



Anthocyanin Fruit Peels and Their Importance

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ABSTRACT

Anthocyanins are colored water-soluble pigments belonging to the group of phenols. Anthocyanins responsible for the colors, red, purple and blue, are found in fruits and vegetables. Fruit peels have gradually gained popularity as scientists have found that the peels in many cases show better biological and pharmacological uses than other parts of the fruit. The aim of this review is to highlight the importance of fruit peel extracts and natural products obtained in the food industry, together with their other potential biological applications, such as apples, plums, pomegranate, dragon fruit, strawberries and grapes.

Keywords: Anthocyanins, Fruits, Peels.

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Received 16 February 2023, Accepted 27 March 2023

Please cite this article as: Swathi P *et al.*, Anthocyanin Fruit Peels and Their Importance. American Journal of Pharmacy & Health Research 2023.

INTRODUCTION

Fruit peels are the primary by-product of the fruit industry, accounting for up to 30% in some variants. Increased fruit production must lead to increased waste production. Therefore, active research is focused on the effective use of fruit peels to solve everyday life and serious problems of humanity. Fruit peels of fruits such as apple, banana and mango contain high amounts of minerals such as calcium, zinc, iron, manganese, etc. (Feumba et al., 2016)¹.





These minerals are essential for human well-being and can be obtained for use in other products. In this context, research on husks as a versatile biomass for water purification is already underway (Mallampati and Valiyaveetil 2013)². For example, banana peels have been shown to remove cadmium contamination (Memon et al. 2008)³. Fruit peels are used in fertilizer formulation (Mercy S 2014)⁴. In addition, fruit peels also contain significant amounts of phenolic compounds that are used in the food and cosmetic industries.









Importance of fruit peels:

Fruit peels are used in many activities those are mentioned below:

- 1) Regulating the blood glucose levels.
- 2) Having anticarcinogenic property.
- 3) To treat wrinkles, discolored skin, and scars.
- 4) Improves digestion.
- 5) Improves respiratory health.
- 6) Weight loss.

Table 1: List of fruits with purple peels

Fruit name	Biological name	Family	Fruit image	Peels image
Apple	<i>Malus domestica</i>	Rosaceae		
Plum	<i>Prunus domestica</i>	Rosaceae		

Pomegranate	<i>Punica granatum</i>	Punicaceae		
Dragon fruit	<i>Hylocereus undatus</i>	Cactaceae		
Strawberry	<i>Fragaria ananasa</i>	Rosaceae		
Black grapes	<i>Vitis vinifera</i>	Vitaceae		

Fruit Name: Apple (*malus domestica*)

Apple is the only fruit that contains high levels of antioxidants. It is an important source of flavonoids and phenols, which are consumed throughout the year. Apple consumption is associated with the prevention of chronic diseases and a lower incidence of cancer (Jakopic et al., 2009)⁵. Apple consumption is also associated with a reduced risk of coronary heart disease in women (Sesso et al., 2003)⁶. The high amount of polyphenol has protective effects against oxidation, tumor formation and cell signaling. More use of apples and their various products in the diet reduces the likelihood of chronic diseases such as cancer, heart disease, asthma and Alzheimer's disease (Hyson, 2011)⁷.

Biological description:

The apple is an ellipsoid to obovoid, globose spike, indented at the base and apex. The fruits are usually larger than 5 cm in diameter weighing 200-350 grams. Fruits vary in color and may be uniformly red, green, or yellow, or bicolored. Bicolored fruit can be striped or reddish on a yellow or green background. Each fruit contains a rind of (edible) pulp between the skin and the

pith line. The central core has a fleshy pith with a papery capsule of five fused carpels. Each carpel usually contains two seeds. The seeds are smooth, shiny and chestnut brown (Jackson, 2003 et, al)⁸.

Collection and cultivation:

Apples are grown throughout the temperate world. Their adaptive range ranges from the extreme cold of places like Siberia and northern China to the much warmer surroundings of Colombia and Indonesia. More than 60 countries produce more than 1,000 metric tons or more of apples, with the leading producers being China, USA, Turkey, Iran, France, Italy, Poland and Russia. World production now exceeds 57,000 million metric tons (FAOSTAT, 2004)

Phytochemical constituents:

Apples contain a large concentration of flavonoids, as well as a number of other phytochemicals, and the concentration of these phytochemicals can depend on many factors, such as the apple cultivar. Some of the best-studied antioxidant compounds in apples include quercetin-3-galactoside, quercetin-3-glucoside, quercetin-3-rhamnoside, catechin, epicatechin, procyanidin, cyanidine-3-galactoside, coumaric acid, chlorogenic acid, gallic acid, and phloretin. researchers examined the average concentrations of major phenolic compounds in six apple cultivars. They found that the average phenolic concentrations among the six cultivars were quercetin glycosides, 13.2 mg/100 g fruit; vitamin C, 12.8 mg/100 g of fruit; procyanidin B, 9.35 mg/100 g fruit; chlorogenic acid, 9.02mg/100g fruit; epicatechin, 8.65 mg/100 g fruit; and phloretin glycosides, 5.59 mg/100 g fruit (Leek et al., 2003).

Pharmacological actions:**Antioxidant:**

The antioxidant capacity of whole fruit, skin, pulp and centre was determined by the FRAP (ferric reducing ability of plasma) method. Golden delicious has the highest phenol content (408 mg / fruit) compared to Fuji (194 mg / fruit) and Gala (162 mg / fruit). This results in Golden Delicious having antioxidant capacities of 2.5 and 3.6 times higher than those found in Fuji and Gala. Consumption of apple pulp can provide 48–78% antioxidant capacity (Ribeiro et al., 2014)⁹.

Anti-Obesity:

The results of research conducted on adult male Wistar rats gave an inhibitory effect of supplementation with apple pectin molecule on obesity. The phytochemical effects of apple viz pectin against the oxidative effects of a high-fat diet observed. The study results stated TBARS concentration in the liver, kidney, and blood serum of mice that received a high-fat diet, and

simultaneously apple pectin (HFD + Pec) decreased by 20%, 29%, and 19%, Tests carried out in this study were carried out on a total of 28 adult male Wistar rats weighing 230 10 g. Thin young apple polysaccharide (TYAP) has been investigated in high fat diet (HFD) induced fat rat due to its effect on metabolic disorders. Administration of TYAP at doses of 400 mg/kg/day and 800mg/kg/day significantly saved HFD induced hepatic metabolic disorders, reduced weight gain, and improved liver oxidative stress caused by HFD. The results of this study suggest that TYAP is successful in lowering obesity-related hepatic metabolic disorders, possibly by activating hepatic mitochondrial respiratory function (Oliveira, .M et al.,2003)This study is to encourage women's weight loss at a rate of 1 kg/month. After 12weeks of weight loss, results obtained 1.21kg. A decrease in blood glucose was also observed for women who consumed fruit (5.2 mg / dL, P 0.02) (Zeng X et al.,. 2019).

Cardiovascular activity:

The effect of a dietary supplement of 20% of three Portuguese apple cultivars containing different concentrations of phenolics and fibre on the serum lipid profile and OXLDL of male Wistar rats fed a cholesterol-enriched diet (2%) was evaluated (Serra et al., 2012). After 30 days, it was able to significantly reduce serum triglyceride levels, total and LDL cholesterol concentrations (27.2%, 21.0% and 20.4% reductions, respectively, relative to the cholesterol-enriched diet group). OXLDL levels were also significantly improved by consumption of this apple variety (20.0% and 11.9% reduction) relative to the cholesterol-enriched diet group and the control group, as well as Mala Serra apples (9.8% reduction) relative to the cholesterol-enriched diet group. Atherosclerotic effects of apple polyphenols and fibre on ants were investigated (Auclair et al., (2008)¹⁰.

Anti cancer:

The study was conducted to assess the likely resistance effect of apple polyphenols, with particular attention to colon carcinogenic anthocyanin, retarding (or) reducing the occurrence of various precancer markers. Colorectal cancer (CRC) is the fourth cancer with the most recent cases reported in 2018 worldwide. In addition to flavonoids, apples also contain anthocyanins, especially cyanidin-3-O-galactose (Cy3Gal). This research shows the effects of apple polyphenols and (cy3Gal) on the carcinogenic colon, delaying or reducing the occurrence of various markers of precancers studied.

Treatment of Diabetes:

Not only can apples help reduce the risk of heart disease, cancer, and asthma, but eating apples may also be associated with a lower risk of diabetes. In the previously discussed Finnish study of

10,000 people, a reduced risk of type II diabetes was associated with apple consumption. A higher intake of quercetin, the main component of apple peels, was also associated with a reduced risk of type 2 diabetes. Myricetin and berry intake was also associated with a reduced risk of type 2 diabetes. (Knekt P *et al.*, 2002)¹¹.

Fruit Name: Plum (*Prunus domestica*)

Plums are one of the most important stone fruit crops in the world. Plums also include several well-known stone fruits – apricot, cherry and peach. There are more than 2000 varieties of plum, of which relatively few are of commercial importance (Somogai LP 2005)¹². Plums are an important source of substances that affect human health and prevent many diseases (Stacewicz SM *et al.*, 2000)¹³. Plums contain a number of bioactive compounds such as phenolic acids, anthocyanins, carotenoids, minerals and pectin. For many decades, plums have been used in Indian medicine as a component of natural remedies used in cases of leucorrhoea, irregular menstruation and abortion (Kayano S *et al.*, 2002)¹¹

Biological description:

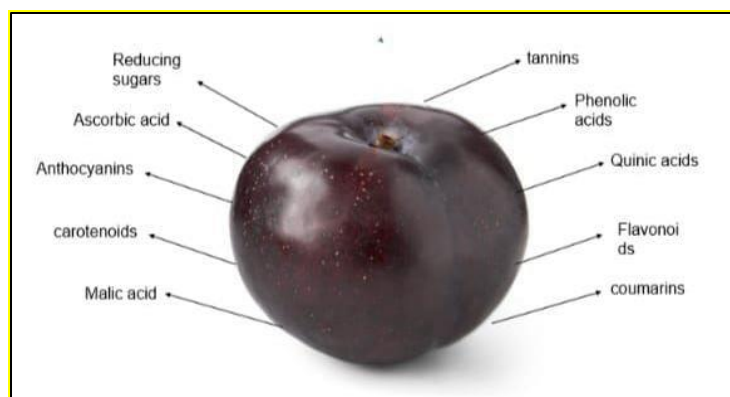
Trees of some plum species reach heights of 6 to 10 meters (20 to 33 ft), while others are much smaller; some species are small shrubs with drooping branches. The flower buds on most varieties are borne on short spurs or along the terminal shoots of the main branches. Each bud can contain one to five flowers, with two or three being the most common, and often create the appearance of densely packed, showy flower clusters when the trees are in full bloom. Each flower is characterized by a hollow cup-like structure known as a hypanthium, which bears the sepals, petals and stamens at the outer edge and surrounds a single pistil. After fertilization, the hypanthium and its appendages fall off and the ovary develops into a drupe. As the fruit grows, the outer part ripens into a fleshy, juicy exterior, and the inner part forms the pith, or stone, that encloses the seed. The fruits show a wide range of size, taste, color and texture. As the trees begin to bear, they do not require much pruning and can be grown satisfactorily in the home orchard if disease and pests are controlled (Potter D *et al.*, 2007)¹⁴.

Collection and cultivation

India produces significant quantities of all leafy fruits including stone fruits (apples and pears) and stone fruits (peaches, plums, apricots and cherries). These are mainly grown in the hills of Uttar Pradesh (U.P.). Plum requires well-permeable moisture-retaining and loamy soil and a sheltered position. The fruits are better in a sunny place. It prefers heavy clay soils and chalk in the soil, but is likely to become chlorotic if present in abundance. The plant grows well at a pH between 6 and 6.5. Plum is widely grown in temperate regions. A sunny south or west wall is

very suitable for most cultivars. Most members of this genus have shallow roots and will develop suckers if the roots are damaged. Plants of this genus are potential hosts of honey fungus (Usmanghani K *et al.* 2007)¹⁵

Phytochemical constituents:



Plum skin consists of anthocyanins, flavonoids, phenolic acids and tannins and it also consists of reducing sugars and vitamin-c like ascorbic acid (Jaiswal R *et al.*,2013)¹⁶

Pharmacological actions:

Plum having different pharmacological activities, those are

Antioxidant activity:

The antioxidant activity of PPE increased with increasing concentration and at the highest tested concentration (8000 $\mu\text{g/ml}$), DPPH inhibition of $92:31 \pm 0:27\%$ was observed, but at the same concentration vitamin C led to $97:44 \pm 0:21\%$ DPPH12 inhibition IC50 values representing the concentration of test compound required for 50% DPPH inhibition were estimated by non-linear regression and determined to be 360.6 $\mu\text{g/ml}$ for PPE and 298 $\mu\text{g/ml}$ for vitamin C (Traore *et al.*, 2021)¹⁷. He reported that the antioxidant activity of black plum peel was almost 3 times higher than that of plum pulp, and IC50 values of plum peel for DPPH inhibition were reported to be in the range of 0.48-0.91 mg/mL. The antioxidant activity and various other bioactive potentials of fruits and their by-products are associated with the presence of various phenolic compounds.

Anti-Cancer activity:

Protection of red blood cells against hemolysis has been demonstrated The ethanol fraction of plum juice suppresses proliferation and induces apoptotic changes in human colon carcinoma cells (Fujii *et al.*, 2006). Protocatechuic acid in prunes and other fruits has been shown to prevent epithelial cell malignancy in various tissues. The anti-cancer effects of prunes are probably associated with the antioxidant activity of its components. Interference with the metabolic activation of carcinogens or direct blocking of carcinogen binding to DNA molecules leading to mutation and neoplastic transformation can also contribute to the anti-cancer activity.

Anti-haemolytic activity:

The protection of red blood cells against haemolysis is known as anti-haemolysis. The anti-haemolytic activity of plum and plum DMSO extract was measured at different concentrations (5, 10, 50, 100, 200, 400 µg/ml) and compared. The highest activity was found ($31.35 \pm 0.28\%$) at a concentration of 400 µg/ml for plum (El-Beltagi HS *et al.*, 2019)¹⁷.

Anti-inflammation activity:

A complex biological response of vascular (tubular) tissues in opposition to aggressive agents such as pathogens, irritants or damaged cells known inflammation. Inhibition of inflammation in the so-called anti-inflammatory activity (Andrade LN *et al.*, 2013)⁷⁸. Hooshmand *et al.* conducted a study to prove the anti-inflammatory properties of dried plum polyphenols in macrophage raw 264.7 cells and their findings indicated a strong anti-inflammatory activity by lipopolysaccharide (LPS)-induced production of pro-inflammatory markers, nitric oxide (NO) and cyclooxygenase-2 (COX-2) (Hooshmand S, *et al.*, 2015)¹⁸

Fruit Name: Pomegranate (*Punica granatum*)

Pomegranate, (*Punica granatum*), a shrub or small tree of the family Lythraceae and its fruit. The juicy fruits of the fruit are eaten fresh and the juice is the source of grenadine syrup, which is used in flavorings and liqueurs. Pomegranate is high in fiber, folic acid, vitamin C and vitamin K. The pomegranate, or *Punica granatum*, is a visually striking, spherical fruit with a thick, reddish skin that houses hundreds of juice-trapping seeds, or pips, in its inner chambers. It is valued in many cultures and religions and in science for many health-related properties. It has enormous medicinal and nutritional value and is one of the richest sources of antioxidants. Several processed products such as juices, squash, jelly and mouth freshener are prepared by processing the fruit (Debjit *et al.*, 2013)¹⁹.

Biological Description

The plant, which can reach 5 or 7 meters (16 or 23 ft) in height, has elliptical, pale green leaves about 7.5 cm (3 in) long. The beautiful axillary orange-red flowers are borne at the ends of the branches. The calyx (containing the sepals) is tubular and persistent and has five to seven lobes; the petals are lanceolate, inserted between the calyx lobes. The ovary is embedded in the calyx tube and contains several compartments in two series above one another, and the pomegranate plant is a large shrub or small tree that has smooth, evergreen leaves and showy orange to red flowers. It has rounded fruits with a dry outer covering (husk) consisting of two layers: a hard outer layer called the pericarp, a soft inner layer called the mesocarp. The inner mesocarp has

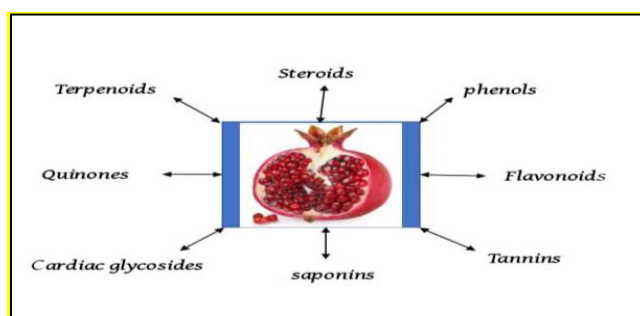
distinct chambers that contain the fleshy seeds. The color of the edible succulent layer can vary from white to dark red depending on the variety (Levin *et al.*, 2006)²⁰.

Collection and cultivation:

Pomegranate (*Punica granatum L.*) is one of the commercially important fruit crops in India. It comes from Iran (Persia). India ranks first in terms of area and production of pomegranate in the world. Pomegranate is grown commercially only in Maharashtra. Small plantations are also seen in Gujarat, Rajasthan, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Punjab, Haryana. Maharashtra accounts for about 73% of the total area, followed by Karnataka and Andhra Pradesh. India exports pomegranate to UAE, Netherlands, UK, Saudi Arabia, Russia, Bangladesh, Egypt, Nepal and Oman (Singh 2004)²¹.

Phytochemical constituents:

The pomegranate peel consists of following phytochemical constituents, those



Various phytochemical investigations were carried out using the obtained extract. The procedures are already reported by the number of workers and used without any modifications. The phytochemical name and investigation methods are as follows (Sawant RS *et al.*, 2013)²². These are phenols, saponins, tannins, cardiac glycosides, flavonoids, terpenoids, etc.

Pharmacological actions:

Anti-viral activity:

Pomegranate has been used in phage amplification assays as a viricidal agent (De Siqueira, Dodd *et al.* 2006)²⁵. Four different types of polyphenols in pomegranate extracts Ellagic acid, caffeic acid, luteolin and punicalagin have been evaluated by many researchers and found punicalagin as an anti-influenza component (Haidari, Ali *et al.* 2009)²³, inhibits viral RNA replication, reduces virus agglutination of chicken red blood cells and has viricidal effects in chickens. Further investigations have shown that replication of human influenza A/Hong Kong (H3N2) *in vitro* is also inhibited. This effect has also been associated with other flavonoid compounds found in pomegranate (Kwak, jeon *et al.*, 2005)²⁴.

Anti microbial activity:

One of the most practical schemes for controlling the growth of microorganisms is the use of substances that have antimicrobial activity, such as growth reducers, inhibitors or even inactivators. To maintain food safety and quality, preservatives are used as the first choice (Viuda-Martos, Ruiz-Navajas *et al.* 2008)²⁵. Health problems caused by spoiled food, odor, unpleasant taste, textural problems or color changes, which are basically caused by the enzymatic or metabolic systems of the main microorganisms in food, lead to fluctuations in its quality and beneficial effect. Natural antimicrobial substances with a microbicidal or static effect sufficiently extend the shelf life of food and prevent its spoilage (Feng and Zheng 2007)²⁶. Pomegranate has a significant inhibitory effect on various pathogenic bacteria, especially gram-positive bacteria that are methicillin-resistant and methicillin-sensitive *Staphylococcus aureus* (Braga, Leite *et al.* 2005)²⁷, *Streptococcus haemolyticus*, *Vibrio cholera*, *Proteus bacillus*, *Proteus vulgaris*, *Mycoculosis*, *tubererculosis*, *Pseudomonas bacterium* *Listeria monocytogenes*, *Candida albicans*, *Yersinia enterolytica* (Al-Zoreky 2009)²⁸. Tannins, ellagitannins and flavonoids are responsible for the antibacterial activity of pomegranate extracts (Al-Zoreky 2009)²⁸.

Anticancer activity:

Pomegranate juice, peel, and seed oil have been found to have anticancer properties that inhibit proliferation, cell cycle, and angiogenesis (Lansky EP *et al.*, 2007)²⁹. Amin *et al.*⁷⁹, reported that pomegranate fruit, pomegranate juice, seeds, and seed oil are effective in prostate, breast, skin, colon, lung, oral cavity, and leukemia cancers due to their antioxidant and antiproliferative (inhibition of growth, cell cycle disruption and apoptosis). (Adhami VQ *et al.*, 2009)³⁰.

Fruit Name: white Dragon fruit (*Hylocereus undatus*)

Red dragon fruit (*Hylocereus polyrhizus*)

Dragon fruit, also known as pitahaya or strawberry pear, is a tropical fruit known for its bright red skin and sweet flesh studded with seeds. Its unique appearance and recognized superfood capabilities make it popular among foodies and health experts. Dragon fruit is a rich source of vitamin C, calcium and phosphorus (Nurliyana *et al.* 2010; Perween *et al.* 2018)^{31,32}. It offers a wide range of health benefits, such as reducing hypertension and diabetes, as it affects carbohydrate metabolism and heart tissue formation. It is also rich in total ascorbic acid, total dietary fiber, pectin and iron, which helps to balance blood production (Sofowora *et al.* 2013)³³.

Biological description:

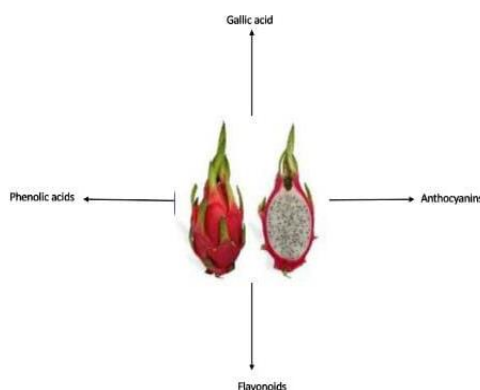
The fruit is a fleshy berry that is oblong and about 11 cm thick with a red or yellow/scaly skin and with or without spines. The color of the pulp can be pink, white, red or purple depending on

the species. The seeds are very small, numerous and embedded in black between the pulp (Crane *et al.*, 2017)³⁴.

Collection and cultivation:

Initially, dragon fruit cultivation was started by farmers from Karnataka, Maharashtra, Gujarat, Kerala, Tamil Nadu, Orissa, West Bengal, Andhra Pradesh, Telangana and Andaman & Nicobar Islands. Currently, its cultivation has spread to Rajasthan, Punjab, Haryana, Madhya Pradesh, Uttar Pradesh, North Eastern states. According to recent estimates, India's dragon fruit production has increased drastically to over 12,000 MT in an area of 3,000-4,000. These estimates are based on first-hand information. Commercial planting can be done at high density with 1100 to 1350 plants per hectare. Plants can take up to five years to reach full commercial production, at which stage yields of 20 to 30 tonnes per hectare can be expected (Britton NL *et al.*, 2018)³⁵

Phytochemical constituents:



Phytochemicals are defined as bioactive, non-nutritive plant compounds (SeptembreMalaterre *et al.* 2018)³⁶. These compounds are secondary plant metabolites and are associated with health benefits (Nyamai *et al.* 2016)³⁷. In recent years, there has been increasing interest not only in the identification of phytochemical compounds present in dragon fruit, but also in the use of their potential medicinal properties. Betacaine, flavonoids, polyphenols, terpenoids, steroids, saponins, alkaloids, tannins and carotenoids are bioactive compounds that can be extracted from all parts of pitaya (Ramli *et al.*, 2014)³⁸

Pharmacological actions:

Antioxidant activity:

The antioxidant properties of dragon fruit are widely recognized, and the antioxidant activity of different species, as well as the antioxidant content of different parts of the plant, have been subjected to many detailed studies (Wu *et al.* 2006;)³⁹ Most of the studies have focused on two

species of the genus *Hylocereus*, which excel in cultivation and by extension: *H. polyrhizus* and *H. undatus*. Two of the most widely used methods for evaluating antioxidant activities are 2,2'-diphenyl- β -picrylhydrazyl (DPPH) (Brand-Williams *et al.* 1995)⁴⁰ and 2,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS \pm) (Re *et al.* 1999)⁶⁵. Both are spectrophotometric techniques based on the quenching of stable colored radicals (DPPH or ABTS+) that determine the ability of antioxidants to scavenge radicals even when present in complex biological mixtures (e.g. plant or food extracts). (Nurliyana *et al.*, 2010)³¹ used DPPH assays to test the radical scavenging activity of the pulp and peels of *H. polyrhizus* and *H. undatus* and found that in both species the peels contained higher radical scavenging activity than the pulps. In addition, the antiradical activity for the peels of both species was higher than that of the positive control, a potent synthetic antioxidant called butylated hydroxyanisole (BHA), at approximate sample concentrations from 0.8 to 1.0 mg ml⁻¹. IC₅₀ [defined as the inhibitory concentration at which response (or binding) halved] values for *H. polyrhizus* and *H. undatus* barks were 0.30 and 0.40 mg ml⁻¹, respectively, higher than BHA (0.15 mg ml⁻¹). In the case of the pulp of both species, they showed a low percentage of radical scavenging activities compared to the measured extract concentrations, suggesting that their IC₅₀ values could be higher than 1.0 mg ml⁻¹. Interestingly, the total phenolic content (TPC) assay showed that the peels both species of *Hylocereus* contained higher phenolics than pulp. In another study with red pitaya (*H. undatus*) (Jerônimo *et al.*, 2011)⁴¹ obtained similar results to (Nurliyana *et al.* (2010))³¹ regarding the higher antioxidant activity of the skin compared to the pulp. Antioxidant activity of pitaya bark (445.2 mg ml⁻¹

Antihyperlipidemic Activity:

Dyslipidemia is a complex disease and a major risk factor for adverse cardiovascular events as it is known to promote atherosclerosis (Pol *et al.* 2018)⁶⁴. In order to evaluate the effect of red dragon fruit (*H. polyrhizus*) peel powder on blood lipid levels (Hernawati *et al.*, 2018)⁴², different groups of hyperlipidemic male Balb-C mice were fed different doses of pitaya peel powder, ranging from 50 to 200 mg kg⁻¹ body weight (BW) for 30 days. After treatment, blood samples from each group were analyzed for levels of total cholesterol, triglycerides, and low-density lipoprotein cholesterol (LDL-c), and the results showed that all of these parameters decreased with increasing doses of red dragon fruit peel powder. (Hernawati *et al.* 2018)⁴² pointed out that pitaya peel powder supplemented in food would contribute to the prevention of hyperlipidemia due to the advantages associated with its composition: i) high crude fiber content in the peel (69.30% of total fiber, divided into 56.50% insoluble dietary fiber and 14.82% soluble dietary fiber) helps reduce energy intake by trapping cholesterol and bile acids in the

small intestine, can increase insulin sensitivity, and also increases satiety; ii) the high content of antioxidants, phenol and especially tocotrienol (vitamin E) reduces cholesterol levels in the liver and the concentration of total cholesterol and LDL-cholesterol in the plasma. Study (Suastuti et al. 2018)⁴³ on the antiobesity and hypolipidemic activity of the methanol extract of *H. costaricensis* meat showed that obese rats fed the meat extract at a dose of 100 mg kg⁻¹ BW significantly decreased their body weight, Lee's obesity index, organ weight, visceral fat weight, total cholesterol, lipoprotein s low-density lipoprotein, triglycerides, very-low-density lipoprotein, and total cholesterol/high-density lipoprotein (HDL) ratio. In contrast, the concentration of HDL-cholesterol, fecal fat and cholesterol increased in these rats. (Sudha et al., 2017)⁴⁴ evaluated the in vitro antioxidant, antidiabetic and antilipase activities of white pitaya (*H. undatus*) juice extract. Phytochemical screening of white dragon fruit revealed the presence of bioactive compounds with antioxidant, antidiabetic and antilipase activities, such as triterpenoids, alkaloids, flavonoids and saponins, which are of great value and potential use. In summary, bioactive compounds in dragon fruit extracts, including crude fiber, phenolic, polyphenolic, and flavonoid content, contribute to lowering the serum lipid profile because these antioxidants are able to inhibit cholesterol absorption in the intestine and facilitate its excretion in feces.

Anti -Inflammatory activity:

Anti-inflammatory activity, Due to its composition, including compounds such as betalains and squalene, dragon fruit has antioxidant and anti-inflammatory properties. (Rodriguez et al., 2016)⁴⁵ reported the anti-inflammatory activity of maltodextrin-encapsulated and non-encapsulated betalains from *H. polyrhizus* peel extract. Beta lains are unstable and sensitive to degradation factors such as temperature, pH, oxygen or light, but their biological activity can be enhanced by encapsulation by adding a protective and impermeable layer (Jackman and Smith et al. 2016)⁴⁶. Betalains inhibited sodium dodecyl sulfate (SDS)-induced vascular irritation of duck embryo chorioallantoic membrane (CAM). Betalains encapsulated by maltodextrin gum arabic or maltodextrin-pectin matrices showed five to six times higher anti-inflammatory activity compared to non-encapsulated betalains. The strong anti-inflammatory activity of betalains from the bark of *H. polyrhizus* can be attributed to their strong antioxidant activity. Free radicals can be major pro-inflammatory mediators; thus, removal of mediators leads to attenuation of the inflammatory response (Rodriguez et al. 2016)⁴⁵.

Anti-Cancer activity:

The antiproliferative potential of dragon fruit is related to its content of powerful antioxidants such as polyphenol, anthocyanin, betalains, steroids, and triterpenoids (Wu et al. 2006³⁹; Luo et al. 2017)⁴⁸. Among these compounds, in addition to antimicrobial and antiviral properties, betalains can also inhibit lipid peroxidation, cyclooxygenase enzymes (COX-1 and COX-2), and human tumor cell proliferation (Strack et al.2017)⁴⁷. Supercritical carbon dioxide extracts of pitaya peels from *H. polyrhizus* and *H. undatus* have antioxidant and cytotoxic activities as demonstrated by (Luo et al. (2014)⁴⁸. Extracts from both pitaya species showed cytotoxic activity against three cell types, i.e. PC3 (cell line human prostate cancer), Bcap-37 (human breast cancer cell line) and MGC-803 (human gastric cancer cell line) with IC50 values ranging from 0.61 to 0.73 mg mL⁻¹. Luo et al. (2014)⁴⁸ also identified β -amyirin, β -sitosterol and stigmast-4-en-3-one as compounds responsible for cytotoxic activities (Guimarães et al. (2017)⁶³ studied the protective effect of *H. polyrhizus* pulp extract against breast cancer.

Fruit Name: Strawberry (*Fragaria ananassa*)

The strawberry (*Fragaria ananassa* Dutch) is a soft fruit crop that belongs to the family Rosaceae and the genus *Fragaria*. The fleshy fruits of strawberry are classified as aggregate fruits (Green, 1971). Strawberries are unique with highly desirable flavor, taste and excellent source of vitamins, potassium, fiber, sugars (Sharma and Sharma, 2004)⁷¹. Compared to other berries, strawberries contain a higher percentage of vitamin C, phenolics and flavonoids (Hakkinen and Torronen, 2000)⁴⁹

Biological description:

Strawberry, (genus *Fragaria*), a genus of more than 20 species of flowering plants from the Rosaceae family and their edible fruits. Strawberries are native to the temperate regions of the Northern Hemisphere and cultivated varieties are widely grown throughout the world. The fruits are rich in vitamin C and are commonly eaten fresh as a dessert fruit, used as a filling for pastries or cakes, and can be preserved in many ways. Strawberry Shortcake – made from fresh strawberries, sponge and whipped cream – is a traditional American dessert. Strawberries are low-growing herbaceous plants with a fibrous root system and a crown from which basal leaves grow. The leaves are compound, usually with three leaflets, serrate and usually hairy. The flowers, mostly white, rarely reddish, are borne in small racemes on slender peduncles emerging, like surface-creeping stems, from the axils of the leaves. As the plant ages, the woody root system and "mother" crown sends out runners (e.g., stolons) that contact the ground and roots, increasing the plant vegetatively. Botanically, the strawberry is considered an "accessory fruit"

and is not a true berry. The pulp consists of a significantly enlarged floral capsule and is set with many true fruits or achenes, which are popularly called seeds (Green, 1971)⁵⁰.

Collection and cultivation:

Satara district known for 80% strawberry production in the country. The fruit is grown mainly in Mahabaleshwar, Wai and Panchagani districts. The Panchgani-Mahabaleshwar belt contributes around 85% of the country's total production. The rest are from Himachal Pradesh and Jammu and Kashmir (Davis 2004)⁵¹

Phytochemical constituents:

Strawberries consist of the following phytochemicals, which are the main class of phenolic compounds in strawberries are flavonoids (mainly anthocyanins, with a smaller proportion of flavanols and flavanols), hydrolyzable tannins (ellagitannins and gallo tannins) and phenolic acids (hydroxybenzoic acids and hydroxycinnamic acids, while condensed tannins (proanthocyanins) are minor components (Aaby *et al.*, 2005)⁵².

Pharmacological Actions:

Anti-aging property of strawberry:

There are many cognitive and motor behavioural deficits that occur during aging and are related to changes in the striatal dopamine (DA) system or in the cerebellum. Long-term exposure to oxidation and inflammation are thought to be contributing factors to the decline in cognitive and motor performance evident in aging and other neurodegenerative diseases. Strawberry exerts its effects directly by altering cellular signalling to improve or enhance neuronal communication, calcium buffering capacity, neuroprotective stress shock, plasticity, and stress signaling pathways. Strawberries have the potential to slow and even reverse age-related behavioral and signal transduction deficits in rats. The researchers kept the rats on a control diet for 8 weeks before being exposed to whole-body radiation to evaluate the effectiveness of the berry diet. It was found that berry diets protected exposure deficits from impaired performance in the Morriswater maze. Eating Strawberries Shows Better Protection against Spatial Deficits Researcher Initiated Studies suggest that phytochemicals present in antioxidant-rich foods such as strawberries may be beneficial in slowing age-related functional deficits, cognitive behavioral deficits, and central nervous system dysfunction. neurodegenerative diseases also in humans (Basu A *et al.*, 2010)⁵³.

Anti-cancerous effect of strawberry phytochemicals:

The phenolic components of berries protect DNA from damage through a multi-mechanistic mode of action, including anti-oxidation, and their effects are also applied outside, leading to

anti-cancer effects. Lignans of plant origin add intensity to mammalian enterolactone in plasma and urine, they are present in sufficient quantity as a component of berries. Past auto-oxidation and multi-step action mechanisms, including antioxidant protection of DNA from oxidative damage, result in strawberry phytochemicals protecting humans from cancer. Viral, parasitic infections, and chronic bacteria can be caused by overproduction of these oxidants, as the imbalance leads to oxidative stress, which can cause oxidative damage to larger biomolecules such as lipids, proteins, and DNA, resulting in an increased risk of cancer and heart disease. Berry extracts have shown apoptotic effects in human cancer cells. It is necessary to consume sufficient amounts of antioxidants to prevent or reduce oxidative stress stimulated by free radicals. The risk of persistent disease and oxidative damage to the cellular system can be prevented or reduced by antioxidant compounds (phytochemicals) such as phenols and carotenoids present in natural fresh foods (Schmidt BM et al., 2006).

Fruit name: Black grapes (*Vitis vinifera*)

Vitis vinifera fruits have been used for thousands of years for their nutritional and medicinal properties. They are rich in sugars, flavonoids, anthocyanins and proanthocyanins, organic acids, tannin, mineral salt, vitamins. The skin of grapes, especially red and black varieties, is rich in resveratrol, which is a derivative of stilbene. Studies have shown that resveratrol is one of the most powerful natural antioxidants known. It is found in large amounts in black grape juice, skin and seeds (Ruaaazizjassim et al., 2010)⁵⁵. The seeds and leaves of the vine are used in herbal medicine and its fruit is used as a dietary supplement (MarjanNassiri-Asland et al., 2009)⁵⁴

Biological description:

Grapes belong to the Vitaceae family. The plants are climbing vines that have thin and smooth shiny leaves. The vine produces round or oval berries. Grapes are born in clusters that consist of a stalk, a spindle, and a berry. The grapes grow in clusters of 6 to 300 berries. The fruit is a berry. Berries can be green, black, blue, gold, purple, red, pink, brown, peach or white. The berry consists of skin, pulp and seeds. The skin of the berry skin consists of a thick layer of cells that make up 5%-12% of the total weight of the berry. The peel is covered with a cut or flower, it makes up 1% to 2% of the weight of the peel. Most grape varieties are self-pollinating. The genus *Vitis* is largely distributed between 25° and 50° N in Europe, the Middle East, North America and East Asia. The genus *Vitis* is divided into 2 subgenera: 1. *Euvitis* - "True grapes"; characterized by elongated clusters of fruits with berries attached to the stalk when ripe, branched tendrils, diaphragms in the pith at the nodes, also called "bunch of grapes". Most of the cultivated species are in these subgenera. 2. *Muscadinia* - Muscadine grapes; clusters of small fruits, fruits with strong skin, berries

that separate one by one as they ripen, simple tendrils, and lack of pith diaphragms at nodes (Liu, X.-Q et al., 2017)

Collection and cultivation:

In Andhra Pradesh, it is grown in Mahbubnagar, Rangareddy, Medak, Anathapur, Chittoor and Kurnool districts in an area of 1676 ha with a production of 33520 tonnes (G.K.Jayaprakasha,T et al.,2003)⁵⁶

Phytochemical constituents:

Flavonoids: Grape seeds contain flavonoids (4-5%), including kaempferol-3-O-glucosides, quercetin-3-O-glucosides, quercetin, and myricetin. Polyphenols: Grapes are rich in polyphenols and 60-70% of the polyphenols in grapes are in the grape seeds. Grape seed polyphenols are flavan-3-ol derivatives. The main compounds are (+)-catechins, epicatechin, -epicatechin-3-O-gallate, procyanidin dimers (B1-B5), procyanidin C1 and procyanidin B532-gallate. Grape seeds contain procyanidins or proanthocyanins (mostly hexamers). All acylated grape seed procyanidins are gallic acid esters (Fuleki and Ricardo da Silva, 1997); however (+)-catechin, -epicatechin and epicatechin-3-O-gallate monomers, 14 dimeric, 11 trimeric, and one tetrameric procyanidin was also described.

Anthocyanins: Anthocyanins that have been reported for *V. Vinifera* include 3-glucosides, 3-acetylglucosides, 3-coumaroylglucosides, 3-caffeoylglucosides, 3,5-diglucosides, 3-acetyl-diglucosides, 3-coumaroyl-5-diglucosides, caffeoyl- cyanidin diglucosides, delphinidin, peonidin, petunidin and malvidin. Stilbene derivatives: Trans-Resveratrol (trans-3, 5, 40-trihydroxystilbene) has also been reported in grapes (MarjanNassiri et al., 2009)⁵⁴.

Pharmacological actions:

Anti-Bacterial activity:

Black grapes contain higher amounts of dimmers and trimers (-) epicatechin, which have higher antimicrobial activity than monomers (NurmahaniMM et al., 2012)⁵⁸. Scalbert (Droby S et al., 1997)⁶⁰ suggested that the antibacterial activity of tannins may be due to the inhibition of extracellular microbial enzymes, may be the reason for the antibacterial effect of black grapes. In addition, the complexation of metal ions from the bacterial growth environment could also be a possible mechanism of their antimicrobial properties. Almost similar results were obtained by Nirmala and Narendhirakannan (Nirmala G et al., 2011)⁵⁷, they found that the zone of inhibition of ethanol extract of grape (Muscat variety) skin extract against *S. aureus* and *E. faecalis* was 7 mm and 5.9 mm at 250 mg/ml of grape skin extract.

Anti-fungal activity:

Grape skin contains significant amounts of catechins and epicatechins (NurmahaniMM *et al.*, 2011)⁵⁹. Catechins and other polyphenols are highly negatively charged phytochemicals, which may be related to the antifungal activity of black grapes (Xia EQ *et al.*, 2010)⁶¹. Although the acetone extract had a large amount of polyphenols, it showed less antifungal activity compared to the methanol extract. Different solubility of antifungal compounds in solvents lead to differences in percent growth inhibition. Some growth retardation effect has been attributed to isolated phenolic acids such as coumaric acid, caffeic acid, ferulic acid and sinapic acid, as well as isolated flavonoids such as (+)-catechin, kaempferol and quercetin (Bennett JW *et al.*, 2003)⁶² Presence and thus, the solubility of some of these compounds in the extracts is probably responsible for the growth inhibitory effect of the various extracts.

List of phytochemicals of purplepeels:

Fruits	Phytochemicals	References
Apple	Anthocyanins, Flavonoids, Phenols, Quercetin-3-glucoside, Quercetin-3-rhamnoside, Catechin, Epicatechin, Procyanidin, Cyanidin 3galactoside, Coumaric acid, Gallic acid.	Serra AT <i>et al.</i> , 2012 ⁶⁸
Plum	Phenolic acids, Chlorogenic acids, Anthocyanins, Flavanols, Coumarins.	Jaiswal R <i>et al.</i> , 2013
Pomegranate	Phenols, Flavonoids, Quinones, Saponins, Cardiac glycosides, Terpenoids.	Sawant RS <i>et al.</i> , 2013
Dragon fruit	Flavonoids, Anthocyanins, Phenols, Gallic acid	Nurliyana, R <i>et al.</i> , 2010
Strawberry	Anthocyanins, Flavanols, Hydrolyzable tannins, Catechin.	Chung <i>et al.</i> , 2002 ⁶⁶
Black grapes	Phenols, Phenolic acids, Flavanols, Anthocyanins.	Yang <i>et al.</i> , 2009 ⁶⁷ Mattivi <i>et al.</i> , 2006 ⁷³ Makris <i>et al.</i> , 2006 ⁷⁴ Shi <i>et al.</i> , 2003 ⁶⁹

Pharmacological actions:

Fruit name	Pharmacological actions	Reference
Apple	Antioxidant activity, Anti-obesity activity, Cardiovascular activity, Diabetes treatment	Ribeiro <i>et al.</i> , 2014 Oliveira, M <i>et al.</i> , 2003 ⁷² Auclair <i>et al.</i> , 2008 Knekt P <i>et al.</i> , 2002
Plum	Antioxidant activity, Antimicrobial activity,	Cardador-Martínez A <i>et al.</i> , 2002 ⁷⁶ Prior RL <i>et al.</i> , 2000 ⁷⁰
Pomegranate	Antiviral activity, Antimicrobial activity, Antiulcer activity, Anticancer activity, Cardiovascular treatment.	Dodd <i>et al.</i> , 2006 Ferlay <i>et al.</i> , 2010 Khateeb <i>et al.</i> , 2010
Dragon fruit	Antioxidant activity, Antihyperlipidemic activity,	Wu <i>et al.</i> , 2006. Pol <i>et al.</i> , 2018.

	Anti-inflammatory activity,	
	Anticancer activity.	Jackson and smith et al .,2016
Strawberry	Antiaging property,	Basu A et al.,2010 ⁷⁷
	Anti cancerous effect.	Schmidt B M et al.,2006.
Black grapes	Antibacterial activity,	Nirmala G et al., 2010
	Antifungal activity.	Xia EQ et al ., 2010.

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