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A REVIEW ON HYLOCEREUS UNDATUS

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Abstract

Hylocereus undatus belonging to the family of Cactaceae. Several species having large edible fruits, which are known as pitayas or dragon fruits. Utilization of dragon fruit in day to day life has great nutritional and commercial importance. It has been in use from time immemorial in traditional system of medicine for relieving constipation and naturally it boots immune system, it also improves eye sight and digestion. The important medicinal properties of white pitaya are antioxidant, anticancer, antimicrobial, wound healing and antidiabetic activity. The present review deals with general and chemical profile and its economic importance including medicinal and other uses.

Introduction

According to World Health Organization [WHO] more than 80% of the world's population, mostly in developing countries depends on traditional plant based medicines for their primary healthcare needs [1]. Use of plants for treating various ailments of both man and animal is as old practice as man himself. These plants are widely used by all sections of the society whether directly as folk remedies or indirectly as pharmaceutical preparation of modern medicine [2]. In recent times, focus on plant research has increased all over the world and a large body of evidence has collected to show immense potential of medicinal plants used in various traditional systems [Ayurveda, Siddha and Unani] [3] and also major source of biodynamic compounds of therapeutic values [4]. Hylocereus undatus is typically most cultivated vine cactus belonging to the family of Cactaceae, [5] better known as "Dragon Fruit", it is with bright red skin studded with green scales and white flesh with tiny black seeds. The flower is so beautiful that is nick named as "Nobel women" or "Queen of the night" and become interest subject to many researchers mainly due to its unique taste, shape and the flesh colour [6]. There are three species of pitaya that have been commercialized, namely Hylocereus polyrhizus, Hylocereus undatus and Hylocereus megalanthus [7-10].

From the centre of its origin, dragon fruit spread to tropical and sub-tropical America, Asia, Australia and the Middle East. It is cultivated in at least 22 countries of the tropics, such as, Australia, Cambodia, China, Israel, Japan, Nicaragua, Peru, Philippines, Spain, Sri Lanka, Taiwan, Thailand, South Western USA and Vietnam etc. [11]. It contains large amount of moisture content [85.30%], protein [1.10 g], fats [0.57 g] and fiber [11.34 g]. Besides, vitamin C and minerals such as calcium phosphorus, magnesium and sodium are present in this species. The glucose, fructose and sucrose present in the fruit were about 64.3-104.3, 40.1-64.9 and 5.47.5 mg/g, respectively [12]. Plants of this family are able to tolerate extreme heat and cold in addition to dry periods and low-nutrient soils. The structure of these plants present stem modification for water storage, reduction or the absence of leaves, surfaces coated with natural waxes and night time stomata opening to absorb carbon dioxide [CAM metabolism], which allows the plants to tolerate the most difficult conditions [13].

White Pitaya is a nutritious fruit with variety of uses. The most valuable and commonly used edible part of the fruit is pulp which constitutes 70-80 % of the ripe fruit and its flavour sometimes similar to kiwi fruit. It is widely used in fruit salads at restaurants [14]. Young stems of H. undatus are edible as well as fresh flower buds that are eaten as vegetables, while dried ones are used for homemade medicine. The peel can be used to produce colouring pigments, and the mucilage used in food or cosmetics industries. Dragon fruit plants are grown as ornamentals for their large, attractive flowers and as bonsai specimens.

Etymology

Greek "hyle" - wood, matter, **Latin** "cereus" - waxen, **Latin** "undatus" - wavy edges.

History

According to the literature- Pitaya fruits date back to the 13th century. It is believed that the fruit was introduced to Vietnam by the French and today, the average yield per hectare is 20-25 tonnes.

In pre-Columbian times, *H. undatus* became widespread in many tropical regions of the Americas and the Caribbean through dispersal by birds and by people propagating and cultivating the species for its edible fruits. It was introduced into the Philippines by the Spanish in the sixteenth century.

In Hawaii, there is a locally famous cactus hedge on a lava rock wall of the Punahou School in Honolulu, the hedge of Kapunahou [15]. In 1836, Mrs. Bingham planted the hedge [16] of Hylocereus undatus, the famed cactus known in Hawaii as paninio kapunahou. People used to come in the evenings from all over the island to see them blooming and "borrow" some cuttings so that now they have this species all over.

In South Africa, it was introduced into the country as an ornamental, has category to invasive status, i.e., it can be grown in gardens but only with a permit [which is granted under very few circumstances]. Infestations, which tend to be limited and localized, and originate mainly from escapes from homestead gardens, impact native plant communities and the local ecology. [23, 24]

Malaysia is another region where you are sure to find the dragon fruit. It was first introduced in 1999 in the Sitiawan, Johor and Kuala Pilah regions. Colombia and Nicaragua are other places where pitahaya fruit is grown for commercial purposes.

These regions attest to the fact that Pitaya cactus fruit requires a warm climate thus prospers well in semi-arid areas. Planting the fruit has very high prospects since it's industrially used in juices, making wine and flavorings, not forgetting its medicinal value which a lot of people have grown to trust.

H. undatus is becoming widely naturalized in eastern Australia where it is regarded as an environmental weed of open woodlands, dry rain forest, riparian areas and coastal vegetation in the warmer areas. It has been recorded in south-eastern and central Queensland and in the coastal districts of northern New South Wales; it appears on local weed lists in Byron Shire in northern New South Wales and Redland Shire in south-eastern Queensland. It is usually found growing on trees as a climber or epiphyte, and can even climb up into the canopy of very tall trees where it can form massive colonies; the weight of its succulent stems can eventually bring trees down. [25]

Taxonomy Classification [5, 17]

Domain	Eukarya
Kingdom	Plantae (plants)
Sub kingdom	Trachebionta (vascular plants)
Sub division	Spermatophyta (seed plants)
Division	Magnoliophyta (Flowering plants)

Class	Magnoliopsida (dicotyledons)
Order	Caryophyllales
Family	Cactaceae (Cactus family)
Sub family	Cactoideae
Tribe	Hylocereae
Genus	Hylocereus (A. Berger)Britton & Rose
Species	Hylocereus undatus(Haw.) Britton & Rose

Synonyms

- Cereus guatemalensis (Eichler) A.Berger
- C. tricostatus Rol.-Goss
- C. undatus Pfeiff
- C. undulatus D.Dietr
- Hylocereus tricostatus (Gosselin) Britton & Rose.

Common Names [18- 22]

Pitaya, Dragon fruit, Night blooming Cereus, Strawberry Pear, Belle of the Night, Cinderella Plant, Jesus in the Cradle, Queen of the night

Origin and Distribution

H. undatus, is native to Brazil, Colombia, Costa Rica, Curacao, Ecuador, El Salvador, Guatemala, Mexico, Panama, Venezuela and Uruguay. Although native to the Central and South American regions, it is now commercially cultivated and widely distributed in many countries with tropical and subtropical climates, including the USA [south Florida, California and Hawaii], Australia, Taiwan, Vietnam, Malaysia and Israel.

Degener tells how this species reached Hawaii in 1830 in a shipment of plants loaded at a Mexican port aboard a ship en route from Boston to Canton, China. He says most of the plants died and were being discarded during a stopover in Hawaii, but the Captain noticed that the white pitaya was still partly alive. Cuttings were planted and flourished and the cactus became a common ornamental in the islands. It blooms there spectacularly but rarely sets fruit. This species is often used as a rootstock on which to graft various ornamental cacti including *Zygocactus, Epiphyllum* and *Rhipsalis.* It blooms and fruits mainly in August and September.

Habitat

H. undatus is a lithophyte or hemi-epiphyte tolerant of shade and, due to crassulacean acid metabolism, resistant to drought [26]. Nothing is known about its native habitat, but it is most likely to be lowland tropical deciduous forest. Naturalized populations are found in tropical deciduous forest, tropical semi deciduous forest, riparian vegetation, thorn scrub and thorn forest [27]. It is also found in disturbed areas, rocky areas, roadsides and maritime scrub. [28]. In Mexico it has been found in highly heterogeneous environments, ranging from 2 to 2750 m above sea level, with annual rainfall ranging from 340 to 3500 mm and annual mean temperature ranging from 13° to 29°C [29]. In eastern Australia it can be found invading open woodlands, dry rainforest, riparian areas and coastal vegetation in the warmer areas [30].

Cultivation

The dragon fruit is promisingly a new crop. India has great potential for its cultivation in semiarid tracts. Dragon fruit can be propagated either through sexual method of seeds or through asexual method of stem cutting and grafting. The seedlings are ready for field planting within 9-10 months. The fruit and stem characteristics are variable due to cross pollination and the seedlings grow very slowly. The easiest, cheapest and convenient method of vegetative propagation in dragon fruit is stem cutting. The plants propagated through stem cuttings starts flowering within 12-18 months after planting. If the dragon fruit crop is propagated through stem cuttings, either the entire stem segment or 15-60 cm long stem cuttings are used. Limited availability and high cost of dragon fruit planting material, has generated interest in use of small cuttings for asexual propagation, for easy transport and to reduce the cost of production. On the other hand, sexual propagation dragon fruit through seeds is very important in breeding programs. Hot water treatment of seeds at 60 ^{o}C for 10 min is also improve the germination and early growth of Dialiumguineense [wild] seed while chilling treatment of dragon fruit seeds also promote the seed germination through leakage of intracellular electrolytes from tissues as a result of cytoplasmic membrane damage. IBA treatment can initiate rooting positively on stem cuttings and also increase the rooting percentage and the other characteristics stem cuttings [31,32].

Morphology

Hylocereus undatus is a sprawling or vining, terrestrial or epiphytic cactus. They climb by use of aerial roots and can reach a height 10 meters or more growing on rocks and trees. Hylocereus undatus [Dragon fruit] plant morphology consists of roots, stems, thorns, flowers, and fruit.

Roots:

- Roots of dragon fruit are aerial and hairy roots growing in the soil on top of the plant.

Stem:

- Green 3-winged, from a few cm up to 5 m long [in mature plants], 4 to 7.5 cm margins undulate and horny wide with wings that are 2, 5 to 5 cm wide. Stem is triangular in shape, prickly very short and inconspicuous, so often considered "spineless cactus".

Spines:

- 1 to 3 conical spines up to 1 cm long [but usually about 2-3 mm long].

Flowers:

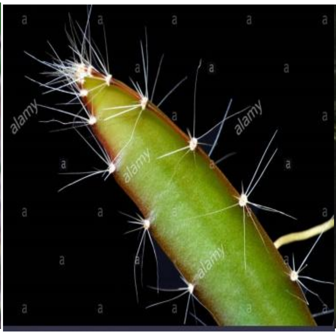
- Flowers are ornate, fragrant and beautiful 25-35 cm long by 30 cm across, white with green outer tepals and bracts.

Flowering:

- The flowers bloom in the early evening when the flower buds are measuring about 30 cm. Outer petals cream-colored, bloom about nine o'clock, and then followed by the crown in the white section, which includes a number of yellow stamens. Flowers like funnel was finally fully open at midnight, because the dragon fruit is known as night blooming cereus. When in full bloom, drag on fruit spreads a fragrance. This scent to lure bats, dragon fruit that pollinate flowers

Fruit:

- Flowers develop into fruit does not fall out. Dragon fruit is round slightly oval shape with a size of an avocado. Bright red fruit leather for the kind of white and red dragon fruit, red dragon fruit is dark to black, and yellow to yellow dragon fruit. All over his skin was filled with tassels are analogous with dragon scales. Therefore, this fruit called dragon fruit.


Aerial Roots **Stem with spines** **Flower**

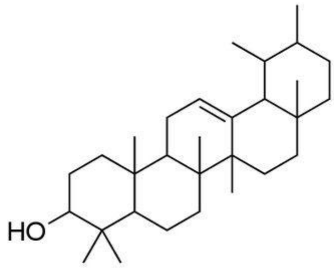


Bud **Fruit**

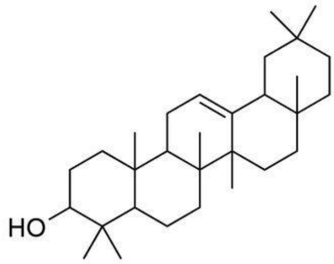
Chemical Constituents

The chemical constituents present in Hylocereus undatus are Phenolic compounds lke β-amyrin[23.39%], B-sitosterol[2.46%], γ-sitosterol[19.32%], and octadecane[9.25%], Heptacosane[5.52%], campesterol[5.27%], nonacosane[5.02%], and trichloroacetic acid, hexadecyl ester [5.21%], Quercetin, Isorhamnetin, Squalne[0.64%]. Fatty acids like Palmetic acid [12.632%], Palmetoleic acid [0.355%], Oleic acid [4.442%], linoleic acid [0.138%], Arachidic acid [0.923%], Oraganic acids [1.72%] constitute of Oelic acid[0.8%], citric acid [0.08%], Malic acid[0.64%], Succenic acid [0.19%], and Fumaric acid [0.01%][320. Sugars constitute of reducing sugars like glucose [30 to 55 g/L] and fructose [4 to 20 g/L]. Sucrose is also detected, at a rate of 2.8 to 7.5% of the total sugars [33].

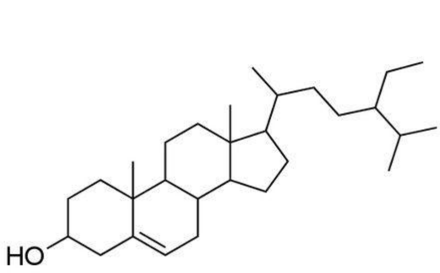
Carbohydrates constitute of Pectin [10.8%], Starch [11.1%], Cellulose [9.255], Lignin [37.2%], Fiber [69.3%]. Proteins and amino acids [1g/100g], Vitamin B1[0.28-0.30mg/100g], Vitamin B2[0.043-0.045 mg/100g], Vitamin B3[1.27-1.300 mg/100g], Vitamin B6,Vitain A[0.005-0.012 mg/100g], and Vitamin C[8-9 mg/100g] and minerals like copper, iron, calcium, magnesium, Lead, Cobalt, Phosphorus, Manganese, Nickel, Sodium and Chrome and Alkaloids, Terpenoids, Steroids, Flavanoids, Tannins and Saponins,.[32]



α-Amyrin



β-Amyrin



γ-Sitosterol

Nutritional Constituents

The typical nutritional values per 100 g of raw pitaya [of which 55 g are edible] are as follows:

• Water 80-90 g

• Ascorbic acid [Vitamin C] 4–25 mg

• Ash 0.4-0.7 g

• Calcium 6–10 mg

• Calories: 35-50

• Carbohydrates 9-14 g

• Carotene [Vitamin A] traces

• Fat 0.1-0.6 g

• Fiber 0.3-0.9 g

• Iron 0.3-0.7 mg Niacin [Vitamin B3] 0.2-0.45 mg

• Phosphorus 16 – 36 mg

• Protein 0.15-0.5 g

• Thiamine [Vitamin B1] traces

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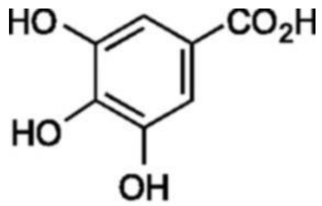
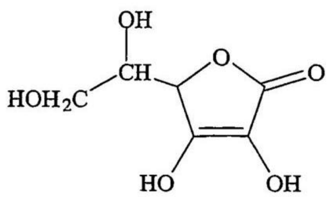


gallic acid (GA)



Ascorbic Acid

Riboflavin [Vitamin B2] traces

Pharmacological Properties

Anti-oxidant activity:

Reactive oxygen species [ROS] for instance hydroxyl radicals, superoxide anion and hydrogen peroxide are known to cause damage to the vital molecules in the body such as DNA, leading to cell death and tissue injuries [33-36]. Therefore, antioxidants such as polyphenols, tocopherols and flavonoids play a vital role in inhibiting or delaying the oxidation of the cellular constituents [33,34,37,38]. High total phenolic content [TPC] in the fruit is usually correlated with high radical scavenging activity [39-41]. Previous studies showed that polyphenols are the main antioxidant compounds in Hylocereus species. These compounds terminated radical chain by acting as a reducing agent that donates electrons to the free radicals [33, 36, 40]. Besides, their singlet oxygen quencher properties and metal chelating ability make them a good antioxidant [40, 42]. On the other hand, betacyanins and flavonoids such as kaempferol, quercetin and isorhamnetin that possessed radical scavenging and metal chelating property [40, 42] are also found in the flesh of H. undatus [43]. Peel and flesh of Hylocereus species were proposed to have different antioxidant capacities [33]. In a research where the peel and flesh of H. polyrhizus and H. undatus were extracted using 70% ethanol, it was found that H. undatus peel showed the highest 2,2-diphenyl-1-picrylhydrazyl [DPPH] radical scavenging activity of 87.02±2.24% at the concentration of 1.0 mg/mL, followed by H. polyrhizus peel [83.48±1.02%]. H. polyrhizus flesh showed lower radical scavenging activity of 27.45±5.03% and H. undatus flesh had the least scavenging activity [16.56±2.96%]. The DPPH radical scavenging ability of the samples tested was closely correlated with their TPC. As such, H. undatus peel showed to possess the highest TPC [36.12 mg of gallic acid equivalents [GAE] /100g], followed by H. polyrhizus peel [28.16 mg of GAE/100g], H. polyrhizus flesh [19.72 mg of GAE/100g] and lastly H. undatus flesh [3.75 mg of GAE/100g] [33]. These showed that high TPC leads to a stronger antioxidant activity. Generally the peel of the pitaya was found to have greater antioxidative capacity as compared to the flesh. This might be due to the presence of different bioactive compounds in the peel and flesh. Previous study showed that polyphenolic compounds were found in both the peel and flesh [44] but flavonoids were present mostly in the peel. On the other hand, non-flavonoid compounds were found abundant in the flesh [33, 38, 41].

These may suggest that the variation in flavonoid content in the different fruit parts caused the difference in the antioxidant activities. The flesh of H. polyrhizus was found to have greater TPC as compared to H.

undatus [37, 33,45]. This is because H. polyrhizus with red flesh contained more phenolic compounds and betacyanin, therefore contributed to the higher antioxidant activity. In contrast, H. undatus with white flesh contained the non-betalainscompounds, therefore the TPC was relatively lesser than the H. polyrhizus[33, 47]. Besides DPPH radical scavenging activity, the antioxidant effect of pitaya was evaluated by metal ion chelating assay. The chelating effects ranged from 18.00 to 36.06% at 0.2 mg/mL of the extracts tested, with the peel of H. undatus showed the greatest chelating effects [33]. However, these chelating effects were considered as rather weak. Hence, the antioxidant compounds in Hylocereus species were good in radical scavenging activity but not the metal chelating ability. Solvent used in the extraction process might affect the antioxidant activity of a sample. In a study conducted by Wu et al. [38], the bioactive compounds of peel and flesh of H. polyrhizus were extracted by 80% acetone. Results showed that TPC of the peel and flesh were 39.7±5.39 and 42.4±0.04 mg of GAE/100g, respectively; and these results were not correlated with the previous studies [33]. The higher TPC detected in the study might be partially attributed to the presence of betacyanin, which also contributed to the total phenolics. Betacyanin contents were 13.8±0.85 and 10.3±0.22 mg of betanin equivalents/100g in the peel and flesh of H. polyrhizus, respectively. Moreover, Chavan and Amarowicz[47] showed that acetone-water system extracted considerably higher amounts of phenolic compounds from beach pea than the ethanol-water systems, suggesting acetone might be able to extract more phenolic compounds in pitaya than ethanol; and this might contribute to the high TPC in the acetoneextracted samples. The TPC of samples detected in the study was correlated with their antioxidant abilities. From the DPPH radical scavenging assay, half maximal effective concentrations [EC50] of peel and flesh were determined as 118±4.12 and 22.4±0.29 µmol vitamin C equivalent/g dried extract, respectively. The results indicated better antioxidant property of peel extract than the flesh due to its slightly higher polyphenolic content. Another antioxidant assay, the 2,2'-azinobis-3ethylbenzothiazoline-6-sulfonic acid [ABTS] radical scavenging assay also showed that the peel extract was a better antioxidant compared to flesh [39]. Sub-fractionation method provided higher values of polyphenolic contents and hence the technique was applied to the extracts from red pitaya peel and flesh [37]. The fractionated peel and flesh extracts showed greater DPPH radical scavenging activity [805.1±1.2 and 999.8±1.4 µmoltrolox equivalents [TE]/100 g fresh weight, respectively] compared to the nonfractionated samples, which were only 95.2±1.2 and 166.4±1.1 µmol TE/100g fresh weight, respectively. Among the fractions tested, fractions contained betacyanins showed the greater DPPH radical scavenging activity. The TPC in the peel [645.6 mg±1.0/100 g fresh weight] was found approximately 10 times higher than the flesh [78.1 mg±1.4/100 g fresh weight] in these betacyanin-containing fractions. Hence, the reducing capacity of the peel fraction was higher as determined by ferric reducing antioxidant power [FRAP] test [37]. All in all, H. polyrhizus exhibited greater antioxidant effects when the active compounds were sub-fractionated, as compared to the conventional non-fractionated method. This is because sub-fractionation of compounds reduced the number of phytochemical classes in a single fraction and thus minimizing potential interferences during the test. The antioxidant property of pitaya was comparable to a few commonly consumed fruits. A research was performed to compare the radical scavenging activity of 95% ethanol peel extract of H. undatus with seven types of fruits that can be easily found, namely Punicagranatum[pomegranate], Nepheliumlappaceum[rambutan], Garcintamangostana[mangosteen], Musa sapientum[banana], Cocosmucifera[coconut], Passiflorafoetida [passion fruit] and Lansiumdomesticum[long-gong]. It was found that the half maximal inhibitory concentration [IC50] for radical scavenging activity of H. undatus [0.084±0.016 mg/mL] was higher than pomegranate, rambutan, mangosteen, banana and coconut, in which their IC50 were ranged from 0.003±0.002 to 0.047±0.005 mg/mL. However, passion fruit [0.104±0.014 mg/mL] and long-gong [1.290±0.001 mg/mL] showed weaker radical scavenging activity as compared to H. undatus [48]. In short, Hylocereus species possess promising antioxidant properties which provides health benefits to human. However, the antioxidant contents vary when different extraction methods are used. The geographical area that the fruit is cultivated may also cause the different antioxidant activity [7].

Anticancer Property:

The anticancer properties of Hylocereus species were recently studied. Several evidences showed that polyphenols, flavonoids and betanins that present in the Hylocereus species are responsible for the anticancer effects [39, 49, 50]. H. undatus peel extracted by ethanol-water [50:50, v/v] solvent system showed anti-proliferative activity towards human hepatocellular carcinoma cell line [HepG2] in a dose dependent manner and it recorded an IC50 at 21.81±0.01 mg/mL after 48 hours of incubation. Polyphenols were believed to be the main phytochemical compound for such effect, although the exact compound was yet to be identified [49]. The polyphenols acted through scavenging nitric oxide [NO] free radicals [51] that promoted tumor vascularization and metastasis. Compounds that inhibited NO might be considered as potential anticancer agents. On the other hand, the presence of C2C3 double bond and three adjacent hydroxyl groups in the flavonoids was suggested to be crucial for anticancer effects [52]. Betacyanins that have similar molecular structure as flavonoids were proposed to have the similar anti-cancer effects [39]. The H. undatus extract also exerted anti-cancer effects on other cells. Significant decrease in cell viability was noted when human breast cancer cells [MCF-7] were pre-treated with various concentrations [0-600 µg/mL] of H. undatus ethanolic flesh extract. To be more specific, H. undatus extract inhibited MCF-7 cell growth by approximately 85% at 600µg/mL [50]. Another in vitro anti-proliferative study on melanoma cell [B16F10] suggested that the peel and flesh of H. polyrhizus that extracted with 80% acetone inhibited the cancer cell growth in a dosedependent manner. The peel extract showed stronger effect, in which the EC50 was recorded as 10.00 µg of GAE, while the EC50 value was not detected in the flesh extract. These results suggest that the higher TPC in peel might contribute to the anticancer effects [33, 39]. The peel of H. polyrhizus and H. undatus prepared via supercritical carbon dioxide extraction demonstrated good cytotoxic effects against human prostate cancer [PC3], human breast cancer [Bcap-37] and human gastric cancer [MGC-803] cell lines in a dose-dependent manner. H. polyrhizus showed lowest IC50 value of 0.43 mg/mL in MGC-803, whereas H. undatus demonstrated lowest IC50 [0.47 mg/mL] in Bcap-37 cell line [53]. A few bioactive compounds were found in these extract. These include β-amyrin that was previously found to promote cytotoxic effects against several cancer cell lines [54-56], βsitosterol and stigmast-4-en-3-one. β-Amyrin was found in the peel extract of both Hylocereus species while β-sitosterol and stigmast-4-en-3-one were found in the H. polyrhizus peel extract. The β-sitosterol and stigmast-4-en-3-one inhibited the growth of MGC803 cells at IC50 of 43.8±0.63 and 56.9±0.81 µM, respectively. The present findings concluded that the bioactive compounds that contributed to the anticancer effects were β-amyrin, β-sitosterol and stigmast-4-en-3-one, in which β-sitosterol exhibited the greatest effects [53].

The exact anticancer mechanism exerted by Hylocereus species is still unknown. However, previous researches reported that the anti-cancer effects of polyphenol might be mediated through suppression of nuclear factor-κB and growth factor receptor-mediated pathway; cell cycle arrest and apoptosis induction; inhibition of angiogenesis and mitogen-activated protein kinases; as well as antioxidant and anti-inflammatory mechanisms [47, 57-60].

Hypocholestrolemic Effect:

Polyphenol contents in H. polyrhizus flesh were proven to be able to reduce cholesterol level in the body [61-62]. Generally, ROS or free radicals in the body interact with lipid leading to the formation of lipid peroxidase. The lipid peroxidase in turn causes the oxidation of low-density lipoprotein [LDL] that interacts with platelet to develop into foam cells. Formation of foam cells increases the rate of atherosclerosis [57, 62, 63]. Polyphenols were found to be able to aid in the prevention of lipid peroxidation and LDL oxidation; hence reducing the risk of cardiac-related diseases [57, 62-64]. Polyphenols also possessed anti-thrombotic effects which further enhanced its cardio-protective properties [57]. Previous research showed that feeding of diluted freeze-dried H. polyrhizus flesh for 5 weeks in hypercholesterolemic rats reduced total cholesterol, triglyceride as well as LDL levels and increased highdensity lipoprotein [HDL]. Reduction in total cholesterol was found the highest in the rats fed with 1.17% of pitaya[from 3.448 to 1.412 mmol/L], followed by 0.83% of pitaya[from 3.435 to 1.487 mmol/L] and lastly 0.5% of pitaya[from 3.356 to 1.707 mmol/L]. Rats fed with 1.17% pitaya showed significant reduction in triglyceride and LDL levels by 59.52% and 39.06%, respectively. On the other hand, increment in HDL level was found to be ranged from 19.31% to 34.42% [61]. Another in vivo study demonstrated the relationship between polyphenol and other antioxidant contents of H. polyrhizus with dyslipidemia in hypercholestrolemic rats. Pitaya flesh was heated at 95°C for 30 minutes [Pit95] and 105°C for 60 minutes [Pit105]. The hypercholestrolemic rats were fed with fresh or the thermal-processed samples. It was demonstrated that the TPC and radical scavenging activity were significantly reduced and the ability to regulate lipid profile was dropped when the H. polyrhizus extracts were exposed to heat. In this study, decrease in LDL and total cholesterol levels were only seen in rats fed with fresh flesh extract. Interestingly, the triglyceride level was the same for the rats treated with fresh or thermal-processed flesh. Although the decline in total cholesterol and LDL levels were not significant in both Pit95 and Pit105 groups, it was discovered that Pit95 showed greater hypocholesterolemic effects compared to Pit105. Overall, the results corroborated the idea that the efficiency of cardioprotective effect of H. polyrhizus is associated with its antioxidant properties. The serum lipid level shown an overall decrease when the radical scavenging strength and polyphenol contents were reduced [62, 65]. PUFA, particularly linoleic acids make up the essential fatty acids that are required but not synthesized by the human body [66]. Numerous researches have proven that consumption of these essential fatty acids is able to counter the increase of cholesterol, specifically the LDL level. Consumption of PUFA also reduces the risk of cardiac-related diseases, especially when it acts as a substitution for saturated fatty acids [66-73]. Research has been carried out to investigate the composition of fatty acids in H. polyrhizus seeds and results showed that 50.8±0.53% of seeds oil consisted of PUFA, in which the linoleic acid [49.6±0.33%] comprised the largest proportion, followed by minute amount of linolenic acid [1.21±0.20%]. A total of 25.6±0.88% of monounsaturated fatty acids [MUFA] that contained mostly oleic acid [21.6±0.53], cisvaccenic acid [3.14±0.30%] and palmitoleic acid [0.91±0.05%] were also detected in the seed oil. Besides, 23.6±1.41% of saturated fatty acids [SFA] was discovered and it was dominated by palmitic acid [17.9±0.53%]. Composition of fatty acids in H. undatus was also being studied, and the results suggested higher PUFA [51.1±0.45%], higher MUFA [27.2±0.25%] and lower SFA [21.7±1.03%] in H. undatus [74]. These observations were in line with other studies, in which the ratio of fatty acids content in pitaya shown in this study was found to be similar with the other studies [45, 52, 53]. Another study was conducted to compare the fatty acids composition in H. polyrhizus, H. undatus and H. megalanthus seed oil. The results showed that the PUFA composition is the highest in H. megalanthus, followed by H. undatus and H. polyrhizus. The MUFA content was higher than SFA in H. polyrhizus and H. undatus. The fatty acid content was found the lowest in H. megalanthus[75].

Prebiotic Effect:

Prebiotics are non-digestible oligosaccharides that are beneficially affect the host by stimulating the growth of normal flora in the colon [76]. Several studies showed that prebiotics provide protective effects against colon cancer and reduce the tendency of inflammation-associated bowel diseases. Growth of microflora in the colon for instance lactobacilli and bifidobacteria prevents the invasion of pathogenic bacteria into the gastrointestinal tract, hence promoting healthy digestive system [77]. The mixed oligosaccharides content in the H. undatus ethanolic flesh extract was detected as approximately 85%. These oligosaccharides had higher resistance towards the human salivary αamylase compared to inulin. The maximum hydrolysis of the samples in α-amylase of increasing pH [4, 5, 6, 7 and 8] were 2.90, 3.08, 3.28, 6.8% and 11.18%, respectively; while the maximum hydrolysis of inulin were 5.72, 8.03, 7.39, 12.32 and 16.22%, respectively. The oligosaccharides also showed higher resistance to the hydrolysis by the artificial human gastric juice. Approximately 50% of the consumed pitaya mixed oligosaccharides would reach the colon despite the hydrolysis by salivary α-amylase [16%], stomach acids [2.5%] and other brush-border enzyme in the small intestine [30%][78]. The mixed oligosaccharides in pitaya also promoted the growth of good bacteria such as Lactobacillus delbrueckii and Bifidobacteriumbifidium. The microbial count of L. delbrueckii and B. bifidium increased from 9.02x107 to 6.17x109 and 1.70x108 to 2.22x109 cell/mL, respectively when using extracts obtained from H. undatus as carbon sources [78].

Antimicrobial Property:

The antibacterial activity of ethanol, chloroform and hexane extracts from H. polyrhizus and H. undatus peel was studied. From the disc diffusion assay results, both of the Hylocereus species exhibited inhibition zone of about 7 to 9 mm against Grampositive[Staphylococcus aureus, Bacillis cereus, Listeria monocytogenes, and Enterococcufaecalis] and Gram-negative [Escherichia coli, Salmonelatyphimurium, Yersinia enterocolitica and Klebsiellapnuemoniae] bacteria. Result of the minimum inhibitory concentration showed that all extracts inhibited the growth of bacteria in the range of 1.2510.00 mg/mL [79]. Interestingly, Camphylobacterjejuni was found resistant towards all the extracts tested except for H. undatus chloroform extract. C. jejuni is a highly pathogenic bacteria with the cell wall composed of lipopolysaccahrides that are broken down to secrete enterotoxins [80]. It is readily penetrating the gastrointestinal mucus [81] and causing the onset of gastroenteritis [82]. As such, chloroform extract of H. undatus that was able to inhibit the growth of the bacteria showing a great potential as an antimicrobial agent. Overall, chloroform extract of both H. polyrhizus and H. undatus peel showed the most potent antibacterial activity [79].

Anti parkinson’s activity:

The anti parkinson’s activity was present in the Ethanolic extract of the Hylocereus undatus fruit pulp which has high amounts of flavonoids, amino acids and alkaloids was recently studied. The activity was performed in mice and the results showed that they have this activity.

Laxative activity:

It was studied in some recent studies that the ethanolic extract of the fruit pulp of Hylocereus undatus shows laxative activity. The study was conducted on mice by nuber, and weight of faecal matter.

Wound Healing Property:

Aqueous extracts of leaves, rind, fruit pulp and flowers of *Hylocereus undatus* were studied for their wound healing properties. Wound healing effects were studied on incision [skin breaking strength], excision [percent wound contraction] and the nature of wound granulation tissues, which were removed on day 7 and the collagen, hexosamine, total proteins and DNA contents were determined, in addition to the rates of wound contraction and the period of epithelialization. In streptozotocin diabetic rats, where healing is delayed, topical applications of *H. undatus* produced increases in hydroxyproline, tensile strength, total proteins, DNA collagen content and better epithelization thereby facilitating healing.[83]

Other Uses

- Dragon fruit boosts immune system. Dragon fruit is rich in vitamin C and fibres that help provide an overall healthy body. [84, 85]
- Dragon fruit promotes healing of wounds and cuts.
- Dragon fruit improves eye sight.
- Dragon fruit helps for digestion. Because of the richness in fibres, Dragon fruit aids in the digestion of food, Studies also suggest that Dragon fruit promotes the growth of probiotics.[86, 87]
- Dragon fruit help to lower blood glucose levels in type 2 diabetes. Studies also suggest that the glucose found in Dragon fruit aids in controlling the blood sugar level for diabetes patients. [88]
- Dragon fruit helps to control cholesterol level. Dragon fruit is also rich in flavonoids that are known to have favourable effects against cardio related disease.
- Dragon fruit is also rich in flavonoids that act against cardio related, also dragon fruit aids to treat bleeding problems of vaginal discharge. [89]

Toxicity of Pitaya

Toxicological studies are particularly relevant to help prove the safety of foods and ingredients, since they contribute to the identification of potential adverse effects; definition of exposure conditions required to produce these effects; evaluation of dose-response relationship for adverse effects, including the definition of doses that do not produce such effects and interpretation of experimental data for risk assessment, like information on the mode of action and its relevance to humans, as well as data on metabolism and toxicity, extending the results from animals to humans [90]. According to Hor et al. [2012], there is little information on toxicity studies related to the safe exposure of pitaya fruit. In this context, the potential toxicity of the methanolic extract from this fruit was assessed by acute and subchronic administration in rats. In the study on acute toxicity, single doses of fruit extract [1250, 2500 and 5000 mg/kg] were administered for rats by oral gavage, and animals were then monitored for 14 days. In the study of subchronic toxicity, pitaya extract was also administered orally to rats at doses of 1250, 2500 and 5000 mg/kg/day for 28 days. The authors neither observed mortality, nor signs of acute or subchronic toxicity, nor significant difference in body weight, organ weight or hematologic parameters in subchronic study. No abnormalities of internal organs were observed between the treatment and control groups, and the lethal oral extract of pitaya was determined to be higher than 5000 mg/kg, and doses with no observable adverse effects of the extract for male and female rats was considered to be 5000 mg/kg per day for 28 days.[91]

In studies carried out by Luo et al. [2014], the authors used the MTT assay [3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyltetrazolium bromide] to determine the cytotoxic activity of the supercritical carbon dioxide extract obtained by gas chromatography mass spectrometry of the H. polyrhizus and H. undatus bark in tumor cell line human prostate cancer cell line [PC3], human breast cancer cell line [Bcap-37] and human gastric cancer cell line [MGC-803]. The authors used Adriamycin [ADM] as positive control and after 72 h of contact with the pitaya extracts of cells, dose-dependent inhibition of cell proliferation was observed.

Conclusion

White Pitaya is a promising source of alternative medicine that might serve as antioxidant, anticancer, hypocholestrolemic, antimicrobial, Anti parkinson’s, Constipation as well as prebiotic agent. However, further studies on identification, purification and quantification of bioactive compounds from pitaya are necessary; and determination of its mechanism of action should be conducted to gain a better view on the fruit’s medicinal properties. It is widely used in various traditional system of medicine as a medicine. It has been used since centuries as a food and a component of drugs. Further works n this fruit may provide a wide variety of benefits.

References

1. Gland I. No Title: Guidelines on the conservation of medicinal plants. WHO, IUCN. 1993.
2. Uniyal B. No Title: Utilization of medicinal plants by the rural women of Kulu. Indian J TradKnowl., 2(4): 366–70
3. Dahanukar SA, Kulkarni AR RN. No Title: Pharmacology of medicinal plants and natural products. Indian J Pharmacol, 2000; 32: S81–118.

4. HarshaVH ,Hebbar SS, Hegde GR S V. No Title: Ethnomedical knowledge of plants used by Kunabi tribe of Karnataka in India. Fitoterapia, 2002; 73(4): 281–7.
5. Britton NL, Rose JN (1937) The Cactaceae: Descriptions and illustrations of plants of the cactus family. The Carnegie Institution of Washington U S A 2: 1-334.
6. Mizrahi Y, Nerd A, Nobel PS (1997) Cacti as crops. Hort Rev 18: 291-319.
7. Nurul SR, Asmah R. Variability in nutritional composition and phytochemicals properties of red pitaya (Hylocereus polyrhizus) from Malaysia and Australia. Int Food Res J. 2014; 21(4): 1689-97.
8. Lim TK. H. polyrhizus. In: Edible medicinal and nonmedicinal plants. 1st edition. Springer; 2012; p. 643-48.
9. Lim TK. H. undatus. In: Edible medicinal and non-medicinal plants. 1st edition. Springer; 2012; p. 650-55.
10. Lim TK. H. megalanthus. In: Edible medicinal and nonmedicinal plants. 1st edition. Springer; 2012; p. 640-42.
11. Mizrahi, Y and A. Nerd. 1999. Climbing and columnar cacti: New arid land fruit crops. In: Janick, J. (ed) Perspective on new crops and new uses. ASHS press, American Society of Horticultural Science, Alexandria, Verginia: 358-366.
12. Lim TK. H. undatus. In: Edible medicinal and non-medicinal plants. 1st edition. Springer; 2012; p. 650-55.
13. Marenco RA, Lopes NF (2011). Fisiologia Vegetal. 3:486.
14. Luders, L. (2004). The pitaya or Dragon fruit (Hylocereus undatus), Agnote 778 No. D 42, Nothern Territory of Australia.
15. Staples, G.W. &Herbst, D.R. 2005. A tropical garden flora. Bishop Museum Press,Honolulu. 908 pp
16. Donald Fitzgerald, 1991. Pearl Harbor, the Army Corps of Engineers, and Punahou's Cereus Hedge., The Hawaiian Journal of History, vol. 25
17. USDA/NRCS (2015) Hylocereus undatus (Haw.) Britton & Rose - nightblooming cactus. The PLANT Database.
18. IPGRI, (2006). Fruits from America. An ethnobotanical inventory, International plant genetic Resources Institute, Rome.

19. (2002) Hylocereus undatus (Haw.) Brit. & Rose. Institute for Systematic Botany, USA.
20. USDA (2005), National Genetic resources program. Germplas Resources Information Network (GRAIN). United States Department of Agriculture, Agriculture research service (online).
21. Zee, F., Yen, C.R. and Nishani, M.(2004). Pitaya (Dragon Fruit, Strawberry pear). Cooperative Extension service, College of Tropical Agriculture and Human resources, University of Hawaii at Manoa, Honololu, Hawaii.
22. www.toptropicals.com
23. Walters M, Figueiredo E, Crouch NR, Winter PJD, Smith GF, Zimmermann HG, Mashope BK, 2011. Naturalised and invasive succulents of southern Africa. Abc Taxa, 11:359 pp.
24. Invasive Species South Africa, 2015. Night blooming cereus. http://www.invasives.org.za/invasive-species/item/671-night-blooming-cereus-hylocereus-undatus.html
25. Queensland Government, 2011. Night-blooming cactus, Hylocereus undatus. Edition. http://keyserver.lucidcentral.org/weeds/data/080c0106-040c-4508-8300-0b0a06060e01/media/html/Hylocereus_undatus.html
26. Andrade RA, Martins ABG, Silva MTH, 2007. Influence of the material source and the cicatrize time in vegetative propagation of red dragon fruit (Hylocereus undatus). RevistaBrasileira de Fruticultura, 29(1):183-186.
27. Arias Montes S, Gama Lopez S, Guzman Cruz LU, 1997. Flora of the Tehuacan-Cuicatlan Valley. Part 14. Cactaceae A. Juss (Flora del Valle de Tehuacan-Cuicatlan. Fasciculo 14. Cactaceae A. Juss). Mexico DF, Mexico: Instituto de Biologia, UNAM, 146 pp.
28. Taylor NP, Zappi DC, 2004. Cacti of eastern Brazil. Kew, UK: Royal Botanic Gardens, 644 pp.
29. Cali de Dios H, 2004. Geographical distribution of pitahayas(Hylocereus) in Mexico (Distribuciongeografica de laspitahayas (Hylocereus) en la RepublicaMeicana.) Cactaceas y SuculentasMeicanas. 49(1):4-23.
30. Queensland Government, 2011. Night-blooming cactus, Hylocereus undatus. Weeds of Australia, Biosecurity Queensland Edition. http://keyserver.lucidcentral.org/weeds/data/080c0106-040c-4508-8300-0b0a06060e01/media/html/Hylocereus_undatus.html

31. Dr. C. ChandrasekharaRao, V.MrunaliniSasanka. Dragon Fruit – “The Wondrous Fruit” – for the 21st century. Volume-4, Issue-10, Oct-2015 • ISSN No 2277 – 8160.
32. Jamilah B. et al. Physico-chemical characteristics of red pitaya (Hylocereus polyrhizus) peel. International Food Research Journal. 2011, 18: 279-286.
33. Le Bellec et al. Pitahaya (Hylocereus spp.): a new fruit crop, a market with a future. Fruits. 2006, 61(4):237-250.
34. Vaillant F, Perez A, Davila I, Dornier M, Reynes M. Colorant and antioxidant properties of red-purple pitahaya. Fruits. 2005; 60(1): 3-12.
35. Kamarul Rahim k. Antioxidant study of pulps and peels of dragon fruits: a comparative study. Int Food Res J. 2010; 17: 367-75. 20. Khurana S, Piche M, Hollingsworth A, Venkataraman K, Tai TC. Oxidative stress and cardiovascular health: therapeutic potential of polyphenols. Can J PhysiolPharmacol. 2013; 91(3): 198-212.
36. Silva JP, Gomes AC, Coutinho OP. Oxidative DNA damage protection and repair by polyphenolic compound in PC12 cells. Eur J Pharmacol. 2008; 601(1-3): 50-60.
37. Tenore GC, Novellino E, Basile A. Nutraceutical potential and antioxidant benefits of red pitaya (Hylocereus polyrhizus) extracts. J Funct Foods; 2012. 4(1): 129-36.
38. Wu LC, Hsu HW, Chen YC, Chiu CC, Lin YI, Ho JA. Antioxidant and antiproliferation activities of red pitaya. Food Chem. 2005; 95(2): 319-27.
39. Luo H, Cai Y, Peng Z, Liu T, Yang S. Chemical composition and in vitro evaluation of the cytotoxic and antioxidant activities of supercritical carbon dioxide extracts of pitaya (dragon fruit) peel. Chem Cent J. 2014; 8: 1.
40. Santhakumar AB, Bulmer AC, Singh I. A review of the mechanism and effectiveness of dietary polyphenols in reducing oxidative stress and thrombotic risk. J Hum Nutr Diet. 2014; 27: 1-21.
41. Paixao N, Peresterlo R, Marques JC, Camara JS. Relationship between antioxidant capacity and total phenolic content of red, rose and white wines. 2007; 105(1): 204-14.
42. Omidizadeh A, MohdYusof R, Ismail A, Roohinejad S, Nateghi L, Abu Bakar MZ. Cardioprotective compounds of red pitaya (Hylocereus polyrhizus) fruit. J Food Agri Environ. 2011; 9(3&4): 152-6.
43. Angaji SA. Antioxidants: a few key points. Ann Biol Res; 2012. 3(8): 3968-77

44. Ahmad I, Beg AZ. Antimicrobial and phytochemical studies on 45 Indian medicinal plants against multi-drug resistance human pathogens. J Ethnopharmacology. 2011; 74(20): 113-23.
45. Wojdylo A, Osmianski J, Czemerys R. Antioxidant activity and phenolic compounds in 32 selected herbs. Food Chem. 2007; 105(3): 940-9.
46. Patricia E, Stintzing FC, Carle R. Phenolic compound profiles and their corresponding antioxidant capacity of purple pitaya (Hylocereus sp.) genotype. Z Naturforsch C. 2007; 62(9-10): 636-44.
47. Chavan UD, Amarowicz R. Effect of various solvent systems on extraction of phenolics, tannins and sugars from beach pea (Lathyrusmaritimus L.). Int Food Res J. 2013; 20(3): 1139-44.
48. Okonogi S, Duangrat C, Anuchpreeda S, Tachakittirungrod S, Chowwanapoonpohn S. Comparison of antioxidant capacities and cytotoxicities of certain fruit peels. Food Chem. 2007; 103(3): 839-46.
49. Li F, Li S, Li H, Deng G, Ling W, Wu S, Xu X, Chen F. Antiproliferative activity of peel, pulps and seeds of 61 fruits. J Funct Food. 2013; 5(3): 1298-1309.
50. Jayakumar R, Kanthimathi MS. Inhibitory effects of fruit extracts on nitric oxide induced proliferation in MCF-7 cells. Food Chem. 2011; 126(3): 956-60.
51. Jeong JH, Jung H, Lee SR, Hwang KT, Kim TY. Antioxidant, anti-proliferative and anti-inflammatory activities of the extracts from black raspberry fruits and wine. Food Chem. 2010; 123(2): 338-44.
52. Martínez C, Yàñez J, Vicente V, Alcaraz M, Benavente-García O, Castillo J, et al. Effects of several polyhydroxylated flavonoids on the growth of B16F10 melanoma and Melan-a melanocyte cell lines: influence of the sequential oxidation state of the flavonoid skeleton. Melanoma Res. 2003; 13(1): 39.
53. Luo H, Cai Y, Peng Z, Liu T, Yang S. Chemical composition and in vitro evaluation of the cytotoxic and antioxidant activities of supercritical carbon dioxide extracts of pitaya (dragon fruit) peel. Chem Cent J. 2014; 8: 1.
54. Thao NTP, Hung TM, Lee MK, Kim JC, Min BS, Bae K. Triterpenoids from Camellia japonica and their cytotoxic activity. Chem Pharm Bull. 2010; 58: 121–4.
55. Lin L, Gao Q, Cui C, Zhao H, Fu L, Chen L, et al. Isolation and identification of ent-kaurane-type diterpenoids from Rabdosiaserra (MAXIM.) HARA leaf and their inhibitory activities against HepG-2, MCF-7, and HL-60 cell lines. Food Chem. 2012; 131:1009–14.

56. Habsah M, Ali AM, Lajis NH, Sukari MA, Yap YH, Kikuzaki H, et al. Antitumour-promoting and cytotoxic constituents of Etlineraelatior. Malays J Med Sci. 2005; 12: 6–12.
57. Santhakumar AB, Bulmer AC, Singh I. A review of the mechanism and effectiveness of dietary polyphenols in reducing oxidative stress and thrombotic risk. J Hum Nutr Diet. 2014; 27: 1-21.
58. Fresco P, Borges F, Diniz C, Margues MP. New insights on the anticancer properties of dietary polyphenols. Med Res Rev. 2006; 26(6): 747-66.
59. Khan HY, Zubair H, Ullah MF, Ahmad A, Hadi SM. Oral administration of copper to rat leads to increased lymphocyte cellular DNA degradation by dietary polyphenols: implication for a cancer preventive mechanism. Biometals. 2011; 24(6): 1169-78.
60. Sharif T, Auger C, Bronner C, Alhosin M, Klein T, EtienneSelloum N, et al. Selective proapoptotic activity of polyphenols from red wine on teratocarcinoma cell, a model of cancer stemlike cell. Invest New Drugs. 2011; 29(2): 239-47.
61. Khalili MA, Norhayati AH, Rokiah MY, Asmah R, SitiMuskinah M, Abdul Manaf A. Hypocholestrolemia effects of red pitaya (Hylocereus sp.) on hypercholestrolemic-induced rat. Int Food Res J. 2009; 16: 431-40.
62. Omidizadeh A, MohdYusof R, Ismail A, Roohinejad S, Nateghi L, Abu Bakar MZ. Cardioprotective compounds of red pitaya (Hylocereus polyrhizus) fruit. J Food Agri Environ. 2011; 9(3&4): 152-6.
63. Annuzzi G, Bozzetto L, Costabile G, Giacco R, Mangione A, Anniballi G, et al. Diet naturally rich in polyphenols improve fasting and postprandial dyslipidemia and reduce oxidative stress: a randomized controlled trial. Am J ClinNutr. 2013; 99: 463-71.
64. Wybraniec S, Platzner I, Geresh S, Gottlieb HE, Haimberg M, Mogilnitzki M, et al. Betacyanins from vine cactus Hylocereus polyrhizus. Phytochem. 2001; 58(8): 1209-12.
65. Liaotrakoon W, Clereq ND, Hoed VV, Walle DV, Lewille B, Dewettinck K. Impact of thermal treatment on physiochemical, antioxidant and rheological properties of white-flesh and redflesh dragon fruit (Hylocereus spp.) purees. Food Bioprocess Technol. 2013; 6(2): 416-30.
66. Liaotrakoon W, Clercq ND, Hoed VV, Dewettinck K. Dragon fruit (Hylocereus spp.) seed oils: their characterization and stability under storage conditions. J Am Oil Chem Soc. 2012; 90(2): 207-15.

67. Mozzaffarian D, Micha R, Wallace S. Effects in coronary heart disease of increasing polyunsaturated fats in place of saturated fat: a systemic review and meta-analysis of randomized controlled trials. PLoS Med. 2010; 7(3): e1000252.

68. Akobsen MU, Reilly EJO, Heitmann BL, Pereira MA, Balter K, Fraser GE, et al. Major types of dietary fat and risk of coronary heart disease: a pooled analysis of 11 cohort studies. Am J ClinNutr. 2009; 89(5): 1435-32.

69. Harris WS. Linoleic acid and coronary heart disease. Prostaglandin, Leukotrienes and Essential Fatty Acids (PLEFA). 2008; 79(3-5): 169-71.

70. Patty W, Siri-Tarino, Qi S, Frank B, Ronald M. Saturated fatty acids and risk of coronary heart disease: modulation by replacement nutrients. Current Atherosclerosis Reports. 2010; 12(6): 384-90.

71. Patty W, Siri-Tarino, Qi S, Frank B, Ronald M. Saturated fat, carbohydrate and cardiovascular disease. Am J ClinNutr. 2010; 91(3): 502-9.

72. Ramsden CE, Zamora D, Lee BS, Majchrzak-Hong SF, Faurot KR, Suchindram CM, et al. Use of dietary linoleic acid for secondary prevention of coronary heart disease and death: evaluation of recovered data from the Sydney diet heart study and updated meta-analysis. BMJ. 2013; 346: e8707.

73. Rui H, Zhang L, Li Z, Pan Y. Extraction and characteristic of seed kernel oil from white pitaya. J Food Eng. 2009; 93(4): 482-6.

74. Ariffin AA, Bakar J, Tan CP, Abdul Rahman R. Essential fatty acids of pitaya (dragon fruit) seed oil. Food chem. 2009; 114(2): 561-4.

75. Chemah TC, Aminah A, Noriham A, Wan Aida WM. Determination of pitaya seeds as a natural antioxidant and source of essential fatty acids. Int Food Res J. 2010; 17: 100310.

76. Gibson GR, Probert HM, Loo JV, Rastall RA, Roberfroid MB. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. Nutr Res Rev. 2004; 17(2): 259-75.

77. Slavin J. Fiber and prebiotics: Mechanism and health benefits. Nutrients. 2013; 5(4): 1417-35.

78. Wichienchot S, Jatupornpipat M, Rastall RA. Oligosaccharides of pitaya (dragon fruit) flesh and their prebiotic properties. Food Chem. 2010; 120(3): 850-7.

79. Nurmahani MM, Osman A, Abdul Hamid A, MohamadGhazali F, Pak Dek MS. Antibacterial property of Hylocereus polyrhizus and Hylocereus undatus peel extract. Int Food Res J. 2012; 19(1): 77-84.

80. Skirrow MB. Diseases due to Campylobacter, Helicobacter and related bacteria. J Comparative Pathol. 1994; 111(2): 11349.
81. Wallis MR. The pathogenesis of Campylobacter jejuni. Br J Biomed Sci. 1994, 51: 57–64.
82. Hani EK, Chan VL. 1995. Expression and characterisation of Campylobacter jejunibenzolglycineamidohydrolase (hippuricase) gene in Escherichia coli. J Bacteriology. 1995; 177: 2396-402.
83. Perez G RM, Vargas S R, Ortiz H YD (2005) Wound healing properties of Hylocereus undatus on diabetic rats. Phytother Res 19(8): 665-668.
84. Duarte TL, Lunec J (2005) Review: When is an antioxidant not an antioxidant? A review of novel actions and reactions of vitamin C. Free Radic Res 39(7): 671-686.
85. Ruzlan, Nurliyana, Syed O I, Syed Z I, Koya, (2010) Antioxidant study of pulps and peels of dragon fruits: a comparative study. Journal of International Food Research 17(2): 367-375.
86. Lim Y, Lim T, Tee J (2007) Antioxidant properties of several tropical fruits: A comparative study. Food chemistry 103(3): 1003-1008.
87. Jing Tao, GuangQiao, Xiao Peng Wen, Guo Li Gao, Tao Liu, et al. (2014) Characterization of genetic relationship of dragon fruit accessions (Hylocereus spp.) by morphological traits and ISSR markers. Journal of ScientiaHorticulturae 170(2): 82-88.
88. Wee SimChoo, Wee Khing Yong (2011) Antioxidant properties of two species of Hylocereus fruits. Advances in Applied Science Research 2(3): 418-425
89. WijitraLiaotrakoon, Nathalie De Clercq, Vera V H, Davy V W, Benny Lewille, et al. (2013) Impact of Thermal Treatment on Physicochemical, Antioxidative and Rheological Properties of WhiteFlesh and Red-Flesh Dragon Fruit (Hylocereus spp.) Purees. Food and Bioprocess Technology 6(2): 416430.
90. AgênciaNacional de VigilânciaSanitária (ANVISA) (2013). GuiaparaComprovação da Segurança de Alimentos e Ingredientes. 1-37.
91. Hor SY, Ahmad M, Farsi E, Ahmad M, Farsi E, Yam MF, Hashim MA, Lim CP, Sadikun A, Asmawi MZ (2012). Safety assessment of methanol extract of red dragon fruit (Hylocereus polyrhizus): acute and subchronic toxicity studies. Regul. Toxicol. Pharmacol. 63(1):106-14.