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Unveiling the pharmaceutical and cosmetological applications of phytoconstituents in Dragon fruit: A review

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Abstract

Dragon fruit is renowned for its vibrant appearance and refreshing taste. Beyond its culinary appeal, this exotic fruit harbours a treasure trove of phytoconstituents with significant pharmaceutical and cosmetological potential. The fruit are rich in antioxidants, betalains, hydrocinnamates, flavonoids, which helps to combat oxidative stress and inflammation in the body. The antioxidants play an important role in preventing cellular damage, reduces the risk of chronic diseases, making dragon fruit an excellent choice for pharmaceutical applications in developing antioxidant supplements or medications. Betalains which are responsible for the red colour flesh, tends to have antiviral property against dengue virus type 2. In cosmetology, usage of ultrasonic assisted extraction is used to enhance betalain stability. The fruit containshigh vitamin C content which increases the collagen production, improving skin elasticity and reducing the wrinkles and fine lines. Additionally, betalains helps to soothe irritated skin and may aid in treating conditions such as acne and eczema. Furthermore, dragon fruit extracts are increasingly being incorporated into skin care products like creams, serums, and masks due to their hydrating and rejuvenating effects. These products capitalize on the fruit's ability to moisturize the skin and improve its overall texture and radiance.This review describes about the therapeutic role of phytoconstituents in dragon fruit and its cosmetalogical potential.

1. Introduction

Dragon fruit (*Hylocereus* spp.) also known as Pitaya, is a hemiephiphytic climbing cactus known for its market potential and fruit value. It is a perennial plant with long days that can yield fruit after, around 20 years of planting (Crane *et al.* 2017). This fruit is migrated from its original center to tropical and subtropical America, Asia, Australia, and the Middle East. South-Western USA, Vietnam, Australia, Cambodia, China, Israel, Japan, Nicaragua, Peru, Philippines, Spain, Sri Lanka, Taiwan, and Thailand, where it is widely grown (Nobeland De la Barrera, 2002). In India, the fruit is widely grown in Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat and few parts of West Bengal (Dharani *et al.*, 2023). Eventhough dragon fruit is widely grown in areas of tropical condition like North, south America, the production value is highly increasing due to its tolerance to abiotic stress conditions like drought, heat stress, adapting to light intensity, tolerance to wide range of soil conditions, salinity and has more benefits regarding the health conditions of humans (Mercado-Silva, 2018). Dragon fruit is being considered as a "Wonder fruit ", due to its attractive flesh colour and skin type. The off-season production technologies, such as artificially extending daylight through electric lighting, enables the tree to produce fruits all year round (Jiang *et al.*, 2016).

This fruit contains more number of antioxidants, betalains, hydrocinnamates and high level of flavonoids (Moshfeghi *et al.*, 2013). It can help to lower the blood levels of LDL cholesterol, enhance digestion, boost immunity, and help with weight loss, besides other health advantages. Most fatal disease like cancer can be prevented by the compounds called hydroxycinnamates and heart diseases including cardiac arrest could be reduced by flavonoids which acts on the blood vessels (Verma *et al.*, 2017). The health benefits and economic significance of dragon fruit have led to its increasing cultivation in recent times. The fruits contains abundant amount of nutrients, vitamins and higher amount of fibre content, phytochemicals (Mahdi *et al.*, 2018; Luo *et al.*, 2014; Sushmitha and Sathyamurthy, 2018). This expansion has made it possible to use the fruit as a source of functional materials that contain potent antioxidant phytochemicals (Parmar *et al.*, 2019).

Dragon fruit consists of four different species. They are; *Hylocereus undatus*-red skin with white pulp, *Hylocereus polyrhizus*-red skin with red pulp, *Hylocereus costaricensis*-red skin with pink/purple pulp, *Hylocereus megalanthus*-yellow skin with white pulp. Dragon fruit is widely known for its medicinal and nutraceutical qualities. It has been observed that the peels of dragon fruit have greater nutritional content than the edible part of the fruit (Gondim *et al.*, 2005). The peels of dragon fruit make up 22-44% of the fruit weight and are often thrown away as processing waste, particularly in the beverage industries of production (Liaotrakoon, 2013).

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There is a rise of numerous new illnesses as well as outbreaks of infectious diseases. These days, there is a boom in research on the medicinal application of natural products (Sharifi-Rad *et al.*, 2018). This review views the potential medicinal uses of dragon fruit by focusing on its phytochemical, pharmacological and cosmetological characteristics.

2. Phytoconstituents in dragon fruit

Different bioactive compounds, such as flavonoids (flavones, flavonols, flavanols, anthocyanidins), terpenoids (sesquiterpene lactones, diterpenes, triterpenes, polyterpenes), steroids, phenolic acids (hydroxybenzoic, hydroxycinnamic acids), stilbenes, lignans, quinones, tannins, coumarins (simple coumarins, furanocoumarins, pyranocoumarins), alkaloids, glycosides, saponins, lectins, and polypeptides, that have a great antimicrobial activity are linked to the benefits of plant utilization against a wide range of pathogenic microorganisms (Naseer Unnisa *et al.*, 2012; Fadipe *et al.*, 2013) (Figure 1 and Table 1). Dragon fruit phytoconstituents are extracted from the peel, fruit flesh and seeds, utilizing a variety of extraction methods, such as solvent extraction and Soxhlet extraction, supercritical fluid extraction, microwave assisted extraction and ultrasound assisted extraction (Figure 2).

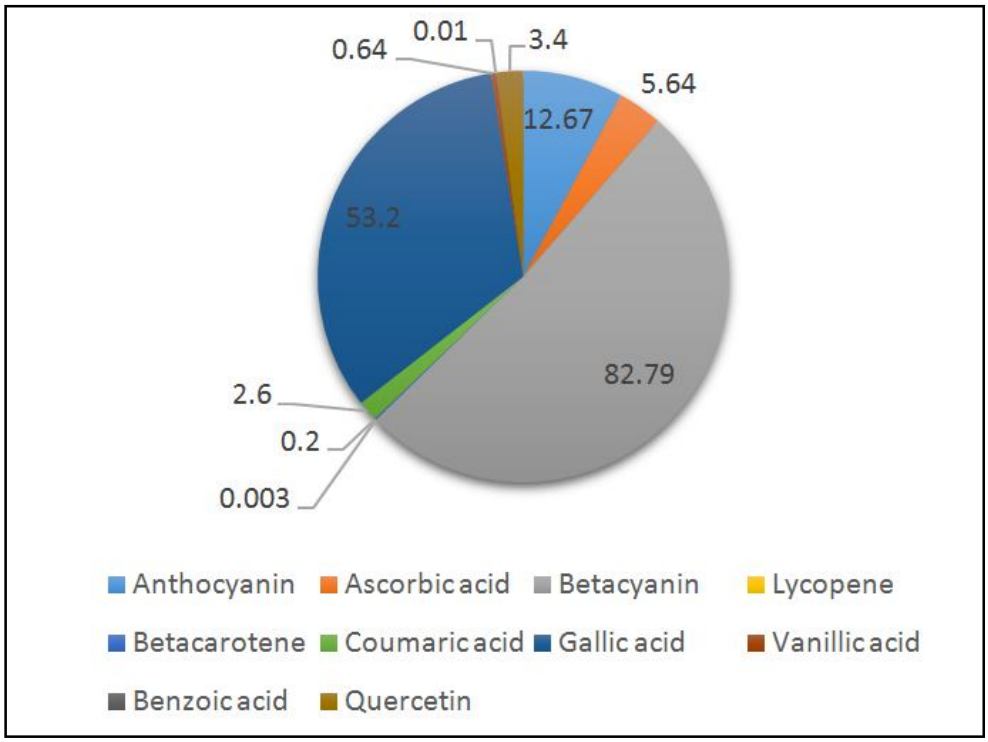


Figure 1: Relative quantity of phytoconstituents in dragon fruit.

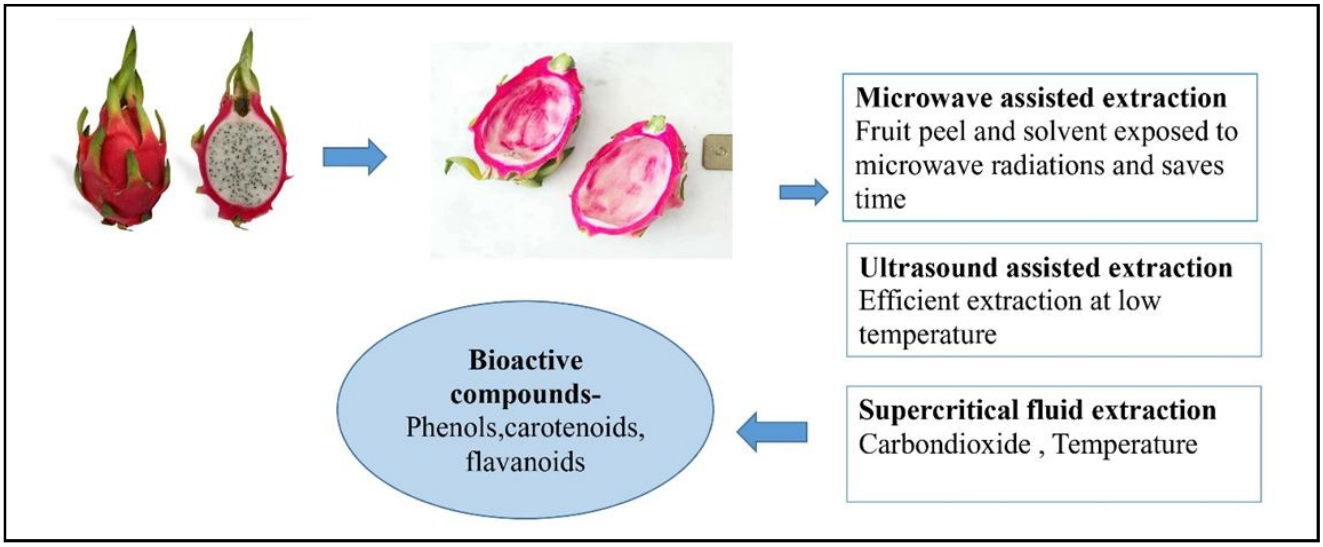
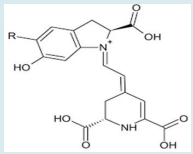
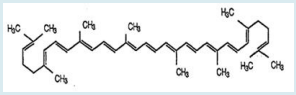
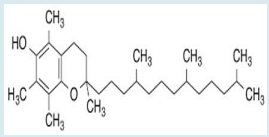
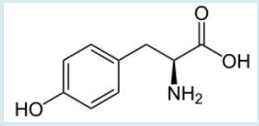
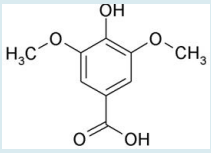
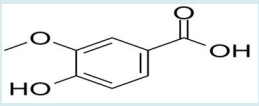
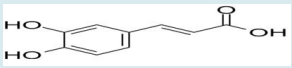
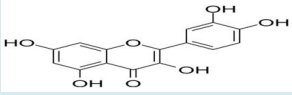
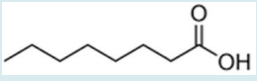
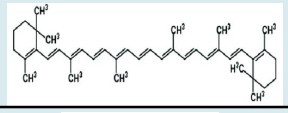
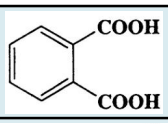
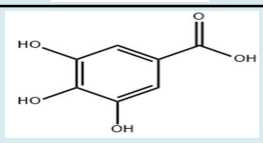


Figure 2: Phytoconstituents extraction from dragon fruit peel.

Table 1: Phytoconstituents and their therapeutic role of dragon fruit

Phytoconstituents	Pulp, seed and peel	Role	Molecular structure	Reference
Betacyanin	Peel and pulp	Possess anticancer properties and suppressing tumour progression, antimicrobial, antiviral		Kumorkiewicz-Jamro *et al.* (2021); Pires *et al.* (2022)
Lycopene	Pulp	Act as potent antioxidants scavenging, act as antidiabetic		Leh and Lee (2022)
Tocopherol	Pulp	Play a role in regulating glucose metabolism and insulin secretion, enhance pancreatic function and glucose uptake in peripheral tissues, contributing to better blood sugar control		Ungurianu and Zanfirescu (2021)
Coumaric acid	Pulp and seed	Anti-inflammatory effect		Attar *et al.* (2022)
Syringic acid	Peel, pulp and seed	Helps to neutralize harmful free radicals in the body, treats chronic diseases including cardiovascular disease, cancer, and neurodegenerative disorders		Joshi and Prabhakar (2020), Srinivasulu *et al.* (2018)
Vanillic acid	Peel and pulp	Contribute to cardiovascular health by reducing cholesterol levels, improving blood vessel function, and lowering blood pressure		Pires *et al.* (2022)
Caffeic acid	Peel and seed	Antioxidant activity		Pires *et al.* (2022) Joshi and Prabhakar (2020)
Quercetin	Peel and pulp	Reduces the inflammatory conditions other autoimmune disorders		Saenjum *et al.* (2021)
Fatty acids	Pulp and seeds	Therapeutic activity		Jeronimo (2017)
Betacarotene	Pulp	Cardiovascular protective activity, Antioxidant		Joshi and Prabhakar (2020)
Pthalic acids	Peel	Antioxidant activity		Joshi and Prabhakar (2020)
Gallic acid	Peel, pulp and seeds	Cures obesity problems, anti-diabetic activity		Pires *et al.* (2022) Xu *et al.* (2021)

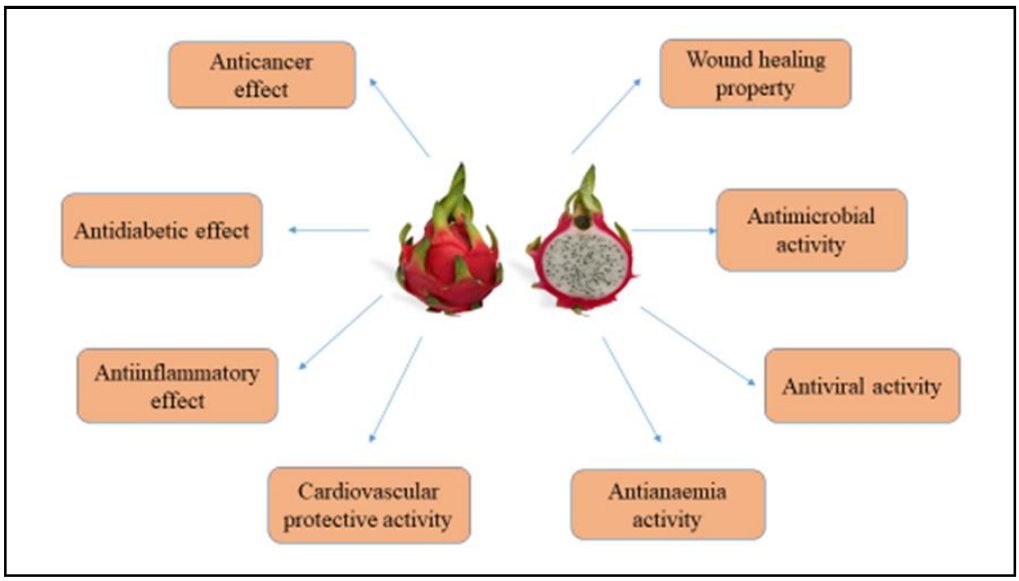


Figure 3: Therapeutic role of dragon fruit.

3. The therapeutic role of dragon fruit

3.1 Anticancer effect

Destructive disease like cancer occurs due to the oxidative stress formed due to disparity between the reactive oxygen species and antioxidants. ROS contains single unpaired electrons in its outermost shell of electrons (Joshiand Prabhakar, 2020). These are the ions, molecules and radicals and increased concentration of ROS results in cancer cells which increases the levels of metabolic activity, mitochondrial dysfunction, peroxisome activity, cellular receptor signalling, oncogene activity, activity of oxidases, cyclooxygenases, lipoxigenases and thymidine phosphorylase or through cross-talk with infiltrating immune cells. The significant cytotoxic activity of a methanolic and aqueous extract of dragon fruit against cell lines of prostate and colon cancer was studied (Pasko *et al*., 2021). Nowadays, chemoprotectants derived from herbs are being utilized to counteract the cytotoxicity of anticancer medications (Picheswararao *et al*., 2015). Peel extracts made with dichloromethane demonstrated cytotoxic activity, in another investigation, as demonstrated by the results of the 3-(4, 5-dimethylthiazolyl-2)-2, 5-diphenyltetrazolium bromide (MTT) assay (Hendra *et al.,* 2021).

Betalains present in dragon fruit, helps to inhibit the lipid peroxidation, cyclooxygenase (COX-1 and COX-2) enzymes and multiplication of cancer cells (Reddy *et al.*, 2005; Afandi *et al.*, 2017). The cytotoxic activity of the extracts from both dragon fruit species was observed against three different cell types: human prostate cancer cell line PC3, human breast cancer cell line Bcap-37, and human gastric cancer cell line (MGC-803). The IC_{50} values of these extracts ranging from 0.61 to 0.73 mg/ml. Some compounds like β-amyrin, β-sitosterol which has the cytotoxic effect (Luo *et al*., 2014).

Most chronic and fatal diseases could be prevented with the help of anti-proliferative agents that is present in peel of white flesh dragon fruit. Lycopene, a naturally occurring antioxidant known to prevent cancer, is present in red flesh of dragon fruit (Guimarães *et al.*, 2017) investigated the pulp extract from red dragon fruit that showed preventive potential against breast cancer, when the pulp extract (500-1000 µg/ml) was applied to the MCF-7 (ER^+) cell line, they saw a reduction in cell proliferation.

3.2 Antidiabetic effect

One of the prevalent systemic diseases worldwide is diabetes mellitus, which is caused by hyperglycemia due to the pancreas's inability to produce enough insulin or from cells' insufficient sensitivity to the hormone's effects (American Diabetes Association, 2009). Diabetes, in general, is a clinical syndrome, characterized by inappropriate hyperglycemia, caused by an absolute deficiency of insulin (Ruby Tiwari and Rana, 2015). Herbs such as a neem (*Azadirachta indica*), chicory (*Cichorium intybus*), jamblon (*Syzygium cumini*), ivy gourd (*Coccinia indica*), bitter gourd (*Momordica charantia*), aloe vera (*Aloe barbadensis*), and jamblon (*Momordica charantia*) were used to treat diabetes mellitus is many traditional cultures across many countries (Kooti *et al.*, 2016 ; Adinortey *et al.*, 2019).

Omidizadeh *et al.* (2014) examined the anti-insulin resistant properties of red dragon fruit in rats which were given a fructose supplement to develop insulin resistance. The results of this study demonstrated that the fruit lowered insulin resistance, highlighting the fruit's anti-insulin resistance is due to its soluble dietary fiber and antioxidant levels in red pulp.

The effects of white dragon fruit juice (WPJ) on metabolic issues associated with obesity, such as insulin resistance was reported (Song *et al.*, 2016). C57BL/6J mice were used in this study. Obese mice treated with white dragon fruit showed reduced insulin and fasting blood glucose levels, suggesting that insulin resistance may be mitigated. The results revealed that reduction of triglycerides was more successful with 400 g of fruit consumed, but the reduction of blood glucose, total and LDL cholesterol, and elevation of HDL cholesterol was more successful with 600 g of fruit. The two treatments did not significantly differ in terms of body weight or total body fat (Abd Hadi *et al.*, 2016). It has been recorded that for counterfeiting diabetes, dragon fruit flesh alone is not responsible. Seeds, skin and flesh of the fruit also contains antidiabetic effect on treating this systemic disease. Saponin compounds are present in pitaya seeds provides antidiabetic effect and are effective if consumed by type 2 diabetes people. Blood sugar levels can be reduced in the body with the help of the fruit skin which contains soluble fibre

responsible for treating diabetes. One of the most potential mode of action of white flesh dragon fruit is that, it aids in diabetic wound healing because it contains DNA collagen, enhanced hydroxypoline and epithelialization, tensile strength, and total protein (Arifia Safira *et al*., 2021). White flesh dragon fruit helps in speeding up the recovery process of wound healing. Dragon fruit's leaves, flower extracts are used for the wound healing. It was found recently that processing fruit purees under high pressure altered their physiochemical characteristics, allowing for a greater drop in glucose range and glycemic index in cases of hyperglycemia. It may be a superior option for managing diabetes.

3.3 Anti-inflammatory effect

Inflammation is a complex set of interactions among soluble factors (cytokines) and cells that can arise in any tissue in response to traumatic, infectious, post-ischaemic, toxic or autoimmune injury (Pushpangadan *et al*., 2015). Fruit has anti-inflammatory properties because it contains substances like betalains and squalene. But, issues arise from betalains instability under standard storage settings and their vulnerability to harmful elements like light, temperature, oxygen, and pH. Consequently, covering them with a shield could increase their biological actions (Luu *et al.*, 2021).

Compounds like vetalains and squalene present in dragon fruit exhibit anti-inflammatory activities.The anti-inflammatory properties of both maltodextrin-encapsulated and non-encapsulated betalains derived from fruit peel extract were documented by Rodriguez *et al.* (2015). The activity of the betalains was assessed using the duck embryo chorioallantoic membrane (CAM) vascular irritation assay after they were encapsulated in maltodextrins. Anti-inflammatory effect along with its bioactive compounds have been identified in the flesh and peel of dragon fruit (Eldeen *et al*., 2020). The strong antioxidant activity of betalains derived from fruit peels is responsible for the potent anti-inflammatory action of these compounds. Radicals are the main mediators that promote inflammation; the inflammatory cascade has been maintained and scavenging free radicals, reduce the inflammatory response.

A study revealed that betalains contains higher radical scavenging activity, and found the presence of squalene in the fruit flesh. According to Rodriguez *et al*. (2016), free radicals are the primary pro-inflammatory mediators. As a result, removing the mediators reduces the inflammatory response.

3.4 Cardiovascular protective activity

Cardiovascular diseases encompasses a range of conditions affecting heart and blood vessels including coronary artery disease, heart failure, stroke and hypertension. This fruit, indeed holds significant promise in combating oxidative stress-related diseases due to its rich content of bioactive compounds, particularly antioxidants. These compounds play an important role in neutralizing harmful free radicals, thereby reducing oxidative stress and its associated to cells and tissues damage. Numerous studies have explored the pharmaceutical and preventive importance of dragon fruit in various oxidative stress-related conditions, including cardiovascular diseases, neurodegenerative disorders, and certain types of cancer.

The antioxidants present in pitaya, such as vitamin C, phenolic compounds, and betalains, contribute to its protective effects against oxidative damage. Red dragon fruit contains cardioprotective compounds that is the polyphenols and antioxidants which was proposed by Omidizadeh *et al*. (2011).

Dragon fruit reduced aortic stiffness in streptozotocin-induced diabetic rats, as measured by pulse wave velocity (Swarup *et al.*, 2010). This suggests a potential therapeutic effect of the dragon fruit extract on cardiovascular health in diabetic conditions. Nurul and Asmah (2014), provided evidence that supplementation with fruit juice reduced diastolic stiffness of the heart in rats with metabolic syndrome induced by a high-carbohydrate and high-fat diet. This finding suggests a potential beneficial effect of pitaya juice on cardiac function in the context of metabolic syndrome.

3.5 Antianaemia activity

Anaemia is characterized by a reduction in the number and size of red blood cells or a decrease in haemoglobin content below the normal level, which impairs the blood's ability to carry oxygen efficiently. At initial stages of pregnancy, there is a notable increase in blood plasma volume, typically by 40-45%. While the volume of erythrocytes (red blood cells) also increases, it does not rise as significantly as blood plasma volume. This leads to a condition known as hypovolemia in pregnancy. Dragon fruit, is indeed recognized for its health benefits, including its use in preventing anaemia during pregnancy. It is believed to serve as a blood booster therapy and increase endurance in pregnant women. The fruit juice had a substantial impact on hemoglobin levels and erythrocyte count, indicating potential antianemic efficacy (Widyaningsih *et al.*, 2017).

Red flesh dragon fruit, in particular, is rich in various nutrients, including iron, vitamin C, calcium, potassium, and magnesium. Iron and vitamin C are particularly notable as they are considered as good sources of antioxidants. Vitamin C enhances absorption of iron from plant-based sources, such as those found in dragon fruit, making it more bioavailable to the body (Chatterjee *et al.*, 2024). Adequate iron intake is crucial at pregnancy to prevent iron-deficiency anaemia.The benefits of using dragon fruit as a dietary supplement include improved fecal output and intestinal motility through laxative stimulation, bulk-forming facilitation, and enhanced colonic smooth muscle contractions without morphological change (Harahap and Amelia, 2019).

Dragon fruit, is indeed rich in essential nutrients that support various bodily functions, including erythropoiesis, the process of red blood cell production. According to Tenore *et al.* (2012) the fruit contains precursors necessary for erythropoiesis, such as: iron vitamins C, E, B12, thiamine, and riboflavin.

On postpartum mothers, an experiment was conducted to test the suspectability of anaemia. The mothers were provided with 400 cc of fruit juice for 14 days . The results indicate that the treatment group experienced significant increases in levels of hemoglobin, hematocrit and erythrocytes compared to the control group. This suggests that the intervention, which likely included supplementation with pitaya or its extract, had a positive effect on red blood cell parameters (Rahmawati *et al.*, 2019).

Antianaemia is beneficial since it contains high amounts of vitamin C content. Iron absorption is a complex process influenced by various factors. Non-heme iron, unlike heme iron present in animal products,

is not as readily absorbed by the body. However, vitamin C impoves the absorption of non-heme iron by converting it into a more soluble form that is easier for the body to absorb (Rahmawati *et al.*, 2019).

3.6 Antimicrobial properties

Plants have evolved various defence mechanisms to protect themselves against attacks by pathogens such as viruses, fungi, and bacteria. The physiological and biochemical basis of plant resistance to pathogens involves several mechanisms, including production of antimicrobial compounds, induced systemic resistance, hyper sensitive response, production of pathogenesis related proteins (Hernán-dez-Alvarado*et al.*,2018; Mickymaray, 2019). Betalains, a compound present in pitaya which is responsible for red pigment in the fruit with red flesh, is known to have antiviral property against dengue virus type 2 (DENV-2) which was reported by (Chang *et al.*, 2020). Red pulp of fruit was extracted from the fruit using methanol.

In an experiment conducted using the vero cells, a type of cell line used in virology research, were infected with dengue virus serotype 2 (DENV-2). After infection, the cells were treated with varying concentrations of betacyanin, a pigment found in certain plants such as beetroot and dragon fruitat 37°C (Mobhammer *et al.*, 2005). The result revealed that, at concentrations lower than 2.5 mg/ml, corresponding to 379.5 µg/ml of betacyanins, the extract did not cause significant toxicity to the Vero cells. Another study was conducted by Ismail *et al.* (2017), antimicrobial, antioxidant effects and phytoconstituents were extracted from fruit stem. The term "phytoanticipins" refers to defensive metabolites that are constitutively generated and stored in plant tissue, based on the method of biosynthesis and accumulation of defense-related phytochemicals, one of the primary criteria (Piasecka *et al.*, 2015).

An experiment for identifying the therapeutic application of antibacterial agents from the dragon fruit peels using disc diffusion and micro-dilution methods was done and reported by Nurmahani *et al.* (2012). The results revealed that peels of both fleshed dragon fruit with chloroform extract showed atmost effect of antimicrobial activity.

A study conducted regarding the antiviral effect of betacyanin as a SARS-Cov-2 inhibitor which was tested using the molecular docking study revealed that the inhibitor has the antiviral potential (Tallei *et al.*, 2021). Studies on red dragon fruit and influenza A virus, revealed that betacyanins had less number of virus in the cells (Lim *et al.*, 2024).

3.7 Wound healing property

Among the potent antioxidants found in fruit extracts, the phenolic and flavonoid contents have the potential uses in food, cosmetic, and nutraceutical applications. These compounds are also implicated in wound healing and DNA protection. Collagen contributed to the increased density and surface tension of the wound, giving it rigidity (Juliastuti *et al.*, 2020). According to a study, dragon fruit helps to promote the production of collagen fiber density, which aids in the healing of wounds.

Without the proper physiological, endocrine, and nutritional support, wound healing frequently fails in clinical pathology (Velnar *et al.*, 2009). Tsai *et al.* (2019) conducted an *in-vitro* investigation of the wound-healing capabilities of ethanol-water extracts from several components, including the peel, stem and flower. Dragon fruit has high level of DNA damage prevention activities.

Perez *et al.* (2005) examined the ability of aqueous extracts of *H. undatus* leaves, rind, pulp, and flowers to cure wounds in streptozotocin-diabetic rats. Fruit is rich in antioxidants, which help protect cells from damaging, which is due to free radicals. This can aid in the healing process by reducing oxidative stress and inflammation around the wound site.

3.8 Prebiotic effect

Oligosaccharides produced from dragon fruit have demonstrated prebiotic properties and can be used as supplements for a variety of gastrointestinal disorders (Khuituan *et al.*, 2019 ; Toktay *et al.*, 2022). The red and white dragon fruits have the potential to be sources of prebiotics, with the red fruit's oligosaccharides having a marginally stronger prebiotic effect than the white fruit's. Additionally, the flesh contains more prebiotic oligosaccharides than the peels.

Glucose, fructose, and oligosaccharides are the primary carbohydrates found in dragon fruit with white and red flesh. Artificial human gastric juice and human α amylase cannot hydrolyze the mixed oligosaccharides (about 34.88% and 4.04%, as well). Additionally, as demonstrated by their prebiotic qualities, mixed oligosaccharides can promote the growth of bifidobacteria and lactobacilli. Dasaesamoh *et al.* (2016) revealed that the dragon fruit oligosaccharide fermentation in the feces enhanced Bifidobacteria and Lactobacillus populations while decreasing Bacteroides and Clostridium populations. Furthermore, there was a beneficial prebiotic effect from this fecal fermentation. Significant amounts of propionic, butyric, acetic, and lactic acids were generated.

3.9 Antilipidemic effect

Red dragon fruit can help people with type 2 diabetes, pre-diabetes, and normocholesterolemia improve their lipid profiles by increasing HDL-c levels and reducing triglycerides and total cholesterol (Dasaesamoh *et al.*, 2016). In dyslipidemic C57BL/6 mice, red pitaya intake also improved lipid levels, which may help prevent cardiovascular illnesses (Holanda *et al.*, 2021). Setiawan *et al.* (2018) experimented the effects of dragon fruit peel powder on male Balb-c mice. Their findings indicated lower levels of LDL-c, total cholesterol, and triglycerides. Additionally, they noticed a rise in HDL-c levels.

4. Dynamic role of betalain colorants in cosmetalogy

Betalains offer a natural alternative to synthetic colorants, which aligns with the growing consumer preference for clean and sustainable beauty products. Their stability and resistance to fading make them an excellent choice for long-lasting cosmetics. Microencapsulation technology including spray drying and freeze drying of pigments provides stability to the pigments and helps in long term storage. Betalains provide a reliable source of natural colour that can be standardized and reproduced consistently, meeting the demands of cosmetic manufacturers and consumers alike.

Formulation of lipstick with betalains which is a pigment extracted from pitaya of red flesh is used which is in demand nowadays fulfilling customer satisfaction. Beetroots are the current commercialized source of betalains which possess unpleasant odour but pitaya contains higher proportion of betalains stability and do not possess any unpleasant odour . Betalains consists of two groups including betacyanins (red-violet) and betaxanthins (yellow-orange). In the cosmetic industry, betalains stands as the stunning natural pigment

to substitute synthetic dye as it contains many antioxidant sources and health benefits (Leong *et al.*, 2018). Improvement of betalain stability of red flesh dragon fruit can be achieved by ultrasound assistance (Figure 4).

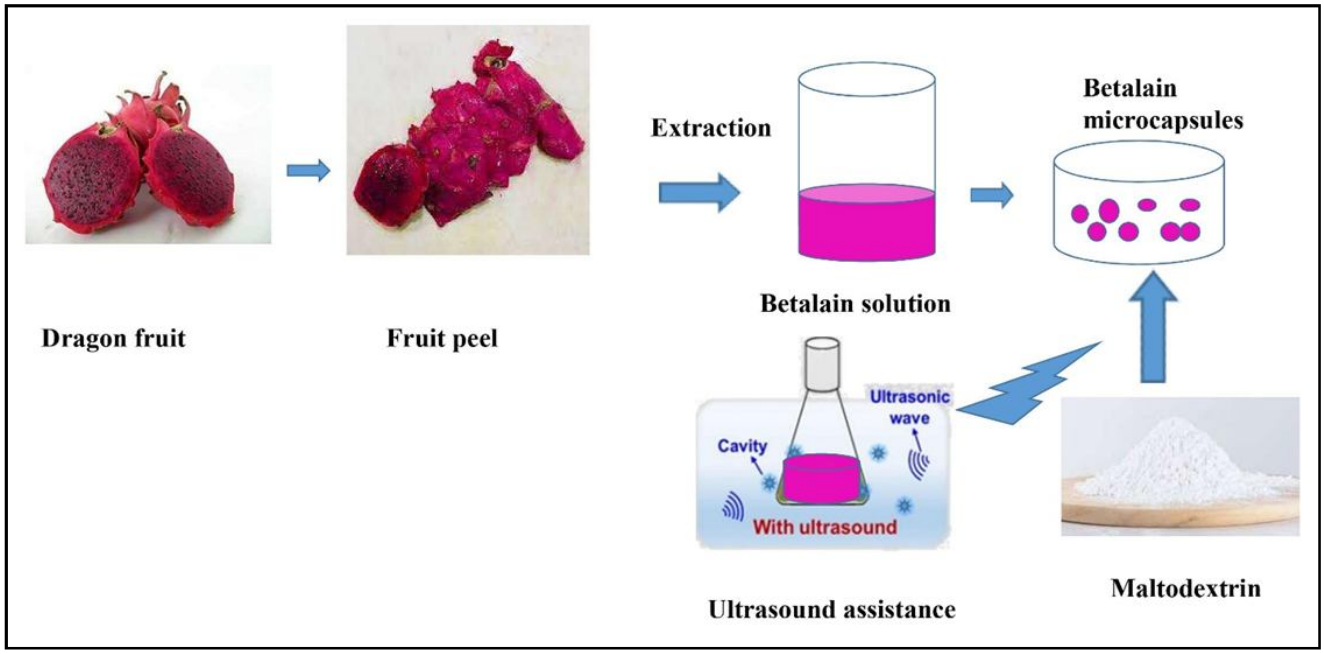


Figure 4: Enrichment of betalain stability from red flesh dragon fruit.

4.1 Lipstick and lipbalm formulations

Lipsticks are incredibly popular in the present cosmetics industry because they colour the lips, which enhances the appearance of makeup. The commercial lipsticks in the market are produced with the application of synthetic dye. These are found to be harmful as it causes dermatitis, allergy, skin diseases and lip drying. The usage of natural dye in cosmetics is only 5 to 15% (Setyawatyand Pratama, 2018).

Recent studies are going on in extracting the betalains from fruits, testing their encapsulation efficiency which is finally made into betalains powder. Formulation of lipstick is analysed based on the following: spreadability, melting point, breaking point, surface anomalies and also skin irritation test. Plant antioxidants known as flavonoids and polyphenols, which are polar and readily soluble in water, have the ability to squelch DPPH free radicals, claim (Zain and Nazeri, 2016). In addition, red dragon fruit contains the powerful antioxidant pigment betacyanin, which is found in amaranth. According to Lwin *et al.* (2020), it may prevent the oxidative damage caused by low lead levels.

Red dragon fruit is an excellent ingredient to incorporate in lip moisturizer formulations. Lip balm is a great treatment for dry and cracked lips. According to Anjarsari and Aditiyarini (2020), this red dragon fruit is known to provide a number of health benefits, including a high antioxidant content and antibacterial properties.

The fruit not only acts as a natural color to improve appearance, but it also boosts the immune system, acts as an antioxidant, and contains vitamins E, C, and A, which help to improve skin blemishes. Sandriani and her coworkers used different oil phases to extract natural dye (Sandriani *et al.,* 2017). When assessed at the proper melting temperature, the final product showed an excellent texture and good fragrance. The fruit may also be utilized as a natural colorant in cosmetics and healthcare (Phebe *et al.*, 2009). Choosing coloring agents for a cosmetic formulation that will enhance its aesthetic appeal and provide lips elegance is crucial (Pawar *et al.*, 2021).

4.2 Moisturizing agent

Essential fatty acids are thought to be abundant in the oil that is produced from tiny red dragon fruit seeds that have been covered with mucilage. These gritty seeds yield an oil that has extraordinarily high concentrations of linoleic and linolenic acids, as well as their isomers. Essential fatty acids are an effective way to balance the flow of oils in the skin and replenish the collagen that makes up the skin's metabolism (Cunnane and Anderson, 1997) .

Dragon fruit seed oil has a significant amount of linoleic acid, and its percentage is similar to the linoleic acids present in sesame seed oil, canola oil, grape seed, and flaxseed oil (Ariffin *et al.*, 2009). The fruit seed oil stands out as a superior moisturizing ingredient due to this unique characteristic. Because of its high linoleic acid content, it helps to maintain the moisture content and smooth out rough, uneven, and flaky skin. In addition, these particular necessary acids, which the body is unable to produce, help to prevent excessive hair loss in addition to improving skin health by curing psoriasis and eczema.

According to Arrifin *et al.* (2009), approximately 50.8% ± 0.53% of the oil extracted from pitaya seeds was made up of polyunsaturated fatty acids (PUFA), with linoleic acid making up the largest share at 49.6 ± 0.33%. The percentage of linolenic acid is merely 1.21 ± 0.20. This means that linoleic acid is a perfect moisturizing agent since it significantly lowers the rate of trans epidermal water loss to encourage skin hydration (Feingold *et al.*, 1986).

4.3 Natural coloring agent

Red beetroot, which has been enhanced with a pigment known as betacyanin, is currently one of the most popular commercial sources of natural colorants. However, the presence of pyrazines and geosmin in red beetroot, along with high amounts of nitrate compounds associated with the synthesis of carcinogenic nitrosamines, are responsible for the insignificance of this crop (Mobhammer *et al*., 2005). The red dragon fruit, in contrast to red beetroot, lacks this disagreeable sensory effect, making it a prime contender to replace red beets as a possible source of natural pigments (Kim *et al.*, 2011; Wybraniec *et al.*, 2007). Red dragon fruit peels and pulp have almost equal concentrations of betalains (Goñiand Hervert-Hernández, 2011). In addition, this fruit has a lot of anthocyanin pigments, which can be red, blue, or purple. This increases the fruit's potential as a natural dye (Sandriani *et al.*, 2017). Consequently, the results support the use of fruit peel in cosmetic color preparation.

4.4 Antiacne activity

Being the chronic inflammation of the skin caused by the blockage of pilosebaceous unit, *Acne vulgaris* occurs among all age group people (Heng *et al*., 2021; Tan *et al*., 2021). *Acne vulgaris* is caused by the following factors: Accelerated production of sebum, hyperkeratinisation of follicles, propionibacterium acnes colonisation, stimulation of inflammation (Agarwal *et al*., 2016). Nowadays plant based products and herbs are being used as an alternative to pharmaceutical drugs. Dragon fruit peels currently are being used as a primary product in various medical and cosmetics products treating various problems of the body.

Antibacterial effects against *Staphylococcus aureus* ATCC 25923 is studied using peels of pitaya fruit methanol extract (Astridwiyanti *et al.,*2019). The minimum fungicidal concentration (MFC) was found to be 25%, and the minimum fungicidal effect (MIC) was reported to be 12.5%, in order to provide an antibacterial impact on both gram-positive and Gram-negative bacteria (Afandi *et al*., 2017). Aqueous extract from dragon fruit peels that may be used as a pigment in lipstick formulations. A study reported led to the development of dragon fruit peel extract as a cosmetic product.The antiacne effect of the fruit peel extract in both *in vitro* and *in vivo* assays in a topical gel form for the treatment of *Acne vulgaris* have also been reported.

4.5 Antiaging agent

Given its detrimental effects on one's confidence and self-esteem, skin aging is probably one of the most common dermatological issues in today's world. The skin's structural support system can be strengthened by the addition of both collagen and elastin. The production of ROS by prolonged exposure to ultraviolet (UV) radiation speeds up the denaturation process of collagen and elastin. Over time, this mechanism causes complicated biochemical pathways to alter the skin physically, resulting in wrinkles and photoaging of the skin (Lagaand Murphy, 2009).

According to Vijayakumar *et al.* (2017), the red dragon fruit peels were put through anti-elastase and anti-collagenase tests to assess their antiageing potential based on how well they inhibited the corresponding enzymes. As per the results of the anti-elastase activity assay using ascorbic acid as a reference, red dragon fruit peels with the maximum concentration of 1000 µg/ml had a high 87.62 ± 0.05% elastase inhibition percentage, while 93.55 ± 0.11% was observed in the ascorbic acid reference solution.

Red dragon fruit peels include polyphenolic chemicals with hydroxyl groups that may interact with the side chain and backbone of the enzymes collagenase and elastase. The benzene ring of polyphenols and collagenase hydrophobically interact to cause conformational changes that impair the activity of the enzymatic component (Madhan *et al.*, 2007). The fruit peel's potential, as a good natural antiageing agent, was highlighted by their ability to inhibit the enzymes collagenase and elastase. Dragon fruit serves as good source for various cosmetics since it has enriched antioxidant (Figure 5).

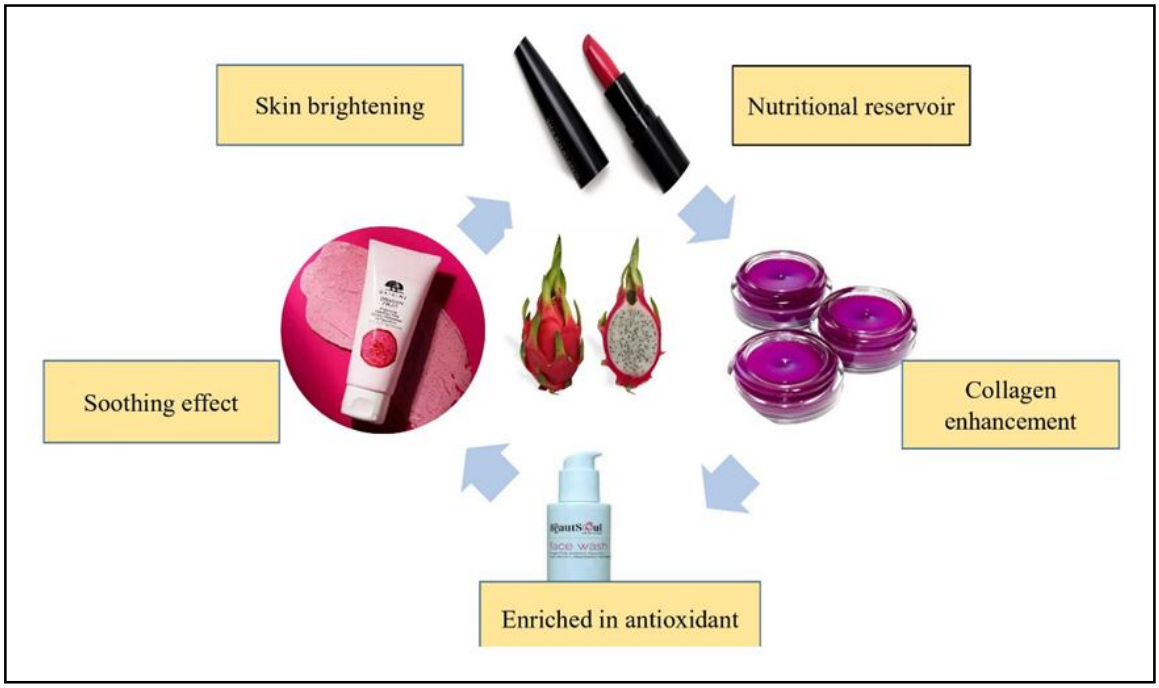


Figure 5: Cosmetalogical application of dragon fruit

5. Future prospectives

Dragon fruit, recognized as a "superfood" for its rich nutritional profile, is gaining popularity across global markets. Its high fiber, antioxidant, vitamin, and mineral content makes it ideal for health-conscious consumers. This versatile fruit is not only featured in high-fiber biscuits and yogurt, but also in innovative applications like natural dyes, fat substitutes in ice cream, and even edible films for food packaging to extend shelf life and preserve nutrients.

In the culinary world, dragon fruit is enhancing flavors and nutritional benefits in products such as beers infused with ginger and dragon fruit pulp, offering unique tastes and higher antioxidant capacities. Moreover, its seeds are being explored for their cholesterol-lowering properties and potential as a source of essential oils rich in functional lipids.

Beyond food, dragon fruit is making strides in skincare as well, with extracts showing promise in depigmentation and photoprotective effects, hinting at future applications in cosmetics. Pharmaceutical research is also underway to harness its bioactive compounds for potential medical uses. Overall, dragon fruit's expanding applications across various industries highlight its adaptability, nutritional value, and potential for innovation in creating healthier and more functional products worldwide.

6. Conclusion

The utilization of food products, as functional components or natural colorants will help increase the overall added value of dragon fruit and lessen its effect on the environment because of the many bioactive compounds that can be recovered. This review have highlighted the key important points of dragon fruit which could treat chronic diseases and cytotoxicity in cancer cells. Also, it has enormous potential to enhance human health. Furthermore, by incorporating antioxidants and dietary fibre, it can enhance several technological elements of food production and quality. The fruit is thus considered as a wonder fruit with vast health benefits and cosmetalogical potential.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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