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MORINDA CITRIFOLIA L. AND HYLOCEREUS SPP: FROM TRADITIONAL USES TO MODERN APPLICATIONS

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Abstract: Since morinda citrifolia (Noni) possesses strong antioxidant properties and well-established health advantages, it has been used as an alternative and complementary medicine for a long time in many countries. As an antibacterial, anticancer, anthelminthic, analgesic, anti-inflammatory, and immunostimulant, it has historically been used to treat a wide range of illnesses. Moreover, studies have demonstrated its efficacy in treating menstruation pain and urinary tract infections, diabetes, gastritis, skin conditions, respiratory infections, fever, and arthritis. The dragon fruit, also known as pitaya, is an exotic tropical plant that provides several health benefits due to its high nutritional content and bioactive components, which include potent natural antioxidants. Dragon fruit, which originates in Central and South America, is prized for its nutritional content and traditional medical applications, such as easing digestion and boosting the body's immune system. The stems, blossoms, peels, and pulps of dragon fruit have extracts that have a range of biologically active medicinal properties against diseases like diabetes, obesity, hyperlipidaemia, and cancer, as well as pathogenic microbes like bacteria, fungi, and viruses. Additionally, dragon fruit extracts show possible prebiotic properties along with cardiovascular and hepatoprotective effects. Furthermore, this analysis supports the pharmacological underpinnings of Noni and Dragon fruit's numerous health advantages as well as their traditional and medical uses. Dragon fruit extracts, including those from the stems, blossoms, peels, and pulps, have a range of biologically active therapeutic benefits against diseases like diabetes, obesity, hyperlipidaemia, and cancer, as well as pathogenic microbes like bacteria, fungi, and viruses. Additionally, dragon fruit extracts show possible prebiotic properties along with cardiovascular and hepatoprotective effects. Furthermore, this analysis supports the pharmacological underpinnings of Noni and Dragon fruit's numerous health advantages as well as their traditional and medical uses.

Objective: The purpose of this review is to examine how Hylocereus and Morinda citrifolia have evolved from their historic uses to contemporary ones. This review of the literature examined the pharmacological activities, chemical composition, historical and cultural relevance, traditional medical use, nutritional qualities, therapeutic uses, and botanical description of Hylocereus and Morinda citrifolia. The intention is to offer a thorough grasp of their possible advantages and prospects in the fields of health and medicine going forward.

Keywords: Morinda Citrifolia, Noni, Hylocereus, Dragon Fruit, Ethnobotany , Traditional Medicine, Modern Applications, Bioactive Compounds, Health Benefits , Pharmacological Activities, Side Effects.

INTRODUCTION

Herbal and natural folk medicine products have been utilized for ages in many different cultures all over the world. Given that these medicines actually improve patient health, scientists and medical experts have shown an increasing interest in this field [1]. Morinda citrifolia and Hylocereus are two traditional herbs that have become increasingly popular in recent years due to their cultural significance and mounting scientific evidence of their health benefits. For more than 2,000 years, Polynesians utilized Morinda citrifolia, which is known as noni, for both food and medicinal purposes [2]. The fruit is said in traditional pharmacopoeia to be able to prevent and treat a variety of illnesses. Inhibiting the formation and spread of tumours, particularly malignant ones, is another of its main uses. Boosting the immune system helps combat bacterial, viral, parasitic, and fungal infections [2,3]. It's also claimed that noni juice lowers inflammation.

Noni is mostly eaten as juice, while it can also be eaten in the form of leaves, blossoms, bark, and roots [2,3,4]. Similarly, because of its vibrant colour and nutrient-rich profile, dragon fruit, also known as pitaya, has long been employed in traditional Asian and Central American treatments. It is recognized for its capacity to support healthy metabolism and boost immunity. It can survive in both semi-arid and humid tropical and subtropical environments. The fruit has an increasing popularity owing to its many health benefits and antioxidants [5]. High water content, high Fiber content, and a wealth of nutrients, including vitamins, minerals, and antioxidants, are all present in the pulp and skins [6]. As modern science delves deeper into the health benefits of these fruits, traditional uses are confirmed and expanded upon, opening the door to new uses in contemporary nutrition and medicine. This review aims to explore the historical background of noni and dragon fruit, as well as their present and potential applications in health and wellness. This article will examine the historical usage of Hylocereus and Morinda citrifolia, as well as their phytochemical profiles and current uses in industry, medicine, and nutrition. In order to provide a whole picture of how these plants can improve current health and wellness, this analysis looks at both historical and modern perspectives.

1. Morinda Citrifolia Linn [Noni Fruit]

The scientific name for the plant that is commercially known as Noni is Morinda citrifolia. The scientific name Morinda citrifolia, which is a member of the Rubiaceae family, was originally formed from the two Latin terms "morus," which means "mulberry," and "indicus," which means "Indian". In India, M. citrifolia is known as Indian mulberry and nuna, or ach, whereas in Hawaii it is called noni. It is known as mengkudu in Malaysia, nhaut in Southeast Asia, and cheese fruit or the painkiller bush in the Caribbean [7]. Around the world, it is also referred to by a variety of regional names, including Cheese Fruit, Forbidden Fruit, Headache Tree, Hog Apple, Mona, Mora de la India, Nino, Nona, Nono, Nonu, Nuna, Pain Bush, Pain Killer Tree, Pinuela, and Wild Pine. There is currently just one cultivar (M. citrifolia cultivar Potteri) and two recognized varieties of M. citrifolia: M. citrifolia var. bracteata and M. citrifolia var. citrifolia. M. citrifolia var. citrifolia is the most widely distributed variety and has the highest health and economic significance [8,9]. At the moment, noni is a common plant found in tropical climate areas of the United States, including Hawaii, Brazil, Tahiti, Malaysia, and the Fiji Islands [10]. Australians and Indians have used the root as a dye for different shades of red, purple, and yellow. Hawaiians and Tahitians have long used various parts of the noni plant, including the stem, bark, root, leaf, and fruits, as medicines to treat conditions like fever, cough, cold, pain, and liver diseases, as well as hypertension, blood pressure, TB, malaria, intestinal worms, diabetes, loss of appetite, hernias, urinary tract infections, menstrual disorders, cancer, cardiovascular diseases, arthritis, and so forth. Seeds and their oil are used topically as an insecticide on the scalp and to treat arthritis [11].

1.1 Botanical Description

Table 1: Taxonomy of Morinda Citrifolia Linn

• Kingdom: Plantae
• Subkingdom: Virdiplantae
• Infrakingdom: Streptophyta
• Division: Embryophyta
• Superdivision: Spermatophytina
• Class : Magnoliopsida
• Superorder: Asternae
• Order: Gentianales
• Family: Rubiaceae
• Genus: Morinada L
• Species: Morinda Citrifolia L

Figure1: Morinda Citrifolia Leaves, Figure 2: Morinda Citrifolia Plant, Figure 3: Morinda Citrifolia flowers, Figure 4: Morinda Citrifolia fruit

The M. citrifolia L. species is a small, evergreen tree that grows in forests up to around 1300 feet above sea level and in open coastal habitats at sea level. The plant is frequently observed growing next to lava flows. M. citrifolia L. is characterized by recognizable leaves, white tubular flowers, and a unique yellow fruit that is ovoid and resembles a grenade. With a height of 3–10 m, Morinda citrifolia is a bush or small tree with an abundance of large, elliptical leaves that are 5–17 cm long and 10–40 cm wide. The tiny white tubular flowers are placed in groups and put onto the peduncle. The corolla is greenish-white, and the petioles leave ring-like imprints on the stalks [12,13,14,15,16]. The noni fruit has an embossed appearance and is oval in shape, measuring 3–10 cm in length and 3–6 cm in breadth [17]. The fruit has a bumpy surface covered in portions that are polygonal in shape, and it can develop to a maximum size of 12 cm or more. The triangular, reddish-brown seeds are buoyant because one end of them has a sealed air sac. This could clarify, why the plant is so widely distributed over the islands of Polynesia. Mature M. citrifolia L. fruit has an unpleasant flavor and smell [18].

1.2 Phytochemicals of noni

The M. citrifolia L. plant contains over 160 phytochemical substances that have already been identified. Phenolic compounds, organic acids, and alkaloids are the main micronutrients. The most significant phenolic compounds that have been identified include aucubin, asperuloside, scopoletin, and anthraquinones (such as damnacanthal, morindone, and morindin[19] . According to Dittmar (1993), the primary organic acids are caprylic and caproic acids [20], while xeronine (Heinicke, 1985) is the primary alkaloid that has been reported[21]. Scopoletin, octanoic acid, potassium, vitamin C, iridoids, terpenoids, alkaloids, anthraquinones (including nordamnacanthal, morindone, rubiadin, rubiadin-1-methyl ether, and anthraquinone glycoside), sitosterol, carotene, vitamin A, flavones glycosides, linoleic acid, alizarin, amino acids, acubin, L-asperuloside, caproic acid, and caprylic acid ursolic acid, rutin and a putative proxeronine are some of the major components of the M. citrfolia L. plant that have been identified.[22]

1.3 Traditional and Modern Applications of Noni

The therapeutic qualities of Morinda citrifolia Linn. (Noni) in Ayurveda
Characteristics of Rasapanchaka:

- Taste: Madhura, which is sweet; Amla, which is sour
- Guna / physical attributes: Snigdha – slimy, Guru – heavy
- Vipaka / metabolic properties: Madhura: after digestion, it takes on a pleasant flavor
- Potency / Veerya: Sheeta - cold

According to reports, Morinda citrifolia L. has a wide range of medicinal applications. It has been used for centuries in complementary and alternative medicine to treat a variety of infections and diseases, including ADD/ADHD, addictions, arthritis, emphysematous, brain disease, burns, cancer, heart disease, chemical intolerance, myalgic encephalomyelitis, diabetes mellitus, gastrointestinal disorders, adenomyosis, chronic fatigue syndrome, gouty arthritis, high blood pressure, immunocompromisation, transmissible disease, inflammation, time zone change syndrome, encephalomyelitis disseminata, muscle and joint pain, polio, rheumatism, severed fingers, sinus, and veterinary medicine[23]. M. citrifolia has demonstrated anticancer properties in pharmacological investigations on a range of cell lines, including breast, cervical, and lung cancer cells [24]. Current research has also demonstrated that M. citrifolia has hepatoprotective, antidyslipidemic, antibacterial, antifungal, antiangiogenic, and antioxidant and Immunomodulatory properties [25].

1.4 Biological properties of noni

1.4.1 Anti-microbial Effects

Certain bacteria, including Staphylococcus aureus, Pseudomonas aeruginosa, Proteus morgaii, Bacillus subtilis, Escherichia coli, Helicobacter pylori, Salmonella, and Shigella, have been shown to be inhibited in growth by M. citrifolia L. The presence of phenolic chemicals such acubin, l-asperuloside, alizarin, scopoletin, and other anthraquinones may be the cause of the observed anti-microbial effect [26]. According to a different study, Pseudomonas aeruginosa, Bacillus subtilis, Escherichia coli, and Streptococcus pyrogene are inhibited in their growth by an acetonitrile extract of the dried fruit [27]. Additionally, it has been discovered that M. citrifolia L. ethanol and hexane extracts have an antitubercular action since they reduce Mycobacterium TB growth by 89–95% [28]. According to Atkinson (1956) and Ancolio et al. (2000), Noni's antibacterial components are primarily treat skin infections, fevers, colds, and other bacterially-related illnesses [26,29].

1.4.2 Anticancer Activity

A Japanese research team has examined the immunomodulatory characteristics (the ability to strengthen the host immune system) of M. citrifolia L. juice [30]. It has been discovered that the juice of M. citrifolia L., which contains glucuronoic acid, galactose, arabinose, and rhamnose, has an ethanol precipitable fraction (ppt) that is rich in polysaccharides and has anti-tumour and immunomodulatory properties against Lewis's lung cancer (LLC). M. citrifolia L.-ppt appears to

promote T-cell, thymocyte, and macrophage production in cell models. Cytokines are vital mediators of tumour cytostasis and cytotoxicity. [Noni phytochemical constituents]. Numerous cell lines, including African human epithelial 2 cells (Hep2), human kidney cells, baby hamster kidney cells, neuroblastoma cells, and human breast adenocarcinoma cells have all been shown to be inhibited in their ability to proliferate by the methanolic extract of Morinda citrifolia Linn. fruit. It has been demonstrated that Morinda citrifolia ethanolic extract exhibits antiproliferative characteristics in B16-F10 melanoma cells (LAN5) [31]. The perennial plant Morinda citrifolia Linn. contains anthraquinones in its roots and leaves, which are used medicinally to treat a variety of chronic illnesses, including cancer and heart problem [32]. Thanks to its cytotoxic properties, TNJ is also utilized to treat cancer.

1.4.3 Antioxidant Effects

Another great natural antioxidant source is Morinda citrifolia Linn. Some portions of Morinda citrifolia, such as fruit juice with or without seeds or leaf juice, might influence antioxidant enzyme activities and cell-mediated immunity in vitro [33]. The purpose of the study was to determine how the TNJ quenched lipid peroxides (LPO) and scavenged super oxide anion radicals (SAR) using the TNB and LMB assays, respectively [34, 35]. Tetrazolium nitroblue (TNB) experiment was used to evaluate SAR scavenging activity in vitro. Three well-known antioxidants—vitamin C, powdered grape seed, and pyncogenol—were compared for their SAR scavenging action with TNJ at the daily dose per serving level suggested by US RDAs or manufacturer's recommendations. The SAR scavenging activity of TNJ was shown to be 2.8 times more than that of vitamin C, 1.4 times greater than that of pyncogenol, and 1.1 times greater than that of grape seed powder under the experimental conditions. As a result, TNJ has a significant capacity to scavenge free radicals with reactive oxygen [35]. In another study, the anti-oxidant activity of M. citrifolia was assessed as a natural anti-pigmentation agent by evaluating the impact of 50% ethanol extracts of the fruit flesh, leaves, and seeds of Tahitian M. citrifolia on the tyrosinase enzyme, which regulates the synthesis of melanin [36].

1.4.4 Antifungal Activity

The antifungal properties of Indian M. citrifolia fruit extract in three different solvents, methanol, ethyl acetate and hexane were tested in an in vitro assay on different fungi including Candida albicans, Aspergillus niger, Trichophyton mentagrophytes, Penicillium species, Fusarium species, Aspergillus fumigates, Rhizopus species, Aspergillus flavus, and Mucor species. The maximum inhibition was in the methanol and ethyl acetate extract of 79.3% and 62.06%, respectively against Trichophyton mentagrophytes, while almost 50% inhibition was recorded in the methanol extract against Penicillium, Fusarium and Rhizopus species, and none of the extracts were active against either Candida albicans or Aspergillus species [37].

1.4.5 Anti Inflammatory Activity

The anti-inflammatory qualities of Morinda citrifolia Linn. have been shown in both in vitro and in vivo models, including a broad range of pathogenic effects linked to inflammation. Morinda citrifolia Linn. juice directly reduces paw edema by inhibiting COX 1 & 2 and reducing the formation of nitric oxide in the J774.G8 cell line. This mechanism is dose-dependent and illustrates the plant's anti-inflammatory properties [38]. The Morinda citrifolia Linn. leaves' aqueous extracts have been shown by Serafini et al. (2011) to be useful in treating pain and inflammation, especially oxidation-related inflammation, and to dramatically inhibit leukocyte migration [39].

1.4.6 Antidiabetic Activity

The hypoglycaemic characteristics of Hawaiian fermented M. citrifolia fruit juice was linked to its capacity to modify transcription factors (FoxO1), which in turn controls the gluconeogenic process, according to findings from a microarray investigation. Male mice's glucose and insulin tolerance, as well as their fasting blood glucose level, were enhanced by a 12-week supplement of fermented M. citrifolia juice administered twice daily at a dose of 1.5 µl/g body weight. More than 80% of the insulin-regulated glucose-producing genes, such as glucose-6-phosphatase and phosphoenolpyruvate

C kinase, were likewise suppressed [40]. By promoting insulin secretion, the saponins and flavonoids in M. citrifolia fruit, such as rutin, may also function as a secretagogue[41].

1.4.7 Immunological Activity

According to an in vivo study conducted on mice, M. citrifolia fruit juices, whether Tahitian or commercial, enhanced immunity. This suggests that M. citrifolia modulates the immune system by activating CB2 receptors, suppressing interleukin-4, and increasing the production of interferon gamma cytokines. Nevertheless, in order to clarify the dosage and precise mechanism of action of M. citrifolia on the immune system, the scientists suggested doing more in vivo and clinical studies. [42]

1.4.8 Anti-arthritic Activity

When given orally to arthritic rats at doses of 1.8 and 3.6 milliliters per kg, an Indian brand of M. citrifolia fruit juice shown a substantial reduction in paw thickness, arthritic index, secondary lesions, mononuclear infiltration, and pannus development that was dose dependent. The use of indomethacin similarly produced similar results, with the exception of a decrease in secondary lesions. Flavonoids and phenols may be the cause of the anti-arthritic action [43].

1.4.9 Wound healing Activity

It was discovered that M. citrifolia leaf extract had wound-healing properties. The inclusion of antioxidants such as β-carotene, flavonol, and iridoid glycosides may be the reason for the decrease in lipid peroxide levels observed in the M. citrifolia treated group [44].

1.4.10 Anti-viral Activity

The fruit component of M. citrifolia, called damnacanthal, has been shown to exhibit antiviral action in vitro by blocking an accessory protein of the HIV-1 virus in Hela cells via an unidentified mechanism. The authors recommended more research to clarify M. citrifolia's antiviral mechanism, which may be helpful in determining how best to treat HIV-1 and other viral illness.[45]

1.4.10 Effect on skin protection

Leaf extracts of noni have protective properties for the skin The skin was shielded from UV-induced redness and swelling (erythema) by noni leaf extract. According to research, leaves can be used topically without risk and may even help lessen skin damage from ultraviolet (UV)B rays.[46]

2.Hylocereus spp [Dragon Fruit]

Dragon fruit, also known as pitaya or strawberry pear (Hylocereus spp. and Selenicereus spp.), or kamalam, is becoming a mega crop everywhere, even in marginal terrain, because of its therapeutic and health benefits. It is essentially a native of Central and South America climbing cactus vine that is resistant to abiotic stressors, illnesses, and pests. It is a member of the family Cactaceae. Its distinct visual appeal has made it well-liked. Its flesh and skin exhibit a variety of vivid colors, such as red and pink, white and pink, red-purple, or yellow and white [47] .Numerous advantages come with it, including low water and nutrient requirements, minimal resources needed to establish and maintain the orchard, the capacity to sustain a high yield for up to 20 years, a high benefit-to-cost ratio, and a high concentration of functional properties and nutraceuticals (rich in antioxidants and fiber, for example). Many people refer to dragon fruit as a "super-fruit" because of its antioxidant qualities. Dragon fruit has many health advantages, such as better digestion and weight control. It is high in fiber, water-soluble chemicals, vitamin C, and antioxidants. Additionally, it helps to lower LDL cholesterol levels and strengthen the immune system [48]. Growers all around the world are being drawn to establish and expand their dragon fruit growing businesses by these qualities. From its original core, this fruit migrated to tropical and subtropical America, Asia, Australia, and the Middle East. Australia, Cambodia, China, Israel, Japan, Nicaragua, Peru, Philippines, Spain, Sri Lanka, Taiwan, Thailand, South-Western USA, and Vietnam are among the countries where it is widely

grown [49, 50]. Known as "Noble Woman" or "Queen of the Night," this plant has a long day and a magnificent blossom that blooms at night.

The fruit is also referred to as Jesus in the Cradle, Night Blooming Cereus, Cinderella plant, Belle of the Night, Dragon Fruit, Pithaya, and Strawberry Pear. Because of the bracts or scales on the fruit's skin, the fruit is known as pitaya, which translates to "the scaly fruit." The huge, creamy white flowers (25 cm in diameter) that bloom at night give it its beautiful significance. It is seen as a crop of fruit for the future [51]. The three types that are primarily grown are Hylocereus undatus (red skin and white flesh), H. polyrhizus (red skin and red flesh), and H. megalanthus (yellow skin and white flesh) [52,53]. These variations are identified by the colour of the skin and flesh. The pulp of the fruit tastes sour and sweet, and it has an oval form. The seeds are tiny and have a black appearance [54,55]. Figures 1 and 2 show the plant, the flower, and the fruit of Hylocereus spp. The edible sections of dragon fruit, such as the flesh and seed, as well as the non-edible parts, such as the peel, are rich sources of several phytoconstituents, including phenolic compounds, pigments, terpenoids, fatty acids, flavonoids, vitamins, carbohydrates, minerals, and dietary fibers [56,57]. The fruit has several therapeutic properties, including anti-oxidant, anti-cancer, anti-diabetic, anti-microbial, anti-hyperlipidaemic, anti-obesity, hepatoprotective, anti-anaemic, anti-inflammatory, antiviral, prebiotic, and wound healing properties, because of these varied phytoconstituents [58,59]. Techniques like microwave-assisted extraction (MAE), ultrasound-assisted extraction (UAE), supercritical fluid extraction (SFE), aqueous enzymatic extraction (AEE), etc. are used to extract phytoconstituents from the various portions of the fruit. Dragon fruit has been used as traditional medicine in Asian nations to treat a wide range of illnesses. For instance, H. undatus blossoms have been used to treat diabetes, mumps, bronchitis, hyperactivity, and tuberculosis. The fruit has been used in Taiwan as a rice substitute and as a source of dietary fiber for people with diabetes [60].

2.1 Botanical Description

The super fruit known as dragon fruit, which has recently been introduced to India, is thought to have enormous commercial potential. Fruit growers from all over India plant this crop because of its eye-catching color, velvety pulp, and tasty black seed imbedded in the pulp. Its outstanding nutritional content further draws them in [61].

Table:2 Taxonomy of Hylocereus species

Domain	Eukaryote
Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Caryophyllidae
Order	Caryophyllales
Family	Cactaceae
Subfamily	Cereoideae
Tribe	Hylocereae
Genus	Hylocereus

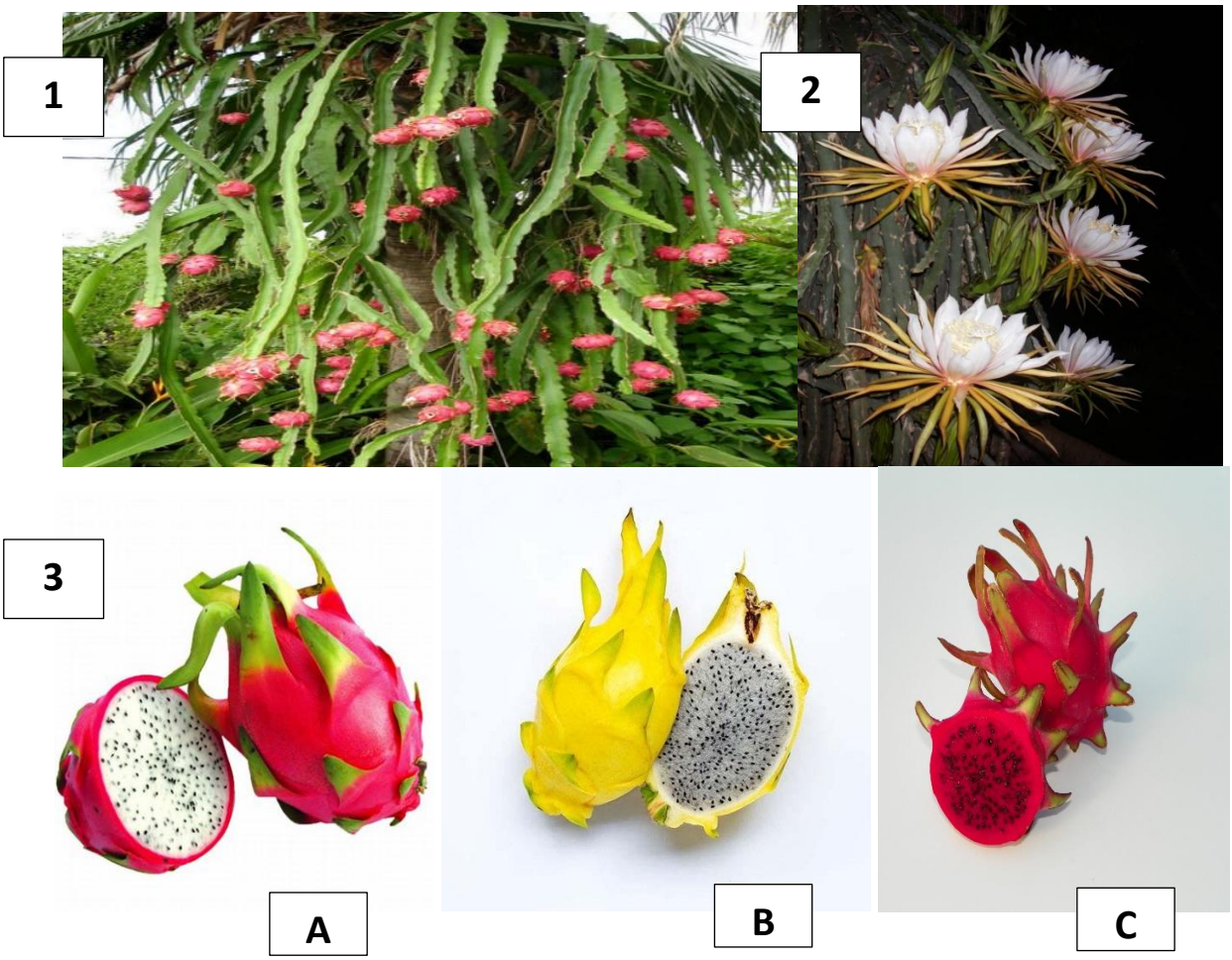

Figure 1: Hylocereus Plant, Figure 2: Hylocereus Flowers, Figure 3: Varities of Hylocereus Species (a) Hylocereus Udantus, (b)Hylocereus Megalanthus, (c) Hylocereus Polyrhizus

The evergreen dragon fruit plant (Hylocereus spp.) grows quickly and can reach a height of 1.5 to 2.5 meters. Its thin, leafless branches resemble vines. It is a green, succulent, three-winged terrestrial or epiphytic cactus. The stem has numerous branching segments and is soft and vine-like. Every segment has three wings that are wavy, one to three spines, or none at all. The plant's aerial roots take in water, develop on the underside of the stems, and maintain the stems on vertical surfaces. Dragon flowers are typically white, and the fruits have a bell-shaped appearance and measure 25 to 30 cm in length and 15 to 17 cm in width. The fruit has stunning brilliant crimson skin that is scattered with green scales and white or red flesh with numerous tiny black seeds. It needs support to hold the vine upward [62].

2.2 Traditional uses and Nutritional values

One such potential crop that may be easily grown across the nation in areas that are prone to drought and deteriorated terrain is dragon fruit. It has become a popular salad fruit due to its vibrant bracts, dark red meat, and tasty little black seeds embedded in white flesh. It was first popularized as an ornamental plant and then as a fruit crop. Dragon fruit pulp can be used to produce value-added products such wine, syrup, candies, jam, and jelly [63]. The dietary and therapeutic properties of dragon fruit contribute to a number of health advantages, chief among them being the control and mitigation of oxidative stress. The pitaya possesses bioactive compounds in its stems, blossoms, peels, and pulps, which are involved in many biological activities such as antioxidant, antibacterial, and anticancer capabilities. For the treatment and prevention of diseases like diabetes, cancer, obesity, hyperlipidaemia, and pathogenic agents like viruses, bacteria, and fungi, these include betalains,

flavonoids, polyphenols, terpenoids and steroids, saponins, alkaloids, tannins, and carotenoids. It has been demonstrated that these natural substances are more efficacious, healthier, safer, and longer-lasting than synthetic drugs [64]. In addition, pitaya has culinary and nutritional uses and can be used in the cosmetic and pharmaceutical industries. The leaves and petals of H. undatus were traditionally utilized by the ancient Maya as a diuretic, hypoglycaemic, and medicinal plant. There are medical uses for pitaya as well. The fruit affects gastritis's, the blossoms and stalk are used to treat kidney issues, the fruit can be eaten or used to make tea, and the seeds have a laxative effect. The pharmaceutical industries can make use of the cactus' vegetative portions. Certain cactus extracts have been linked to blood pressure, appetite, thirst, and sleep regulation as well as central nervous system stimulation [65]. In addition to the nutritional advantages of ripe fruit, fruit peels can also be used as an antioxidant, natural colour, and antibacterial agent. The seeds are mostly used to extract the oil, which contains roughly 50% essential fatty acids, while the skin is used to make natural food coloring and as a source of pectin. Furthermore, a variety of food items, including syrups, ice creams, candies, and yogurts, contain seeds as an ingredient. [66]

2.3 Phytochemistry and Medicinal values of Dragon Fruit

Dragon fruit contains a variety of phytochemicals, the most common of which are phenols, flavonoids, sterols, fatty acids, and tocopherol. Of the many bioactive substances present in the pulp and peel, some worth mentioning are the following: minerals such as calcium, magnesium, potassium, phosphorous, betacyanin, β-carotene, lycopene, p-coumaric acid, protocatechuic acid, vanillic acid, gallic acid, syringic acid, and p-hydroxybenzoic acid [67].The results of the nutritional analysis showed that the average pitaya contains moisture (84-86 g/100 g), protein (0.93-1.33 g/100 g), fat (0.40-1.01 g/100 g), vitamin C (1.0- 6.3 mg/100 g), vitamin A (0.0066-0.186 mg/100 g), ash (0.56 g/100 g), crude fibre (0.88-1.84 g/100 g), glucose (4.63-6.39 g/100 g), fructose (2.16-4.06 g/100 g), sorbitol 0.33 g/100 g), and carbohydrate (10.4-12.3 g/100g). Pitaya also contains several minerals such as iron (1.95-7.4 mg/100 g), potassium (181.0-321.0 mg/100 g), niacin (2.3-3.5 mg/100 g), calcium (7.6-15.6 mg/100 g), magnesium (29.5- 44.3 mg/100 g), phosphorus (22.8-31.8 mg/100 g), sodium (5.0-13.5 mg/100 g), and zinc (0.26-0.42 mg/100 g) . Red dragon fruit contains minerals and nutrients such as vitamin B2, vitamin B3, Vitamin B1, Vitamin C, fat, carbohydrates, protein, betacyanin's, polyphenols, iron, Phyto albumin, carotene, cobalamin, glucose, and phenolic. Red dragon fruit, which is rich in nutrients and minerals, helps the digestive system, is anti-diabetic, lowers blood pressure, eliminates toxins from the body—particularly heavy metal toxins—treats coughs and asthma, and prevents a number of cancers, including colon cancer. The Phyto albumin content of dragon fruit, which has a very high antioxidant content, plays a role in cancer prevention. Red dragon fruit also contains iron, which can be used to cure anaemia by raising haemoglobin and erythrocyte levels. However, the only study on utilizing dragon fruit to treat anaemia is still in rat clinical trials. Pitaya seed oil contains conjugated linoleic acid, omega-3 fatty acids, and phytosterols, and medium chain triglycerides that are beneficial in treating obesity and bone health [68].

2.4 Pharmacological Activities

2.4.1Antioxidant Activity

A class of naturally occurring chemicals called antioxidants is present in a wide variety of fruits and can help shield our bodies' physiological systems from oxidative stress. Because the body uses oxygen on a daily basis, free radicals are constantly produced. Free radicals from oxidative stress cause cell damage in our bodies and are linked to a variety of illnesses, including aging, inflammatory diseases, Parkinson's dementia, Alzheimer's disease, neurological disorders, cardiovascular disease, cancer, and muscular dystrophy [69]. The red-fleshed pitaya, or H. polyrhizus, is rich in betalains, which satisfy consumer demand for antioxidant-rich goods and natural food colouring. Pitaya seed oil has a great deal of promise as a natural antioxidant source [70]. Vitamin C and vitamin E (α-tocopherol) are not as effective antioxidants as phenolic substances, such as phenolic acid (e.g., gallic acid) and polyphenol (e.g., flavonoids), which have been shown to be strongly connected with antioxidant activity [71, 72].

2.4.2 AntiInflammatory Activity

Dragon fruit has anti-inflammatory properties in addition to antioxidant ones. Pitaya red pulp and peel were reported to have three different types of anthocyanins (cyanidin 3-glucoside, delphinidin 3-glucoside, and pelargonidin 3-glucoside) by Saenjum et al. It was discovered by the authors that, in vitro models, pulp enriched in cyanidin 3-glucoside, the first anthocyanin, reduced the generation of reactive oxygen and nitrogen species, cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS), without causing cytotoxicity [73]. Fruit has anti-inflammatory properties because it contains substances like betalains and squalene. Problems arise, though, from betalains' instability under typical storage circumstances and their vulnerability to harmful elements like light, temperature, oxygen, and ph. Consequently, their bioactivities may be increased by encasing them in a protective covering [74]. The anti-inflammatory properties of betalains derived from H. polyrhizus peel extract were noted by Rodriguez et al. The activity was assessed using the duck embryo chorioallantoic membrane (CAM) vascular irritation assay after betalains were encapsulated in maltodextrins [75].

2.4.3 AntiCancer Activity

Degenerative disorders including cancer and Alzheimer's disease arise as a result of oxidative stress in cells, which is caused by an imbalance between ROS species and antioxidants. Dragon fruit phytoconstituents, including unsaturated fatty acids, polyphenolics, betalains, and tocopherols, have been demonstrated to have chemotherapeutic effects on a range of cancer cell lines [76, 77]. For example, dragon fruit extracts in both methanolic and aqueous form shown strong cytotoxic effects on prostate and colon cancer cell lines [78].

2.4.4 AntiDiabetic Activity

Red dragon fruit can help patients with Type II Diabetes lower their blood glucose levels. Glucose is the ingredient in red dragon fruit that reduces blood sugar levels [79]. Apart from glucose, the dietary fiber in dragon fruit also serves to lessen the rate at which food is broken down in the intestines, which lowers the production of blood glucose [80]. Saponins from dragon fruit seeds are soluble in water extracts and have been shown to have antidiabetic properties, particularly for type II diabetics [81].

2.4.5 Antimicrobial Activity

An extract made from ethanol from the flesh of white dragon fruit was found to contain about 85% of mixed oligosaccharides. These oligosaccharides were more resistant to human salivary α-amylase than inulin. Rather than being broken down in the stomach, this acts as prebiotics to support the stomach. The good bacteria Lactobacilli and Bifidobacteria are proliferating [82].The antibacterial activity of chloroform, hexane extract, and ethanol from the skin of white dragon fruit was determined by disc diffusion analysis, and it was found that both Gram-positive and Gram-negative bacteria could be inhibited within an area of 7 to 9 mm [83].

2.4.6 Hypolipidemic Activity

Activity involving hypolipidemia Rats' hypolipidemic activity was assessed using an extract from the flesh of dragon fruits. The extract from dragon fruit flesh has the potential to significantly increase blood HDL cholesterol, total fecal cholesterol, and fat while significantly lowering TG, LDL, total cholesterol, and total cholesterol ratio over HDL cholesterol, body weight, and Lee index obesity. This study demonstrated the biological effects of extract from dragon fruit flesh, including anti-obesity and hypolipidemic properties that may prevent atherosclerosis. Consuming extract from dragon fruit flesh may increase the amount of fat and cholesterol in excrement in addition to binding them from the feed [84].

2.4.7 Antianaemic Activity

Iron, vitamin C, calcium, potassium, and magnesium have all been found in red dragon fruit; the first two are thought to be excellent sources of antioxidants, which lower blood pressure and blood sugar. Red dragon fruit juice was found to have an impact on pregnant women's erythrocyte count and

haemoglobin level as per Widyaningsih et al. Due to its high iron content, red dragon fruit has the potential to treat anaemia. The authors came to the conclusion that the red dragon fruit juice had a noteworthy impact on haemoglobin levels and erythrocyte count on the seventh day after administration, indicating that it may have anti-anaemic properties [85].

2.4.8 Wound Healing Activity

Red dragon fruit contains quercetin and tannins, which are believed to help promote wound healing. When Tahir et al. assessed the red dragon fruit cream's capacity for wound healing, they discovered that the wound's diameter decreased on the third day following treatment. On days 7 and 14, there was a notable decrease as compared to the group that did not get treatment. It was thought that the flavonoids and phenol, which functions as an anti-inflammatory component, were responsible for these effects. Quercetin was thought to be involved for the closure of wounds through the encouragement of angiogenesis, an increase in epithelial cells, and the proliferation of fibroblasts. Flavonoids were demonstrated to be important for the production of collagen [86].

Importance of Studying Their Traditional and Modern Applications

Studying the traditional and modern applications of Morinda citrifolia and Hylocereus is crucial for several reasons:

1. Preservation of Traditional Knowledge: Indigenous knowledge and cultural legacy are preserved when traditional applications of these plants are recognized and documented. This information might offer insightful suggestions for sustainable practices and natural cures.[87]

2. Scientific Validation:The effectiveness and safety of these plants can be confirmed by conducting scientific study on their traditional applications. This may result in the creation of novel medicinal substances and healthcare items derived from natural substances [87].

3. Nutritional and Health Benefits: Hylocereus and Morinda citrifolia are both abundant in bioactive substances that provide several health advantages. Our knowledge of these plants' nutritional profiles and their health benefits can be increased by studying them, which could result in better recommendations for nutrition and functional foods [88].

4. Economic Opportunities: The sale of goods made from these plants can support sustainable development while opening up economic opportunities for nearby people. This covers the production, handling, and distribution of noni and dragon fruit goods.[89].

5. Environmental Sustainability: Encouraging the use and growth of these plants can help maintain the sustainability of the ecosystem. Compared to other crops, both plants have comparatively little environmental impact and may be produced in a variety of climates [89].

Conclusion

Noni, also known as Morinda citrifolia, has long been utilized for its many medicinal benefits, which include antibacterial, antioxidant, and anti-inflammatory activities. Numerous applications have been confirmed by contemporary research, which highlights its promise in medicines, nutraceuticals, and as a functional food ingredient. It is a nutritional supplement that is used in conventional medicine. But some research has revealed worries regarding its possible hepatotoxicity, highlighting the necessity of cautious dose and monitoring.

Hylocereus, which is well-known for its fruit, dragon fruit, has also undergone a change in usage from traditional uses to contemporary ones. Its strong antioxidant, vitamin, and mineral content is now acknowledged as one of its nutritional advantages. Its uses have spread to include natural colorants in food products, health supplements, and cosmetics. It has demonstrated potential for enhancing cardiovascular health, suppressing diabetes, and strengthening the immune system. It has been observed that excessive noni consumption led to gastrointestinal issues like bloating and diarrhoea. Studies on toxicology show that it is typically safe to eat, with no serious side effects observed.

In conclusion, Morinda citrifolia and Hylocereus are two examples of how traditional knowledge may be combined with cutting-edge scientific research to open up new possibilities and uses that will help a variety of sectors and advance wellbeing and health. Both herbs have potential uses in medicine and

provide significant health advantages. To guarantee their safety and effectiveness over the long term, however, and to completely comprehend their mechanisms of action, more research is required. In the end, Morinda citrifolia and Hylocereus' lasting influence emphasizes the ageless benefits of natural cures and their developing place in contemporary medicine.

References

1. Wang, M. Y., West, B. J., Jensen, C. J., Nowicki, D., Su, C., Palu, A. K., & Anderson, G. (2002). Morinda citrifolia (Noni): a literature review and recent advances in Noni research. Acta Pharmacologica Sinica, 23(12), 1127-1141.
2. Nagalingam, S., Sasikumar, C. S., & Cherian, K. M. (2013). International Journal of Universal Pharmacy and Bio Sciences,2(6) ,(ISSN): 2319-8141
3. Dixon, A.R., McMillen, H., Etkin, N.L., 1999. Ferment this: the transformation of Noni, a traditional Polynesian medicine (Morinda citrifolia, Rubiaceae). Economic Botany ,53, 51–68.
4. McClatchey, W. (2002). From Polynesian healers to health food stores: changing perspectives of Morinda citrifolia (Rubiaceae). Integrative cancer therapies, 1(2), 110-120.
5. Jadhav, S. B., & Jadhav, N. Y. (2023). An eye catching and comprehensive review on dragon fruit (An exotic super fruit). Journal of Pharmacognosy and Phytochemistry, 12(6), 243-251.
6. Luu, T. T. H., Le, T. L., Huynh, N., & Quintela-Alonso, P. (2021). Dragon fruit: A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam. Czech Journal of Food Sciences, 39(2), 71-94.
7. Vuanghao, L., & Laghari, M. H. (2017). Morinda citrifolia (Noni): A comprehensive review on its industrial uses, pharmacological activities, and clinical trials. Arabian Journal of Chemistry, 10, 691-707
8. Pawlus, A. D., & Kinghorn, A. D. (2007). Review of the ethnobotany, chemistry, biological activity and safety of the botanical dietary supplement Morinda citrifolia (noni). Journal of Pharmacy and pharmacology, 59(12), 1587-1609.
9. Mathivanan, N., Surendiran, G., Srinivasan, K., Sagadevan, E., & Malarvizhi, K. (2005). Review on the current scenario of Noni research: Taxonomy, distribution, chemistry, medicinal and therapeutic values of Morinda citrifolia. International Journal of Noni Research, 1(1), 1-16.
10. Inada, A. C., Figueiredo, P. S., Santos-Eichler, R. A. D., Freitas, K. D. C., Hiane, P. A., Castro, A. P. D., & Guimarães, R. D. C. A. (2017). Morinda citrifolia Linn.(Noni) and its potential in obesity-related metabolic dysfunction. Nutrients, 9(6), 540.
11. Ali, M., Kenganora, M., & Manjula, S. N. (2016). Health benefits of Morinda citrifolia (Noni): A review. Pharmacognosy Journal, 8(4).
12. Morton, J.F., 1992. The ocean-going Noni, or Indian mulberry (Morinda citrifolia, Rubiaceae) and some of its ‘‘colourful’’ relatives. Economic Botony ,46(3), 241–256
13. Elkins, R., 1998. Hawaiian Noni (Morinda citrifolia) Prize Herb of Hawaii and the South Pacific. Woodland Publishing, Utah.
14. Dixon, A. R., McMillen, H., & Etkin, N. L. (1999). Ferment this: the transformation of Noni, a traditional Polynesian medicine (Morinda citrifolia, Rubiaceae). Economic botany, 51-68.
15. Ross, I. A. (2001). Glycyrrhiza glabra. In Medicinal Plants of the World: Chemical Constituents, Traditional and Modern Medicinal Uses, Volume 2 (pp. 191-240). Totowa, NJ: Humana Press.
16. Cardon, D., 2003. Le Monde des Teintures Naturelles. Belin, Paris.
17. Chan-Blanco, Y., Vaillant, F., Perez, A. M., Reynes, M., Brillouet, J. M., & Brat, P. (2006). The noni fruit (Morinda citrifolia L.): A review of agricultural research, nutritional and therapeutic properties. Journal of food composition and analysis, 19(6-7), 645-654.
18. Krishnaiah, D., Nithyanandam, R., & Sarbatly, R. (2012). Phytochemical constituents and activities of Morinda citrifolia L. Phytochemicals-a global perspective of their role in nutrition and health, 127-150.
19. WANG, M. Y., & Su, C. (2001). Cancer preventive effect of Morinda citrifolia (Noni). Annals of the New York Academy of Sciences, 952(1), 161-168.

20. Dittmar, A. (1993). Morinda citrifolia L.-: Use in Indigenous Samoan Medicine. Journal of Herbs, Spices & Medicinal Plants, 1(3), 77–92.
21. Heinicke, R. M. (1985). The pharmacologically active ingredient of Noni. Bulletin of the national tropical Botanical garden, 15(1), 45-52
22. Mahanthesh, M. C., Manjappa, A. S., Shindhe, M. V., Jamkhandi, C. M., Jalapure, S. S., & Patil, S. S. (2013). Morinda citrifolia Linn; A medicinal plant with diverse phytochemicals and its medicinal relevance. World J. Pharm. Res, 3(1), 215-232.
23. Patil, P., Madkaikar, H., & Shah, N. (2022). Morinda citrifolia L.(Noni)-Its ethnobotanical knowledge, phytochemical studies, pharmacological aspects, and future prospects. Int. J. Nov. Res. Dev.(IJNRD), 7, 331-352.
24. Brown, A. C. (2012). Anticancer activity of Morinda citrifolia (Noni) fruit: a review. Phytotherapy Research, 26(10), 1427-1440
25. Chanthira Kumar, H., Lim, X. Y., Mohkiar, F. H., Suhaimi, S. N., Mohammad Shafie, N., & Chin Tan, T. Y. (2022). Efficacy and safety of Morinda citrifolia L.(noni) as a potential anticancer agent. Integrative cancer therapies, 21, 15347354221132848
26. Atkinson, N. (1956). Antibacterial substances from flowering plants. 3. Antibacterial activity of dried Australian Plants by rapid direct plate test, Australian Journal of Experimental Biology, Vol.34(1), pp. 17-26, ISSN 0004-945X
27. Locher, C. P., Burch, M. T., Mower, H. F., Berestecky, J., Davis, H., Van Poel, B., ... & Vlietinck, A. J. (1995). Anti-microbial activity and anti-complement activity of extracts obtained from selected Hawaiian medicinal plants. Journal of ethnopharmacology, 49(1), 23-32.
28. Saludes, J. P., Garson, M. J., Franzblau, S. G., & Aguinaldo, A. M. (2002). Antitubercular constituents from the hexane fraction of Morinda citrifolia Linn.(Rubiaceae). Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 16(7), 683-685.
29. Ancolio, C., Azas, N., Mahiou, V., Ollivier, E., Keita, A., Timon David, P., (2000 Feb 29). Anonymous Guinea pig antigenicity study. TAHITIAN NONI® . Product safety labs (Eurofins scientific, Inc) East Drunswick, New Jersey, USA
30. Hirazumi, A., Furusawa, E., Chou, S. C., & Hokama, Y. (1996, January). Immunomodulation contributes to the anticancer activity of morinda citrifolia (noni) fruit juice. In Proceedings of the Western Pharmacology Society (Vol. 39, pp. 7-9).
31. Hirazumi, A., Furusawa, E., Chou, S. C., & Hokama, Y. (1994, January). Anticancer activity of Morinda citrifolia (noni) on intraperitoneally implanted Lewis lung carcinoma in syngeneic mice. In Proceedings of the Western pharmacology society (Vol. 37, pp. 145-146).
32. Anekpankul, T., Goto, M., Sasaki, M., Pavasant, P., & Shotipruk, A. (2007). Extraction of anti-cancer damnacanthal from roots of Morinda citrifolia by subcritical water. Separation and Purification Technology, 55(3), 343-349.
33. Ali, M., Singh, P., Singh, L., Kumar, S., & Scholar, P. G. (2020). Phytochemical Constituents and Pharmacological Activities, Profile of Morinda Citrifolia: A Review. World Journal of Pharmaceutical Research, 9(14), 422.
34. Auerbach, B. J., Kiely, J. S., & Cornicelli, J. A. (1992). A spectrophotometric microtiter-based assay for the detection of hydroperoxy derivatives of linoleic acid. Analytical biochemistry, 201(2), 375-380.
35. Wang, M.Y., Su, C., Nowicki, D., Jensen, J. and Anderson, G. (2001). Morinda citrifolia and cancer prevention. J. Nutrition,131 (11S),3151S
36. Masuda, M., Murata, K., Fukuhama, A., Naruto, S., Fujita, T., Uwaya, A., ... & Matsuda, H. (2009). Inhibitory effects of constituents of Morinda citrifolia seeds on elastase and tyrosinase. Journal of Natural Medicines, 63, 267-273.
37. Jayaraman, S. K., Manoharan, M. S., & Illanchezian, S. (2008). Antibacterial, antifungal and tumor cell suppression potential of Morinda citrifolia fruit extracts. International Journal of Integrative Biology, 3(1), 44-49.

38. Dussossoy, E., Brat, P., Bony, E., Boudard, F., Poucheret, P., Mertz, C., Giaimis, J., & Michel, A. (2011). Characterization, anti-oxidative and anti-inflammatory effects of Costa Rican noni juice (Morinda citrifolia L.). Journal of ethnopharmacology, 133(1), 108–115.
39. Serafini, M. R., Santos, R. C., Guimarães, A. G., Dos Santos, J. P., da Conceicão Santos, A. D., Alves, I. A., Gelain, D. P., de Lima Nogueira, P. C., Quintans-Júnior, L. J., Bonjardim, L. R., & de Souza Araújo, A. A. (2011). Morinda citrifolia Linn leaf extract possesses antioxidant activities and reduces nociceptive behavior and leukocyte migration. Journal of medicinal food, 14(10), 1159–1166.
40. Nerurkar, P. V., Nishioka, A., Eck, P. O., Johns, L. M., Volper, E., & Nerurkar, V. R. (2012). Regulation of glucose metabolism via hepatic forkhead transcription factor 1 (FoxO1) by Morinda citrifolia (noni) in high-fat diet-induced obese mice. British Journal of Nutrition, 108(2), 218-228.
41. Nayak, B. S., Marshall, J. R., Isitor, G., & Adogwa, A. (2011). Hypoglycemic and hepatoprotective activity of fermented fruit juice of Morinda citrifolia (Noni) in diabetic rats. Evidence-Based Complementary and Alternative Medicine, 2011(1), 875293.
42. Palu, A. K., Kim, A. H., West, B. J., Deng, S., Jensen, J., & White, L. (2008). The effects of Morinda citrifolia L.(noni) on the immune system: its molecular mechanisms of action. Journal of Ethnopharmacology, 115(3), 502-506.
43. Saraswathi, C. D., Prakash, W. S., & Kunal, P. W. (2012). Anti-arthritic activity of Morinda citrifolia L. fruit juice in Complete Freund's Adjuvant induced arthritic rats.
44. Rasal, V. P., Sinnathambi, A., Ashok, P., & Yeshmaina, S. (2008). Wound healing and antioxidant activities of Morinda citrifolia leaf extract in rats.
45. Kamata, M., Wu, R. P., An, D. S., Saxe, J. P., Damoiseaux, R., Phelps, M. E., ... & Chen, I. S. (2006). Cell-based chemical genetic screen identifies damnacanthal as an inhibitor of HIV-1Vpr induced cell death. Biochemical and Biophysical Research Communications, 348(3), 1101-1106.
46. West, B. J., Deng, S., Palu, A. K., & Jensen, C. J. (2009). Morinda citrifolia Linn.(Rubiaceae) leaf extracts mitigate UVB-induced erythema. Journal of natural medicines, 63, 351-354.
47. Luu, T. T. H., Le, T. L., Huynh, N., & Quintela-Alonso, P. (2021). Dragon fruit: A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam. Czech Journal of Food Sciences, 39(2), 71-94.
48. Hossain, F. M., Numan, S. M. N., & Akhtar, S. (2021). Cultivation, nutritional value, and health benefits of Dragon Fruit (Hylocereus spp.): A Review. International Journal of Horticultural Science and Technology, 8(3), 259-269.
49. Nerd, A., Gutman, F., & Mizrahi, Y. (1999). Ripening and postharvest behaviour of fruits of two Hylocereus species (Cactaceae). Postharvest Biology and Technology, 17(1), 39-45.
50. Nobel, P. S., & De la Barrera, E. (2002). Stem water relations and net CO2 uptake for a hemiepiphytic cactus during short-term drought. Environmental and Experimental Botany, 48(2), 129-137.
51. Perween, T., Mandal, K. K., & Hasan, M. A. (2018). Dragon fruit: An exotic super future fruit of India. Journal of Pharmacognosy and Phytochemistry, 7(2), 1022-1026.
52. Joshi, M., & Prabhakar, B. (2020). Phytoconstituents and pharmaco-therapeutic benefits of pitaya: A wonder fruit. Journal of Food Biochemistry, 44(7), e13260.
53. Lim, H. K., Tan, C. P., Karim, R., Ariffin, A. A., & Bakar, J. (2010). Chemical composition and DSC thermal properties of two species of Hylocereus cacti seed oil: Hylocereus undatus and Hylocereus polyrhizus. Food Chemistry, 119(4), 1326-1331.12.
54. Wong, Y. M., & Siow, L. F. (2015). Effects of heat, pH, antioxidant, agitation and light on betacyanin stability using red-fleshed dragon fruit (Hylocereus polyrhizus) juice and concentrate as models. Journal of food science and technology, 52, 3086-3092.
55. Yi, Y., Wu, X., Wang, Y., Ye, W. C., & Zhang, Q. W. (2011). Studies on the flavonoids from the flowers of Hylocereus undatus. Zhong Yao Cai= Zhongyaocai= Journal of Chinese Medicinal Materials, 34(5), 712-716.

56. Arivalagan, M., Karunakaran, G., Roy, T. K., Dinsha, M., Sindhu, B. C., Shilpashree, V. M., ... & Shivashankara, K. S. (2021). Biochemical and nutritional characterization of dragon fruit (Hylocereus species). Food Chemistry, 353, 129426.
57. Le, N. L. (2022). Functional compounds in dragon fruit peels and their potential health benefits: a review. International Journal of Food Science & Technology, 57(5), 2571-2580.
58. Lodi, K. Z., Cappelari, M. B., Pilatti, G. C., Fontana, R. C., Camassola, M., Salvador, M., & Branco, C. S. (2023). Pre-clinical evidence for the therapeutic effect of Pitaya (Hylocereus lemairei) on diabetic intestinal microenvironment. Natural Product Research, 37(10), 1735-1741.
59. Nishikito, D. F., Borges, A. C. A., Laurindo, L. F., Otoboni, A. M. B., Direito, R., Goulart, R. D. A., ... & Barbalho, S. M. (2023). Anti-inflammatory, antioxidant, and other health effects of dragon fruit and potential delivery systems for its bioactive compounds. Pharmaceutics, 15(1), 159
60. Ibrahim, S. R. M., Mohamed, G. A., Khedr, A. I. M., Zayed, M. F., & El-Kholy, A. A. E. S. (2018). Genus Hylocereus: Beneficial phytochemicals, nutritional importance, and biological relevance—A review. Journal of Food Biochemistry, 42(2), e12491.
61. Singh, A., Swami, S., Panwar, N. R., Kumar, M., Shukla, A. K., Rouphael, Y., ... & Kumar, P. (2022). Development changes in the physicochemical composition and mineral profile of red-fleshed dragon fruit grown under semi-arid conditions. Agronomy, 12(2), 355.
62. Hossain, F. M., Numan, S. M. N., & Akhtar, S. (2021). Cultivation, nutritional value, and health benefits of Dragon Fruit (Hylocereus spp.): A Review. International Journal of Horticultural Science and Technology, 8(3), 259-269.
63. Ganisetti Anitha, M Viswanath, Pushpa Latha G. (2023). Dragon fruit: A review of health benefits and nutritional importance. Pharma Innovation ,12(1),326-331.
64. Sofowora, A., Ogunbodede, E., & Onayade, A. (2013). The role and place of medicinal plants in the strategies for disease prevention. African journal of traditional, complementary and alternative medicines, 10(5), 210-229.
65. Jeronimo, M. C., Orsine, J. V. C., & Novaes, M. R. C. G. (2017). Nutritional pharmacological and toxicological characteristics of pitaya (Hylocereus undatus): A review of the literature. African Journal of Pharmacy and Pharmacology, 11(27), 300-304.
66. Huang, Y., Brennan, M. A., Kasapis, S., Richardson, S. J., & Brennan, C. S. (2021). Maturation process, nutritional profile, bioactivities and utilisation in food products of red pitaya fruits: A Review. Foods, 10(11), 2862.
67. Nishikito, D. F., Borges, A. C. A., Laurindo, L. F., Otoboni, A. M. B., Direito, R., Goulart, R. D. A., ... & Barbalho, S. M. (2023). Anti-inflammatory, antioxidant, and other health effects of dragon fruit and potential delivery systems for its bioactive compounds. Pharmaceutics, 15(1), 159.
68. Safira, A., Savitri, S. L., Putri, A. R. B., Hamonangan, J. M., Safinda, B., Solikhah, T. I., ... & Puspitarani, G. A. (2021). Review on the pharmacological and health aspects of Hylocereus or Pitaya: An update. Journal of Drug Delivery and Therapeutics, 11(6), 297-303
69. Kumar, S., Tripathi, V., Kumari, A., Chaudhary, V., & Kumawat, P. (2022). A-review: on Nutritional and Medicinal Importance of Dragon Fruit (Hylocereus species). Ecol Environ Conserv, 28, 247-253.
70. Hernández, Y. D. O., & Salazar, J. A. C. (2012). Pitahaya (Hylocereus spp.): a short review. Comunicata Scientiae, 3(4), 220-237.
71. Nurliyana R.D., Syed Zahir I., Mustapha Suleiman K., Aisyah M.R., Kamarul Rahim K. (2010): Antioxidant study of pulps and peels of dragon fruits: A comparative study. International Food Research Journal, 17: 367–375.
72. Rice-Evans, C., Miller, N., & Paganga, G. (1997). Antioxidant properties of phenolic compounds. Trends in plant science, 2(4), 152-159.
73. Saenjum, C.; Pattananandecha, T.; Nakagawa, K. Antioxidative and anti-inflammatory phytochemicals and related stable paramagnetic species in different parts of dragon fruit. Molecules 2021, 26, 3565.

74. Luu, T. T. H., Le, T. L., Huynh, N., & Quintela-Alonso, P. (2021). Dragon fruit: A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam. Czech Journal of Food Sciences, 39(2), 71-94.
75. Rodriguez, E. B., Vidallon, M. L. P., Mendoza, D. J. R., & Reyes, C. T. (2016). Health-promoting bioactivities of betalains from red dragon fruit (Hylocereus polyrhizus (Weber) Britton and Rose) peels as affected by carbohydrate encapsulation. Journal of the Science of Food and Agriculture, 96(14), 4679-4689.
76. Joshi, M., & Prabhakar, B. (2020). Phytoconstituents and pharmaco-therapeutic benefits of pitaya: A wonder fruit. Journal of Food Biochemistry, 44(7), e13260.
77. Ibrahim, S. R. M., Mohamed, G. A., Khedr, A. I. M., Zayed, M. F., & El-Kholy, A. A. E. S. (2018). Genus Hylocereus: Beneficial phytochemicals, nutritional importance, and biological relevance—A review. Journal of Food Biochemistry, 42(2), e12491.
78. Paśko, P., Galanty, A., Zagrodzki, P., Luksirikul, P., Barasch, D., Nemirovski, A., & Gorinstein, S. (2021). Dragon fruits as a reservoir of natural polyphenolics with chemopreventive properties. Molecules, 26(8), 2158.
79. Sudha, K., Baskaran, D., Ramasamy, D., & Siddharth, M. (2017). Evaluation of functional properties of Hylocereus undatus (White dragon fruit). International Journal of Agricultural Science and Research, 7(5), 451-456.
80. De Mello, F. R., Bernardo, C., Dias, C. O., Züge, L. C. B., Silveira, J. L. M., Amante, E. R., & Candido, L. M. B. (2014). Evaluation of the chemical characteristics and rheological behavior of pitaya (Hylocereus undatus) peel. Fruits, 69(5), 381-390.
81. Sushmitha, H. S., Roy, C. L., Gogoi, D., Velagala, R. D., Nagarathna, A., Balasubramanian, S., & Rajadurai, M. (2018). Phytochemical and pharmacological studies on hylocereus undatus seeds: an in vitro approach. World Journal of Pharmacological Research, 7(14), 986-1006.
82. Wichienchot, S., Jatupornpipat, M., & Rastall, R. A. (2010). Oligosaccharides of pitaya (dragon fruit) flesh and their prebiotic properties. Food chemistry, 120(3), 850-857.
83. Nurmahani, M. M., Osman, A., Hamid, A. A., Ghazali, F. M., & Dek, M. S. (2012). Antibacterial property of Hylocereus polyrhizus and Hylocereus undatus peel extracts. International Food research journal, 19(1),77-84.
84. Adhi, N. G. M. A. D., Suastuti, N. W. B., & Putra, A. A. B. (2018). Activity of Hylocereus Costarioensis's Extract as Antiobesity and hypolipidemic of obese Rats. Int. J. Pharm. Res. Allied Sci, 7(1), 201-208.
85. Widyaningsih, A., Setiyani, O., Umaroh, U., Sofro, M. A. U., & Amri, F. (2017). Effect of consuming red dragon fruit (Hylocereus costaricensis) juice on the levels of hemoglobin and erythrocyte among pregnant women. Belitung Nursing Journal, 3(3), 255-264.
86. Tahir, T., Febrianti, N., Wahyuni, S., & Syam, Y. (2020). Evaluation of acute wound healing potential of red dragon fruit (Hylocereus Polyrhizus) extract cream on type III collagen and epidermal growth factor (EGF) levels: An animal study. Medicina Clínica Práctica, 3, 100091.
87. Krishnaiah, D., Nithyanandam, R., & Sarbatly, R. (2012). Phytochemical constituents and activities of Morinda citrifolia L. Phytochemicals-a global perspective of their role in nutrition and health, 127-150.
88. Zhang, J. H., Xin, H. L., Xu, Y. M., Shen, Y., He, Y. Q., Lin, B., ... & Du, J. (2018). Morinda officinalis How–A comprehensive review of traditional uses, phytochemistry and pharmacology. Journal of Ethnopharmacology, 213, 230-255.
89. Silalahi, M. (2020). Morinda citrifolia: Bioactivity and utilization as traditional medicine and food for the community. International Journal of Business, Economics, and Social Development, 1(2), 81-89.