in world (Norzaida Yusof *et al.*, 2020). It is prominently cultivated more than 20 countries majorly including United States, Australia, Sri Lanka, Bangladesh, Japan, Malaysia, and China. Whereas India is been an importer of dragon fruit but the cultivation area has been tremendously increased now a days (Kirti Jalgonkar *et al.*, 2020). Dragon fruit is an exotic fruit because of the shape of fruit and colour of flesh in the fruit (Nga Huynh *et al.*, 2021). Flowering and fruit setting time play a significantly role and affect the quality of fruits, on total soluble solids contents. The mature Dragon fruits have more TSS compared to harvested or immature fruits (Paa K. Bordoh *et al.*, 2020). In most of the countries it is considered as an important economic fruit because of its high nutritional value and health benefits and shows well adaption to the elevated temperature and requires less water for its growth and development (Trivellini *et al.*, 2020) ^[37]. It is rich in sugars and antioxidants like Betalains, hydroxycinnamates and flavonoids, high Fiber content and vitamin C (Md. Farid Hossain *et al.*, 2021) ^[21]. The Dragon fruit pulp is juicy and has many black-colored seeds which are considered as potential source of micronutrients and antioxidants. Here are some examples of the antioxidant's compounds and minerals present in the dragon fruit. Dragon fruit can be generally classified by the appearance of the flesh inside the fruit and the peel of the fruit for example red flesh with red peel, white flesh with red peel and white flesh with yellow peel, in which most commonly produced and consumed species are *Hylocereus undatus* (white flesh with red peel), *Hylocereus polyrhizus* (red flesh with red peel) and *Hylocereus megalanthus* (white flesh with yellow peel), whereas the other parts of dragon fruit like peel, seed and other parts are inedible fractions but has an important role in nutritional potentials of these by products (Haitao Jiang *et al.*, 2021) ^[9]. There are many more species which are differentiated by their fruit characteristics. *Hylocereus costaricensis*, it has violet-red pulp with pink skin, *Hylocereus guatemalensis*, it has red pulp with reddish-orange skin (M. Arivalagan *et al.*, 2021) ^[11]. The dragon fruit Nutritional value also varies from each other based on the cultivation region.

Corresponding Author:
Maddela Kiranmai
School of Agriculture, Lovely
Faculty of Technology and
Sciences, Lovely Professional
University, Phagwara, Punjab
India

India has been cultivating the dragon fruit with various varieties of dragon fruit such as White Hirehalli, Andaman,

Red Hiriyyur, Gujarat, Long and Kegwada all over our India (M. Arivalagan *et al.*, 2021)^[1].

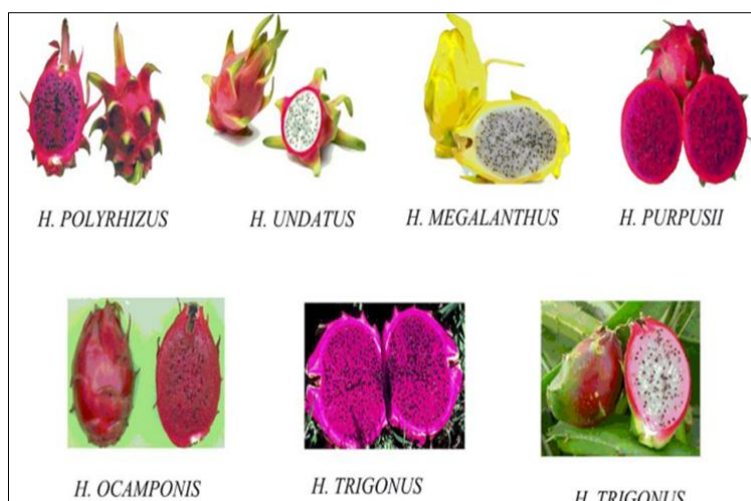


Fig 1: Species of dragon fruit (*Hylocereus* spp) (Sabrin Ragab Mohamed Ibrahim *et al.*, 2017)^[21]

The dragon fruit tree is cultivated as an ornamental vine specially in gardens and landscapes which is also a fast-growing cactus up to 1.5-2.5 meters height (Madhuri Shrikant Sonawane., 2017)^[13]. Dragon fruit is oval shaped and sweet and sour in taste (Monica Joshi *et al.*, 2020)^[25]. These fruits show their proper growth in most of the dry, tropical, and sub-tropical climatic regions which endures temperature up to 40°C, whereas in the wet tropical dragon fruit plant can be grown well but sometimes problem rises with the fruit setting (Madhuri Shrikant Sonawane 2017)^[13]. Not only the fruit is consumed as fresh fruit, it is also chilled by peeling off the skin or as dried fruit but also it used as flavoring agent in drinks, juices and alcoholic beverages sorbet, smoothie, and pastries (Madhuri Shrikant Sonawane 2017)^[13]. The benefits of cultivating the dragon fruit tree are, if it is planted once, it will be grown around 20 years (Kirti Jalgonkar *et al.*, 2020). It is a perennial crop with quick return where production begins in subsequent year after planting and reaches full production within 5 years of planting (Kirti Jalgonkar *et al.*, 2020). As the dragon fruit is highly perishable requires at most precautions for cultivation, harvesting, handling, storage, processing, and transportation to reach the markets. The transportation has a key role as the most of the production of dragon fruit is consumed as fresh fruits (Kirti Jalgonkar *et al.*, 2020). The fruit resembles kiwi fruit as the fruit seeds are embedded in the fruit pulp which are edible in nature. The fruit is eaten as raw and in the forms of candies, jam, jelly, and drinks also. The flesh of the dragon fruit has some essential vitamin C and minerals as phosphorous, calcium, sodium, zinc, potassium, and iron. Pigments like betacyanin, carotenoids, chlorophyll and anthocyanin are present in the dragon fruit flesh and peel (Monica Joshi *et al.*, 2020)^[25]. In the whole fruit the peel is about 1/3rd part tend to be food waste or used as by-product obtained from a fresh cut fruit and incase of the juice processing (Haitao Jiang *et al.*, 2021)^[9]. Whereas dragon fruit peel also places key role in food industrial system by consisting abundant Nutritional value and bioactive substances. Specially in the dried dragon fruit peel contains rich amount of pectin and dietary fiber about 60%-80% which can be a good applicant in food production by playing the role of functional ingredient (Haitao Jiang *et al.*,

2021)^[9]. From the past few years India market had an encouraging growth production but still most fruits come through export so this makes the proper maintaining unit proper channel. As dragon fruit has its own nutritional attributes and commercial important in the Indian market so, the significance of the dragon fruit cannot be overlooked in the processing industry (Kirti Jalgaonkar *et al.*, 2020). Therefore, a systematic review is made on the utilization of the dragon fruit by various techniques and approaches on dragon fruit processing and the by-products and value-added products from the dragon fruit. There are many products produced using the dragon fruit such as jam, drinks, juices, wine, and other products which have ultimate demand in all over India as ready to serve commercial food form. Due to its nutritional benefits, it has been part of every human as a healthy diet.

Dragon fruit is known for its medicinal uses, also used in the folk medicine in most Asian countries, in which herbal medicines are used as traditional practices to cure diseases (Thi-Thuy- Hai Luu *et al.*, 2021)^[12]. Dragon fruit is house of nutrition for example Vitamin C, phosphorous, and calcium but varies from species to species and it is considered to have higher medicinal values like reducing hypertension, reduce cholesterol concentration, balance blood sugar r concentration, prevents colon cancer, strengthen kidney and bone function, strengthen the brain workings, improves eye sight and even used as cosmetic ingredients (Paa K. Bordoh *et al.*, 2020). The pulp and peel of dragon fruit has high water content, rich in fibers and contain many nutrient elements including a high portion of vitamins, minerals, and antioxidants (Thi-Thuy-Hai Luu *et al.*, 2021)^[12]. Red-fleshed dragon fruit is rich in iron resulting in increased hemoglobin level. The pulp is more effective in controlling oxidative damage, decreases aortic stiffness and serves as dietary fibers for diabetic patients and helps in the bleeding problem of vaginal discharge. The seed of dragon fruit is rich in essential fatty acids namely, linoleic acid and linolenic acid (a necessary substrate in human metabolism which cannot be synthesized by humans). Dragon fruit flesh is a natural probiotic, rich in polysaccharides and mixed oligosaccharides (Paa K. Bordoh al., 2020). It also helps in stimulating Gram-positive lactic acid-producing bacteria growth like

Lactobacilli and other bacteria. These bacteria constitute a major part of the intestinal microflora in humans that helps to suppress the growth of gastrointestinal pathogens (Paa K. Bordoh *et al.*, 2020). It is also full of vitamins such as C B1, B2, B3. B1 helps carbohydrate metabolism and energy production. Vitamin B2 plays significant role in the recovering the loss of appetite whereas vitamin B3 helps in decreasing the bad cholesterol level, also helps in skin smoothening and the moisturizing (Tamanna Perween *et al.*, 2018)^[18]. Dragon fruit consumption can help in the eye sight as well as hypertension prevention, and helps in reducing blood sugar levels, specially in case of type 2 diabetes, the glucose present in the food helps in the controlling the blood sugar level. It also vital role in the tissue formation as it consists of high amount of calcium, phosphorus and maintains healthy teeth due to presence of calcium and phosphorus in prominent level (Tamanna Perween *et al.*, 2018)^[18]. It is also containing high amount vitamin C and regular consumption helps in controlling cough, asthma and plays significant role in the immune system enhancing. It also helps in stimulating the antioxidant activity in the human body (Tamanna Perween *et al.*, 2018)^[18].

Nutritional value

There are several species and varieties of the *Hylocereus* spp that have been cultivated for their commercial and their nutritional values varies depending on the different parameters such as, region to region, cultivation practices and species (Thi-Thuy-Hai Luu *et al.*, 2021)^[12]. The proximate values in gram or mg per 100g edible portion of white-flesh dragon fruit are moisture (85.3% average), protein (1.1), fat (0.57), crude fiber (1.34), energy (67.7) (Kcal), ash (0.56), carbohydrates (11.2), glucose (5.7), fructose (3.2), sucrose, sorbitol (0.33), vitamin C (3.0), Mg, K, Na, Zn and P, according to the author Tamanna Perween. whereas in red-flesh dragon fruit varies from the white-flesh dragon fruit in moisture content, fat content and others (Tamanna Perween *et al.*, 2018)^[18]. Vitamin C role has been obtained in the studies of Jeronimo *et al.* (2015) were the antioxidant properties explained that it varies in varied factors such as ascorbic acid concentration varies and depends on the type of cultivation of dragon fruit crop. Many authors have examined the vitamin C content of dragon fruit of three species such as *Hylocereus costaricensis* (super red pulp), *Hylocereus polyrhizus* (red pulp) and *Hylocereus undatus* (white pulp), collected from different regions and vitamin C concentration was oscillated from 3.3 to 6.0 mg 100 g⁻¹ and summarized that the vitamin C concentration varies according to the origin, species, crop, extracting process and the maturity level of the fruit (Thi-Thuy-Hai Luu *et al.*, 2021)^[12]. Every part of the dragon fruit has its own nutritional value. The young or tender stem has high nutrients which includes the raw protein, the raw fiber and some minerals like Ca, Mg, Zn, P, K and Fe. Whereas the pulp and seeds have some of fatty acids, in which the author Jeronimo *et al.* (2015) analyzed that the pulp of *Hylocereus undatus* and found that it contains the most predominant fatty acids in which linoleic acid (50.8%), oleic acid (21.5%) and palmitic acid (12.6%) and analyzed the phenolic compounds such as quinic acid, cinnamic acid and many other minerals which includes carbohydrates, proteins and organic acids.

Proteins-Amino acids and organic acids

It was reported by some of the scientists that some of the contents of nutritional substances for example the amino acids and organic acids are more in dragon fruit peel compared to

the pulp of the dragon fruit (Haitao Jianget *et al.*, 2021)^[9]. It contains essential amino acids such as tyrosine, glutamic acid, leucine, lysine, tryptophan, valine, alanine, serine, and aspartic acid while the organic acids are tartaric acid, malic acid, citramalic acid, fumaric acid, propanedioic acid, talonic acid and mannonic acid Xuejiao, *et al.*, 2019).

Carbohydrates

The dragon fruit is high in carbohydrates, majorly glucose, fructose, and some of the oligosaccharides (Wichienchot .S *et al.*, 2019). Specially the peel of dragon fruit has most abundant macro nutrients and it is in pectin and dietary fibers (Haitao Jianget *et al.*, 2021)^[9]. The peel is also used for the pectin extraction and many researches have been done on the Physico-chemical characteristics of pectin from the dragon fruit peel. The pectin present in the peel has potent absorption capacity towards the cholesterol which helps in the lowering the blood cholesterol effects (Haitao Jianget *et al.*, 2021)^[9].

Vitamins and Minerals

The pulp of dragon fruit contains essential vitamins such as vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin E and vitamin A (Haitao Jianget *et al.*, 2021)^[9]. It also contains essential minerals such as phosphorous, calcium, iron, magnesium, and zinc (Thi-Thuy-Hai Luu *et al.*, 2021)^[12]. There were many studies in which author Thi-Thuy-Hai Luu mentioned that the peel of the dragon fruit contains limited number of vitamins and minerals compared to the pulp.

Antioxidants

The dragon fruit is highly rich in antioxidants which are used as prebiotic enrichment as well as natural colorants in food Processing Industry (Yanyi Huang *et al.*, 2021)^[7]. Like betalains, betacyanin, flavonoids, hydroxycinnamates and polyphenols (Rao and Sasanka 2015). Polyphenols are present in dragon fruit seeds, peel, and pulp whereas seeds and peel have higher polyphenols compared to pulp (Yanyi Huang *et al.*, 2021)^[7]. These are group of antioxidants that are derived from plants which also include flavonoids, phenolic acids, and lignin etc. These have high radical scavenging ability to reduce the risk of chronic diseases. Hydroxycinnamates helps in the cancer prevention, flavonoids have a major function act as brain cells and blood vessels which helps in reducing the risk of heart diseases (Md. Farid Hossain *et al.*, 2020).

Fatty acids

The dragon fruit seed consists of major essential fatty acid near about 50% such as linoleic acid, linolenic acid have laxative on gastroenteritis (Yanyi Huang *et al.*, 2021)^[7] and other fatty acids for example palmitic acid (17.5%), oleic acid (22.7%), cis-vaccenic acid (3.0%) (Thi-Thuy-Hai Luu *et al.*, 2021)^[12]. Ascorbic acid is present in higher amounts specially in premature stem of dragon fruit compared to the pulp of the fruit, its major function is to prevent the risk factor of diseases such as anemia, scurvy, and weakness (Md. Farid Hossain *et al.*, 2020).

Lipids and Betacyanins

There are many analyses done which shows that the red dragon fruit peel contains essential lipids such as stearic acid pentenoic acid, docosanoic acid, propanoic acid and butanoic acid (Haitao Jianget *et al.*, 2021)^[9]. Betacyanin is natural pigment which act as many bioactivities, for example anti-obesity, anti-cancer, antioxidant, antimicrobial and many

more properties. These help in the prevention of coronary artery disease relief and oxidative liver damage also (Haitao Jianget *et al.*, 2021) ^[9]. Betacyanins are used in the food products as natural colorant in yogurts, ice cream and cookies also. Betacyanins were extracted from the dragon fruit peel more abundantly than the dragon fruit pulp which are incorporated into the food products either as functional ingredient or as a natural colorant in the food (Haitao Jianget *et al.*, 2021) ^[9].

Alkaloids

The dragon fruit peel has extracted to detect the alkaloids present in the dragon fruit, it is composed of choline, dopamine hydrochloride, amaranthin, amine and N-benzylmethylene isomethylamine. In which N-benzylmethylene isomethylamine and choline are most common alkaloids found in dragon fruit peel. Whereas the red dragon fruit accumulates higher alkaloids compared with

green dragon fruit. However, much information regarding the alkaloids is still rare and studies and researches are being done (Haitao Jianget *et al.*, 2021) ^[9].

The below table gives the detail nutritional values of distinct species of *Hylocereus* spp which is commonly called as dragon fruit. Depending on the place of cultivation the nutritional values can vary, so here are *Hylocereus polyrhizus* (Australia), *Hylocereus polyrhizus* (Malaysia), *Hylocereus Undatus* (Brazil) (Thi-Thuy-Hai Luu *et al.*, 2021) ^[12] and some more varieties of dragon fruit with their nutritional values White Hirehalli, Andaman, Red Hiriyur, Gujarat, Long, Kegwada (M. Arivalagan *et al.*, 2021) ^[11]. The moisture content, ash percentage, carbohydrates, fat content, proteins, energy, crude fibers, total sugars, vitamin A, vitamin C, iron, magnesium, potassium, phosphorous, zinc, calcium, amino acids, present in the dragon fruit are been motioned. Proximate nutritional values in g or mg per 100 g edible portion of dragon fruit of distinct species (*Hylocereus* spp.)

Table 1: Nutritional Composition of Dragon fruit

Components	<i>Hylocereus polyrhizus</i> (Australia)	<i>Hylocereus polyrhizus</i> (Malaysia)	<i>Hylocereus Undatus</i> (Brazil)	<i>Hylocereus polyrhizus</i> (Malaysia)	White Hirehalli (variety)	Andaman (variety)	Red Hiriyur (variety)	Gujarat (variety)	Long (variety)	Kegwada (variety)
Moisture (g 100 g ⁻¹)	89.98	82.5-83.00	86.03	85.5	84.8±0.9	84.3±0.7	84.8±0.2	83.9±0.7	84.7±0.3	82.4±1.9
Ash (g 100 g ⁻¹)	1.19	Nd	Nd	0.54	0.794±0.2	0.838	0.706±0.1	0.704±0.1	0.823	0.775±0.1
Carbohydrate (g 100 g ⁻¹)	8.42	Nd	10.79	12.97	6.26±0.29	7.32±0.30	5.97±0.32	5.91±0.22	5.42±0.18	6.04±1.07
Fat (g 100 g ⁻¹)	nd	0.21-0.61	0.6	nd	nd	nd	Nd	Nd	nd	Nd
Protein (g 100 g ⁻¹)	0.41	0.159-0.229	2.27	1.45	0.938 ± 0.1	1.11±0.1	0.887	0.898±0.1	1.00±0.1	1.08
Energy (Kcal 100 g ⁻¹)	35.36	Nd	67.7	62.95	nd	nd	Nd	nd	nd	Nd
Crude fibre (g 100 g ⁻¹)	nd	0.70-0.90	0.7	nd	0.829±0.1	0.806±0.1	1.018±0.1	1.125±0.1	0.967±0.1	0.985±0.2
Total Sugar (g 100 g ⁻¹)	nd	Nd	5.92	nd	6.06±0.26	7.06±0.29	5.60±0.37	5.50±0.31	5.13±0.20	5.57±1.12
Vitamin A (mg 100 g ⁻¹)	0.89	Nd	0.01	0.085	nd	nd	Nd	nd	nd	Nd
Vitamin C (mg 100 g ⁻¹)	0.03	8.00-9.00	0.84	0.024	nd	nd	Nd	nd	nd	Nd
Iron (mg 100 g ⁻¹)	0.03	Nd	Nd	0.30	nd	nd	Nd	nd	nd	Nd
Magnesium (mg 100 g ⁻¹)	13.70	Nd	38.9	26.40	nd	nd	Nd	nd	nd	Nd
Potassium (mg 100 g ⁻¹)	437.35	Nd	3.09	nd	nd	nd	Nd	nd	nd	Nd
Phosphorus (mg 100 g ⁻¹)	nd	Nd	0.003	nd	nd	nd	Nd	nd	nd	Nd
Zinc (mg 100 g ⁻¹)	0.40	Nd	0.35	nd	nd	nd	Nd	nd	nd	Nd
Calcium (mg 100 g ⁻¹)	1.55	Nd	10.2	nd	nd	nd	Nd	nd	nd	Nd
Amino Acid (mg 100 g ⁻¹)	nd	Nd	Nd	nd	32.9±5.1	29.2±3.2	35.4±6.0	35.1±2.0	36.8±4.3	28.1±4.5
Betalains (mg 100 g ⁻¹)	nd	Nd	Nd	nd	nd	nd	20.4±1.9	20.9±1.2	21.4±2.2	23.0±0.6
Reference	Thi-Thuy-Hai Luu <i>et al.</i> , 2021 ^[12] And Ramli and Rahmat 2014	Thi-Thuy-Hai Luu <i>et al.</i> , 2021 ^[12] and Ruzainah <i>et al.</i> 2009	Thi-Thuy-Hai Luu <i>et al.</i> , 2021 ^[12] And Ramli and Rahmat 2014	Thi-Thuy-Hai Luu <i>et al.</i> , 2021 ^[12] And Jerônimo <i>et al.</i> 2015	M.Arivalagan <i>et al.</i> , 2021	M.Arivalagan <i>et al.</i> , 2021	M.Arivalagan <i>et al.</i> , 2021	M.Arivalagan <i>et al.</i> , 2021	M.Arivalagan <i>et al.</i> , 2021	M.Arivalagan <i>et al.</i> , 2021

FW-Fresh weight

nd – no data

The Nutraceutical activities of Dragon fruit-

Dragon fruit is rich source of minerals which also includes the vitamin C, vitamin A, vitamin B, fats, carbohydrates, antioxidants, flavonoids, betacyanin's, polyphenols, carotene iron and Phyto albumins which have high antioxidant properties (Pandya Prutha Hitendraprasad et al., 2020)^[6].

Antioxidant activity

The natural antioxidant substrates exploitation in medicinal plants has a major influence on cellular damage by the free radicals which has major involve in major diseases like cancer is increased (Thi-Thuy-Hai Luu et al., 2021)^[12]. The peel of dragon fruit peel is high in the flavonoids even compared to the meat, the dragon fruit as well as peel is extracted through the ethanol because of its distinct capacities of different oxidants (Pandya Prutha Hitendraprasad et al., 2020)^[6]. The vitamin C so, called the ascorbic acid has contribution for the antioxidative properties which acts as a reductant to protect cellular components from oxidative damage because ascorbic acid acts as scavenger for free radicals and is oxygen derived species in case of hydrogen peroxide, singlet oxygen and hydroxyl radical during their process oxidation (Mahan Mahesh et al., 2021)^[14]. There were many studies undergone, Nurliyana et al., (2010) had specially on two species *H. polyrhizus*,

H. undatus and found higher radical scavenging activity in both species' peel compared to the dragon fruit pulp (Thi-Thuy-Hai Luu et al., 2021)^[12]. Later (Md. Farid Hossain et al., 2020)^[21] had the same result of antioxidant activity having higher antioxidant activity of the peel compared the antioxidant activity of the pulp. The leftover discarded peel has high concentration of antioxidative compounds, nutrients, rich in fibers and bioactive compounds (Thi-Thuy-Hai Luu et al., 2021)^[12]. Betalain has high antioxidant activity which inhibits the lipid peroxidation and heme decomposition required at low concentration of betalain and counteract to the lipoperoxidases which may damage the gastrointestinal cells while the process of food digestion (W. S. Choo 2019). According to Ezzah Abd Manan et al., (2019) total phenolic content, antioxidant capacity and total flavonoid content were determined from the *H. polyrhizus* pulp water extract and resulted with pharmaceutical and nutraceutical uses. Dragon fruit has strong antioxidant properties, with high antioxidants, high phenolic content, flavonoids betalain, and ascorbic acid so, it is exhibiting a high potential nutritive natural agent which drive away cancer, hypertension, atherosclerosis, diabetes, Parkinson's disease, and inflammation (Thi-Thuy-Hai Luu et al., 2021)^[12]. Some of the antioxidant activity and its functional use are flavonoids (present in red flesh) helps in reducing the risk of heart diseases as the flavonoids directly act on the brain cells and the blood vessels. Linoleic acid and Linolenic acid lower the triglycerides and risk of cardiovascular disorders as the dragon fruit seeds contains high amount polyunsaturated fats (omega-3 and omega-6 fatty acids). Betalains (present in the fresh pulp) helps in suppressing the cancer cells as they can combat oxidative stress. Also helps in weight loss, reduces the LDL cholesterol in the blood, it helps in strengthening Immune system and improves digestive system. Dragon fruit has incredibly good amount of vitamin (present in pulp) which functions against the cough and asthma and stimulates the antioxidants present in the body. Best example is it has played a vital role during pandemic duration. Carotenoids It helps in reducing the risk of cancer and cardio-vascular diseases.

Hydroxycinnamates (hydroxycinnamic acid) help in preventing cancer. Phosphorous and Calcium (minerals) Plays

significant role in tissue formation and reinforces bones as high amount of phosphorous and calcium are present in dragon fruit. Iron (mineral) helps in increasing the hemoglobin and erythrocytes level during pregnancy (Md. Farid Hossain et al., 2021)^[21].

Antimicrobial activity

Every plant has physiological and biochemical resistance to counteract for different pathogens when infection occurs (Thi-Thuy-Hai Luu et al., 2021)^[12]. Zain et al., (2019) recent studies tested the anti-bacterial activity of dragon fruit peel extract, betacyanin's, phenolics, fatty acids, terpenes and tannins can be responsible for the dragon fruit antimicrobial activity (Thi-Thuy-Hai Luu et al., 2021)^[12]. Dragon fruit was undergone study which found that the antibacterial activity of chloroform, ethanol and hexane extract were obtained from *H. undatus* peel. From the result, the exhibited inhibition zone is about 7 to 9 mm against the gram-negative and gram-positive bacteria (Pandya Prutha Hitendraprasad et al., 2020)^[6]. Betalain also plays wide role in mechanism of microbial inhibition, but only specific cellular and molecular mechanism of antimicrobial activity of betalains further should be investigated (W. S. Choo 2019). The stem of *H. polyrhizus* MeOH extract has strong antimicrobial against *S. aureus*, *P. aeruginosa*, *C. albicans*, *Aspergillus niger*, and *F. oxysporum* with inhibition zones 29, 29, 29.5, 17.5, and 29.5 mm and 9.5, 11, 10, 8, and 16.5 mm, respectively, using cup agar and disk diffusion methods, studied by Ismail et al., 2017 (Sabrin Ragab Mohamed Ibrahim et al., 2017)^[21].

Prebiotic activity

The ethanolic extraction of *H. undatus* pulp found that it contains approximately 85% of mixed oligosaccharides, these have higher resistance towards human salivary α -amylase compared to inulin which cannot be digested in stomach, but act as prebiotics (Pandya Prutha Hitendraprasad et al., 2020)^[6]. It assists in the growth of healthy bacteria such as lactobacilli and bifidobacteria which helps in digestion and keeping immune system strong (Pandya Prutha Hitendraprasad et al., 2020)^[6]. It also acts as dietary supplement (Kharunakaran et al. 2019).

Anticancer activity

As we know cancer is been one of the leading death causes in worldwide. Natural anticancer activity constituents have wonderful use in the cancer treatment. The author Hui Luo et al., have made studies on the extraction of cytotoxic activity of dragon fruit which showed the cytotoxic effect against PC3- it is human prostate cancer cell line, Bcap-37 - it is human breast cancer cell line, MGC-803- it is human gastric cancer cell line were studied (Monica Joshi et al., 2019). *H. polyrhizus* has shown better cytotoxic activity than compared to the *H. undatus* on MGC-803 cells which is gastric cancer cell. As a conclusion the dragon fruit peel contains bioactive compounds which has potential to inhibit the cancer cell proliferation includes B16F10, AGS, MCF-7. MGC- 803, PC3, Bcap-37 helps in the morbidity of cancer (Haitao Jiang et al., 2021)^[9].

Anti-diabetic activity

Diabetics is also included in one of the leading deaths causing world widely. It is metabolic disorder which is called as Diabetes mellitus which has natural and herbal treatment

remedies (Monica Joshi *et al.*, 2019). Dragon fruit is to be reported to have phosphodiesterase inhibitory activity which are helps in decreasing the blood glucose levels. Author Ajie *et al.*, (2015) mentioned in his studies flavonoids content helps in decreasing the oxidative stress by the antioxidants effect and inhibits phosphodiesterase which thereby increases the insulin retention (Ajie *et al.*, 2015, Monica Joshi *et al.*, 2019).

Other Nutraceutical activities of Dragon fruit

Dragon fruit has many health-promoting in addition to the bioactivities as well as anxiolytic effect, anti-inflammation activity, antiaging, photoprotective property etc. as follows.

Hypocholesterolemic activity: - *H. polyrhizus* pulp consists of polyphenol content which helps in reducing cholesterol level in the human body and cholesterol like V-LDL and RLP can be reduced (Pandya Prutha Hitendraprasad *et al.*, 2020)^[6]. Specially in the *H. polyrhizus* meat the polyphenol content has anti-thrombotic effect, which enhances the cardio-protective qualities (Mahan Mahesh *et al.*, 2021)^[14].

Hepatoprotective activity

Author Mihir Y Parmar *et al.*, (2019) supported the hepatoprotective potential and the antioxidant potential of the dragon fruit at both histological and enzymatic level. At the enzyme levels of alkaline phosphate, alanine, aspartate aminotransferase and total protein, as well as oxidative stress at such level of malondialdehyde, which reduces glutathione and the superoxide activity dismutase and catalase found to be restored towards the normalizing the extract od dragon fruit, silymarin comparably and dragon fruit even at the highest dose was non-toxic (Thi-Thuy-Hai Luu *et al.*, 2021)^[12].

Anti-Obesity activity

H. costaricensis was mentioned by author Suastuti *et al.*,

(2018) on the anti-obesity activity of methanol flesh extract of the *H. Costaricensis* fed to the rats for experimentation. Sudha *et al.*, (2017) made evaluation on the antioxidants, anti-lipase, and antidiabetic activity in the juice extract of *H. Undatus*. In the result the dragon fruit found the presence of bioactive compounds such as saponin, triterpenoid with high potential uses. The extract of dragon fruit had crude fibers, lipid profile, flavonoids, which can inhibit the adsorption of the intestinal cholesterol (Thi-Thuy-Hai Luu *et al.*, 2021)^[12].

Wound healing activity

Dragon fruit leaves and flowers extract were fed to the wounded-diabetic rat in result the rat had wound healing activity significantly by Suastuti *et al.*, (2018) (Sabrin Ragab Mohamed Ibrahim *et al.*, 2017)^[21]. Whereas these bioactive compounds like hydroxyproline, DNA collagen content, total proteins present in the dragon fruit pulp increase the tensile strength by facilitating the healing activity, it used to be a traditional medicine for the treatment of injuries (Sabrin Ragab Mohamed Ibrahim *et al.*, 2017)^[21].

Ageing activity and Weight loss activity

As we know dragon fruit is reliable source of vitamin E and beta carotenes which acts as inhibitor for the growth of malignant cells. Specially the red dragon fruit helps in preventing premature aging. Dragon fruit is reliable source of fibers, consuming dragon fruit can reduce the fat cells in the body Suastuti *et al.*, (2018).

Food Application

It is observed that dragon fruit demand has been increased in last few years because of its nutritional values and health benefits. It has been playing key role in the food industry and has attention from researchers with the different processed products.

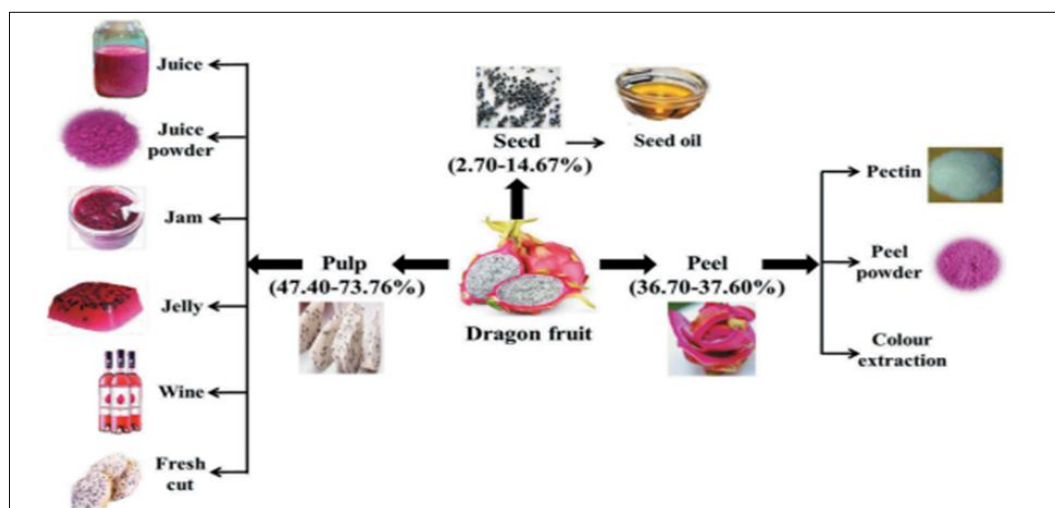


Fig 2: Different processed food products of dragon fruit (Kirti Jalgaonkar *et al.*, 2020).

Dragon fruit Juice

Dragon fruit juice is a high nutritious fruit juice, it is rich in vitamin C and antioxidant activity which are phenolic compounds and betacyanin. Dragon fruit juice is one of the common and important processed product of dragon fruit. As it has higher turbidity and viscosity the clarification is done to obtain the commercial importance and acceptability because consumer prefer low viscous and clear nutritious fruit juice

(Kirti Jalgaonkar *et al.*, 2020). Dragon fruit juice has wider recognition and attractiveness, it also includes other characteristics like retention of nutrients and organoleptic properties with higher shelf-life, the handling ease, and makes juice more valuable product for both the food industry and the consumers with increasing its global availability (Kirti Jalgaonkar *et al.*, 2020).

Fresh cut or minimal processing

The fresh cut of dragon fruit has a limited production because many reasons like storage, shelf life, etc. Later author Goldman *et al.*, mentioned the cut slice can be adhered together and improved storage. Application of edible coating which is suitable for the dragon fruit which are packed in microperforated package, it also maintains the organoleptic and microbiological quality (Kirti Jalgaonkar *et al.*, 2020). Calcium chloride has higher concentration has longer effect on the fresh-cut fruit (Kirti Jalgaonkar *et al.*, 2020).

Dragon fruit Juice powder

Dragon fruit is known for its nutritional composition but it is not available all the seasons so, to make available in all the seasons fruit juice has been introduced (Kirti Jalgaonkar *et al.*, 2020). It has high self-life with good economic value which can be used as functional food by adding it in different processed foods. It is obtained by the process called spray

drying which is most preferred industrial method (Kirti Jalgaonkar *et al.*, 2020). These juice powders have drawback as they have stickiness when obtained so, maltodextrin is used to avoid the stickiness in the fruit powders. The incorporation of dragon fruit powder into different composite foods can increase the nutritional level and can meet any nutritional deficiency if required (Kirti Jalgaonkar *et al.*, 2020).

Dragon fruit wine

As we know wine is being served as traditional drink from our ancient ages. By using the modern technology, the wine processing from fruit pulp of dragon fruit (Kirti Jalgaonkar *et al.*, 2020). The pH of the dragon fruit wine is 4.29 and TS of 23.07°Brix. This juice extracted is fermented with specific yeast in a ferment tank with many layers alternatively arranged with fruits and sugar. It is left for 8 weeks for fermentation and later pasteurized and stored (Kirti Jalgaonkar *et al.*, 2020).

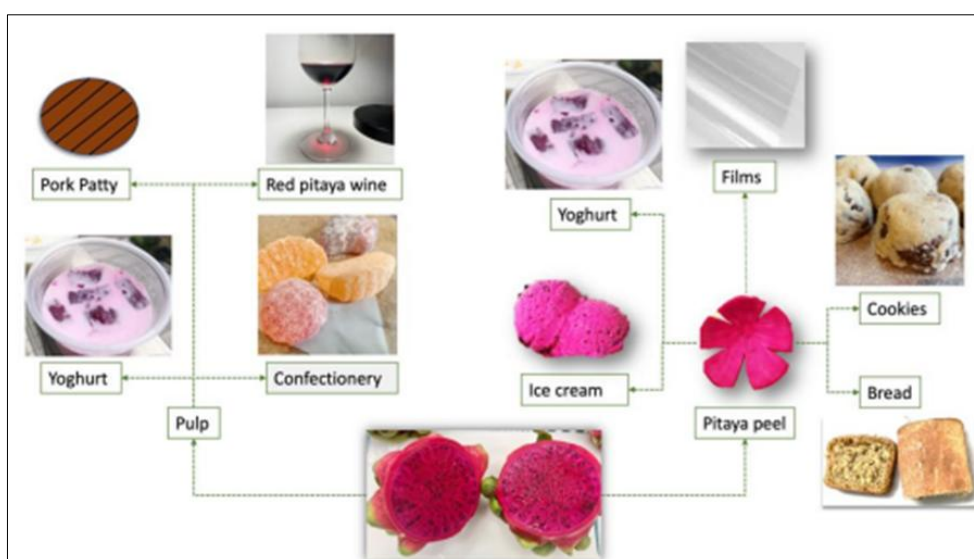


Fig 3: Different food applications of dragon fruit (Yanyi Huang *et al.*, 2020).

Ice cream with dragon fruit

Incorporating the dragon fruit into ice cream is a nice fusion, in which the dragon fruit is homogenized by pulp cut into pieces assessing physiochemical properties that included melting rate, texture, colour, betacyanin content, antioxidant activity and sensory profile (Yanyi Huang *et al.*, 2020). Combined with milk, whipping cream and sugar, beating till getting a homogenized liquid mixture. After the ice cream mix is rest for aging for 4-6 hours under 4 °C in refrigerator. Stabilizer is added and beaten again to incorporate air into it. Finally, it is tested with sensory characteristics of dragon fruit ice cream evaluated (Mahan Mahesh *et al.*, 2021)^[14]. Perera *et al.*, 2013 determined that ice cream with 12% dragon fruit pulp has increased the acceptability that meet the market needs (Mahan Mahesh *et al.*, 2021)^[14]. In ice cream dragon fruit was replaced with fat made from whole milk or skim milk (Lima *et al.*, 2020). It also increased total dietary fibers, protein content, antioxidant capacity in the ice cream and the lipids were decreased which helped in the improving the texture and the overrun of the ice cream. (Lima *et al.*, 2020)^[10].

Dragon fruit Yoghurt

Dragon fruit can be a proper utilization of prebiotic

oligosaccharides and colorant applicant in the dairy product such as, dragon fruit yoghurt, dragon fruit milk. There were many studies made on the nutritional properties and antioxidants present in the yoghurt made with the dragon fruit (Yanyi Huang *et al.*, 2020). In the result, it was shown that the presence of the dragon fruit pulp or flesh can increase the fermentation process with decreasing the Ph of the milk (Yanyi Huang *et al.*, 2020). It enhanced the water holding capacity and had better whey content in yoghurt by the adding of dragon fruit. The author Lima *et al.*, had studied a detail metabolic and potential application on the red- purple dragon fruit it was observed that it did not show much effect on the sensory analysis like aroma. However, it had enhanced the colour and the appearance visually and, in the result, showed that it can be used as a natural enhancing colour quality in the food products and the food industry (Lima *et al.*, 2020)^[10].

Wheat products with dragon fruit

Wheat lays a key role in every food product specially in baked products such as breads, cookies, noodles, and pasta (Yanyi Huang *et al.*, 2020). There are two protein fractions of gluten, glutenin and gliadin whose presence can make wheat flour an elastic dough when it is combined with water so, the dragon fruit is incorporated as it contains dietary fibers in the

traditional wheat-based products. It has been studied because of increased health-conscious consumers (Yanyi Huang *et al.*, 2020). As well it shows the red colour which can be attractive with enrichment of the antioxidant and phenolic acid in dough improves. Both red dragon fruit and white dragon fruit can be used for enriching the bread with physical properties. Moreover, the peel of dragon fruit can be added in the cookies and noodles. It was reported that dragon fruit peel powder has higher beta carotene and flavonoid content compared to the plain wheat noodles in the market (Yanyi Huang *et al.*, 2020).

Confectionery

Confectionery are food products such as hard candies, gummies and marshmallows which are rich in sugars and carbohydrates food products (Sultana S *et al.*, 2018)^[20]. The dragon fruit has high betalains and high oxidant activity which is used as natural colorant in the food application the dragon fruit was incorporated in the confectioneries. It was shown that after the addition of dragon fruit puree it has given a good texture to the gummies and the antioxidant capacity in the gummy confections (Yanyi Huang *et al.*, 2020).

Flower-Based Tea

The fresh flowers were dried at different periods of time. The juice was extracted from the dried flower by boiling water for 2 min, and then the extracted juice was filtered. The filtered juice was supplemented with syrup 65o B, citric acid 1%, liquorice juice 10%, and dragon fruit flavor in various blending ratios and subjected to a panel of 60 people for sensory evaluation to find out the most suitable ratio. To determine the suitable drying temperature and time, the flower was dried at 70-100 °C for 20-50 min. The juice was extracted and measured for absorbance value at 520 nm. To determine the suitable extraction time and raw material: water ratio, the dried flower was submerged in boiled water for 2-7 min and the resulting juice was extracted with water at different ratios. All samples were evaluated for sensory quality (S.M. Dam., 2012)

Meat production

Different meat has different composition and varies in protein content, essential amino acids, and lipids (Yanyi Huang *et al.*, 2020). The major issue that comes in meat production or the meat storage is the meat deterioration which occurs due to the oxidation of lipids leads to the colour change, flavor change, texture, and nutritional changes. So, the natural oxidants from the fruits and vegetables are utilized to extend the shelf life of the meat product and prevents lipid oxidation and the meat spoilage. The author Bellucci reported the addition of dragon fruit powder to the pork patties which helps in the extending shelf-life of the pork patties and prevents the lipid oxidation (Yanyi Huang *et al.*, 2020).

Packing films

Dragon fruit is used as edible coating for the fruits, it increases the shelf-life due to the antioxidant properties present in the dragon fruit. Specially the bioactive compounds betacyanin improves the protein profile (Yanyi Huang *et al.*, 2020). There are many more value-added products that have been processed from dragon fruit for example, Extract of Betacyanin from Fruit Peel Dragon fruit skin (Kirti Jalgaonkar *et al.*, 2020).

Conclusion

This review summarises the exotic fruit which is Dragon fruit belongs to the highly nutritious fruits and most commonly consumed all over the world. Dragon fruit has 18 different species with different nutritional values for each of the fruit present in *Hylocereus* spp. A wide range of minerals and nutrients are present so, it provides phytochemical such as, antioxidant capability, anti-microbial capability, anti-cancer property, anti-aging properties and many other due to this the utilization of dragon fruit is become economically important and nutritional important in recent years. Its nutrition has Nutraceutical parameters helps in the prevention of the nutrition-related illness and enhances the human defence system. There are various Nutraceutical properties such as Antioxidant activity, Anti-diabetic activity, antimicrobial activity, anti-cancer activity, anti-obesity activity, prebiotic activity, and wound healing properties etc. It can be known as house of phytochemicals which enhance the health and economic development. The main dragon fruit products are the juice, fresh cut and many more products for example dragon fruit wine, dairy products (ice cream, milk, fermented milk, yoghurt), dragon fruit bread, dragon fruit chicken nuggets, dragon fruit pork patty and many more products in which the dragon fruit is incorporated for either increasing the shelf-life of product by the antioxidants present in the fruit or to increase the value of the product by adding the dragon fruit. Even the dragon fruit peel is used for the pectin, betalains extraction which are used as natural colorant in the food industry. Dragon fruit has vast use in the food processing industry as well as nutraceutical and cosmetic industries.

References

1. Ajie Bayu Rizky, White Dragon fruit (*Hylocereus undatus*) potential as diabetes mellitus treatment, 2015.
2. Alice Trivelli, Mariella Lucchesini, Antonio Ferrante, Matteo Orlando, Luca Incrocci, Anna Mensuali-Sodi: Pitaya, an Attractive Alternative Crop for Mediterranean Region *Agronomy*. 2020;10(8):1065; <https://doi.org/10.3390/agronomy10081065>.
3. Arivalagan M, Karunakaran G, Roy Dinsha M, Sindhu BC, Shilpashree VM, Satisha GC, *et al.* Biochemical and nutritional characterization of dragon fruit (*Hylocereus* species). *Food Chemistry*. 2021;353:129426. <https://doi.org/10.1016/j.foodchem.2021.129426>.
4. Cheah L, Eid AM, Aziz A, Ariffin FD, Elmahjoubi A, Elmarzugi NA. Phytochemical Properties and Health Benefits of *Hylocereus undatus*. *Nanomedicine & Nanotechnology*. <https://doi.org/10.23880/NNOA-1600010>.
5. Chen R, Luo S, Wang C, Bai H, Lu J, Tian L, *et al.* Effects of ultra-high pressure enzyme extraction on characteristics and functional properties of red Pitaya (*Hylocereus polyrhizus*) peel pectic polysaccharides. *Food Hydrocoll*. 2021;121:107016.
6. Dnyaneshwar PS, Pravinkumar DP, Gurunath VM, Aakshya KS. Potential Use of Dragon Fruit and Taro leaves as functional food: a Review, *European Journal of Engineering Science and Technology*. 2018;1(1):10-20.
7. Edumundo M. Mercado-Silva, Pitaya-*Hylocereus undatus* (Haw), Exotic Fruits, 2018. <https://doi.org/10.1016/B978-0-12-803138-4.00045-9>.
8. Ezzah Abd Manan, Siti Salwa Abd Gani1, Uswatun Hasanah Zaidan, Mohd Izuan Effendi Halmi:

- Characterization of Antioxidant Activities in Red Dragon Fruit (*Hylocereus polyrhizus*) Pulp Water-based Extract, Journal of Advanced Research in Fluid Mechanics and Thermal Sciences. 2019;61(2):170-180.
9. Haitao Jiang, Wanli Zhang, Xiangxin Li, Chang Shu, Weibo Jiang, Jiankang Cao. Nutrition, phytochemical profile, bioactivities, and applications in food industry of pitaya (*Hylocereus* spp.) peels: A comprehensive review. Trends in Food and Technology. 2021, 2022;116:199-217. <https://doi.org/10.1016/j.tifs.2021.06.040>.
 10. Jeronimo MC, Orsine JVC, Borges KK, Novaes MRCG. Chemical and physical-chemical properties, anti-oxidant activity and fatty acids profile of red pitaya [*Hylocereus undatus* (Haw.) Britton & Rose] grown in Brazil. Journal of Drug Metabolism and Toxicology, 2015;6:1-6.
 11. Paa Brodoh K, Asgar Ali, Mthwe Dickinson, Yasmeen Siddiqui, Gianfranco Romanazzi. A review on the management of postharvest anthracnose in dragon fruits caused by *Colletotrichum* spp. Crop Protection. 2020;130:105067. <https://doi.org/10.1016/j.cropro.2019.105067>.
 12. Pandya Prutha Hitendraprasad, Karunakar Hegde Shabaraya AR. *Hylocereus undatus* (Dragon fruit): A Brief Review. Int. J Pharm. Sci. Rev. Res. Article No. 09. 2020 Jan-Feb;60(1):55-57.
 13. Karunakaran G, Arivalagan M. Dragon Fruit - A New Introduction Crop with Promising market. Indian Horticulture. 2019;63(1):8-11.
 14. Kirti Jalgaonkar, Manoj Kumar Mahawar, Bhusan Bibwe, Pankaj Kannaujia. Postharvest Profile, Processing and Waste Utilization of Dragon Fruit (*Hylocereus* Spp.): A Review. Taylor & Francis, 2022. <https://doi.org/10.1080/87559129.2020.1742152>.
 15. Lima ACV, Dionisio AP, de Abreu FAP, da Silva GS, Junior RDL, Magalhães HCR, et al. Microfiltered red-purple pitaya colorant: UPLC-ESI-QTOF-MSE-based metabolic profile and its potential application as a natural food ingredient. Food Chem. 2020;330:127222.
 16. Liu J, Liu S, Wu Q, Gu Y, Kan J, Jin C. Effect of protocatechuic acid incorporation on the physical, mechanical, structural and antioxidant properties of chitosan film. Food Hydrocoll. 2017;73:90-100.
 17. Tamana Perween, Hasan M, Mandal KK. Dragon fruit: An exotic super future fruit of India. Journal of Pharmacognosy and Phytochemistry. 2018; E-ISSN: 2278-4136 P-ISSN: 2349-8234 JPP 2018;7(2):1022-1026
 18. Thi-Thuy-Hai Luu, Truc-Linh Le, Nga Huynh, Pablo Quintela-Alonso Dragon fruit: A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam. Czech Journal of Food Sciences. 2022, 2021;39:(2):71-94. <https://doi.org/10.17221/139/2020-CJFS>.
 19. Madhuri Shrikant Sonawane. Nutritive and medicinal value of dragon fruit. Nutritive and medicinal value of dragon fruit. Asian J Hort. 2017;12(2):267-271. <https://doi.org/10.15740/HAS/TAJH/12.2/267-271>.
 20. Mahan Mahesh, Dr. AR Praveen, Dr. Arun Kumar H. Characterization of Novel (*Hylocereus* Spp.) Dragon Fruit and Their Applications: A Review. International Journal of Research Publication and Reviews. 2021;2(11):1188-1191.
 21. Mercado-Silva E. *Pitaya-Hylocereus undatus* (Haw), 2022. <http://dx.doi.org/10.1016/B978-0-12-803138-4.00045-9>
 22. Md. Farid Hossain, Sharker Md. Numan, Shaheen Akhtar. Cultivation, Nutritional Value and Health Benefits of Dragon Fruit (*Hylocereus* spp.): A Review. International Journal of Horticultural Science and Technology. 2021;8(3):259-269.
 23. Md. Farid Hossa, Sharker Md. Numan, Shaheen Akhtar: Cultivation, nutritional Value and Health Benefits of Dragon Fruit *Hylocereus* spp, International Journal of Horticultural Science and Technolog. 2021;8(3):259-269. <http://dx.doi.org/10.22059/ijhst.2021.311550.400>.
 24. Mihir Parmar Y, Antioxidant and Hepatoprotective Potential of Dragon Fruit Extract in Opposition to Acetaminophen-Induce Liver Smash Up in Rats. <http://dx.doi.org/10.19080/ARGH.2019.12.555846>.
 25. Monica Jhosi, Bala Prabhakar. Phytoconstituents and Pharmaco-therapeutic benefits of Pitaya: A wonder Fruit, 2020. <https://doi.org/10.1111/jfbc.13260>.
 26. Norzaida Yusof, Noranizan Mohd Adzahan, Kharidah Muhammad. Optimization of Spray Drying Parameters for White Dragon Fruit (*Hylocereus undatus*) Juice Powder using Response Surface Methodology (RSM). 2022;5(2):45-56. <http://dx.doi.org/10.37231/myjas.2020.5.2.262>.
 27. Nga Huynh, Thi-Thuy-Hai Luu, Truc-Linh Le, Pablo Quintela-Alonso, Dragon fruit. A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam, Czech J. Food Sci. 2020;39:71-94. <https://doi.org/10.17221/139/2020-CJFS>
 28. Pasko P, Galanty A, Zagrodzki P, Gyu Ku Y, Luksirikul P. Bioactivity and cytotoxicity of different species of pitaya fruits – A comparative study with advanced chemometric analysis. Food Bioscience. 2022, 2021;40:10088. <https://doi.org/10.1016/j.fbio.2021.100888>.
 29. Rao CC, Sasanka VM. Dragon Fruit ‘The Wondrous Fruit’ for the 21st century. Global Journal for Research Analysis. 2015;4(10):261-262.
 30. Santad Wichienchot, Nattha Pansai, Korawan Chakree, Chutha Takahashi Yupanqui, Pritsana Raungrut, Niracha Yanyiam. Gut microbiota modulation and immune boosting properties of prebiotic dragon fruit oligosaccharides, 2019. <https://doi.org/10.1111/ijfs.14230>.
 31. Sultana S, Hossain MM, Zaidul I, Ali ME. Multiplex PCR to discriminate bovine, porcine, and fish DNA in gelatin and confectionery products, 2016.
 32. Sabrin R, Ibrahim M, Gamal Abdallah Mohamed, Amgad Ibrahim Mansour K, Mohamed Fathalla Z, Amal Abd-Elmoneim S. Genus *Hylocereus*: Beneficial phytochemicals, nutritional importance, and biological relevance A review. J Food Biochem. 2017, 2018, e12491. <https://doi.org/10.1111/jfbc.12491>.
 33. Dam SM. Development of different Processed products from edible and inedible parts of the dragon fruit (*Hylocereus undatus*), 2012. ISHS Acta Horticulturac <https://doi.org/10.17660/ActaHortic.2013.989.35>.
 34. Suastuti NGMADA, Bogoriani NW, Putra AAB. Activity of *Hylocereus costaricensis* extract as antiobesity and hypolipidemic of obese rats. International Journal of Pharmaceutical Research & Allied Sciences. 2018;7:201-208.

35. Sudha K, Baskaran D, Ramasamy D, Siddharth M. Evaluation of functional properties of *Hylocereus undatus* (White dragon fruit). *International Journal of Agricultural Science and Research*, 2017;7:451-456.
36. Wichienchot S, Jatupornpipat M, Rastall RA. Oligosaccharides of pitaya (Dragon fruit) flesh and their prebiotic properties. *Food Chemistry*. 2010;120(3):850-857
37. Trivellini A, Lucchesini M, Ferrante A, Massa D, Orlando M, Incrocci L, Mensuali-Sodi A. Pitaya, an Attractive Alternative Crop for Mediterranean Region. *Agronomy* 2020;10(1065).
38. Wong Y, Siow L. Effects of heat, pH, antioxidant, agitation, and light on betacyanin stability using red-fleshed dragon fruit (*Hylocereus polyrhizus*) juice and concentrate as models, 2015. <https://doi.org/0.1007/s13197-014-1362-2>.
39. Choo WS, Yong YY, Dykes G, Lee SM. Biofilm inhibiting activity of betacyanins from red pitahaya (*Hylocereus polyrhizus*) and red spinach (*Amaranthus dubius*) against *Staphylococcus aureus* and *Pseudomonas aeruginosa* biofilms. 2019.126(1):68-78. <https://doi.org/10.1111/jam.14091>.
40. Xuejiao Wu, Xin Liu, Rui Guo, Sen Tian, Xujiao Li, Deshun Li, *et al.* Pectic polysaccharides from purple passion fruit peel: A comprehensive study in macromolecular and conformational characterizations, 2020. <https://doi.org/10.1016/j.carbpol.2019.115406>.
41. Yanyi Huang, Margaret Anne Brennan, Stefan Kasapis, Samantha Richardson J, Charles Stephen Brennan. Maturation process, nutritional profile, Bioactivities and Utilisation in Food Products of Red Pitaya Fruits- A Review, Academic Editor: Eleni Tsantili *Foods*. 2021;10(11):2862. <https://doi.org/10.3390/foods10112862>.
42. Zain NM, Nazeri MA, Azman NA. Assessment on bioactive compounds and the effect of microwave on Pitaya peel. *Jurnal Teknologi*, 2019, 81.