THE ROLE OF RED DRAGON FRUIT IN PROTECTING AGAINST OXIDATIVE STRESS

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Abstract

Red dragon fruit is commonly found in everywhere, including tropical countries. The rich antioxidant content of red dragon fruit might protect against oxidative stress. The impacts of oxidative stress are tissue damage, metabolic disease, cancer, and inflammation. This paper highlights the role of red dragon fruit in protecting against oxidative stress. Methods: This paper is a narrative literature review. Articles were retrieved from ScienceDirect, Google Scholar, and PubMed websites. The publication date is within 5 years. Results: Red dragon fruit (Hylocereus spp.) contains antioxidants such as phenolics, flavonoids, and betalains. These antioxidants neutralize free radicals. Cellular function and tissue damage are reduced. The protective properties of red dragon fruit against oxidative stress are beneficial in inflammatory diseases, diabetes, and cancer. In conclusion, the role of red dragon fruit in protecting against oxidative stress is by enhancing antioxidant enzyme activity and minimizing the production of reactive oxygen species.

Keywords: antioxidant, oxidative stress, red dragon fruit

A. INTRODUCTION

Red dragon fruit (RDF) is commonly found in everywhere, including tropical countries. The rich antioxidant content of red dragon fruit might protect against oxidative stress. The impacts of oxidative stress are tissue damage, metabolic disease, cancer, and inflammation (Flores-Verastegui et al., 2025; Lim et al., 2025).

Dragon fruit, also known as pitaya or pitahaya, is a popular tropical fruit with aesthetic appeal, sweet flavor, and nutritional benefits. The fruit pulp is categorized into red, yellow, and white dragon fruit. Red dragon fruit has gained attention due to its betalain content, which exhibits antioxidant, anti-inflammatory, anticancer, antilipidemic, and antibacterial properties. Red dragon fruit is a natural source of betacyanin, with a milder flavor and aroma compared to beets. However, the peel is often discarded as waste (Flores-Verastegui et al., 2025; Loan et al., 2025).

Betacyanins, the pigment found in red dragon fruit, have several advantages over other natural colorants, including higher solubility, wider pH stability, and greater antioxidant activity. However, the production of betacyanins from red dragon fruit is limited by the

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sensitivity of the pigment to thermal processing and degradation during processing. The development of functional food products using red dragon fruit and its betacyanins could provide a valuable alternative to synthetic colorants and contribute to the prevention of non-communicable diseases caused by oxidative stress. Further research is needed to explore the potential of RDF as a functional food ingredient and to develop methods for the efficient production and stabilization of betacyanins (Lim et al., 2025).

Red dragon fruit, a tropical fruit rich in bioactive compounds, has been shown to have positive health effects. The frozen red dragon fruit (FRDF) beverage showed a decrease in blood pressure and a non-significant decrease in insulinaemic response. The study suggests that dragon fruit may be a useful addition to a healthy diet, particularly for individuals at risk. The FRDF beverage also showed a numerical non-significant reduction in total cholesterol levels (Flores-Verastegui et al., 2025). The presence of bioactive compounds, such as polyphenols, in dragon fruit may contribute to its positive health effects. The study suggests that dragon fruit may be a useful addition to a healthy diet, particularly for individuals at risk of diabetes mellitus type 2. Phytochemicals, plant-derived compounds, have garnered attention for their potential health benefits, despite contributing minimally to nutritional value. These compounds significantly influence human health, with antioxidant properties found in fruits and vegetables (Anggitasari et al., 2023; Intan et al., 2025; Martemucci et al., 2022; Rustanti et al., 2025; Wiguna et al., 2024)

Metabolic syndrome causes significant health problems and financial burden. Approximately almost 40% of Indonesian adult people have metabolic syndrome. Oxidative stress will induce metabolic syndrome. Hyperlipidemia, hyperglycemia, and obesity might trigger oxidative stress. Therefore, patients with metabolic syndrome have higher risks of cardiovascular diseases and diabetes type 2 (Midah et al., 2021; Rustanti et al., 2025).

This paper aims to describe the role of red dragon fruit in protecting against oxidative stress.

B. RESEARCH METHOD

This paper is a narrative literature review. Articles were retrieved from ScienceDirect, Google Scholar, and PubMed websites. The publication date is within 5 years (2020-2025). The articles were selected based on the keywords, title, abstract, and full text. Based on the selection process, there were 18 articles (2020: 1 article; 2021: 3 articles; 2022: 5 articles; 2023: 3 articles; 2024: 1 article; 2025: 5 articles). The selected articles were summarized and narrated.

C. FINDINGS AND DISCUSSION

Red dragon fruit (Hylocereus spp.) (RDF) is a tropical fruit that is native to Latin America and is a member of the Cactaceae family. It is a rich source of betacyanins, a type of pigment that has antioxidant properties and can be used as a natural food colorant. Compared to red beetroot, RDF is relatively understudied and underexploited, despite its potential as a functional food ingredient. Red dragon fruit contains antioxidants such as phenolics, flavonoids, and betalains. These antioxidants neutralize free radicals. Cellular function and tissue damage are reduced. The protective properties of red dragon fruit against oxidative

stress are beneficial in inflammatory diseases, diabetes, and cancer (Chaturvedi et al., 2023; Flores-Verastegui et al., 2025; Intan et al., 2025).

Betacyanins have several advantages over other natural colorants, but their production is limited by sensitivity to thermal processing and degradation. The development of functional food products using RDF and its betacyanins could provide a valuable alternative to synthetic colorants and contribute to the prevention of non-communicable diseases. Further research is needed to explore the potential of RDF as a functional food ingredient (Banwo et al., 2021; Chaturvedi et al., 2023; Manzoor et al., 2020).

Red dragon fruit has a unique morphology, with elongated climbing and branching stems that are triangle-shaped and have short spines. The fruit itself has a vibrant red color and is rich in nutrients, making it a popular choice for consumption as it seen in Figure 1. Oxidative stress is a major contributor to the development of chronic diseases, and functional foods like RDF can play a crucial role in preventing these diseases. The demand for functional foods is increasing, and RDF can be a valuable addition to this market. RDF can be a valuable addition to the functional food market, which is growing rapidly due to increasing demand for healthy and nutritious food products (Lim et al., 2025).

Anti oxidant content

Flavonoids, anthocyanins, betalains, betacyanins, and betanin

Betalains are a class of nitrogenous heterocyclic pigments derived from the amino acid tyrosine, comprising a core structure of betalamic acid. They are hydrophilic pigments accumulating in cell vacuoles of epidermal and subepidermal tissues in approximately 17 plant families within the Caryophyllales order. Betalains are categorized into two subgroups: red-violet betacyanins and yellow-orange betaxanthins. Betacyanins, responsible for the purplish-red color of red dragon fruit (RDF), exhibit higher antioxidant capacity than betaxanthins, which are absent in RDF (Kumar & Kumar, 2022; Lim et al., 2025). Notably, betalains and anthocyanins are mutually exclusive, never co-occurring in the same plant, despite serving similar vegetative and reproductive functions. Research on betalains' biochemistry, function, and application is relatively limited compared to other major plant pigments. Betacyanins, comprising betanin, are prominent in RDF, contributing to its vibrant color and potential health benefits, including antioxidant, anti-inflammatory, and antimicrobial properties (Lim et al., 2025; Sadowska-Bartosz & Bartosz, 2021).

Red dragon fruit, including its skin and flesh, is rich in flavonoids, anthocyanins, betacyanins, and betanin, which possess antioxidant properties. The antioxidant mechanisms of these compounds are well-established. Flavonoids can scavenge free radicals directly and indirectly upregulate endogenous antioxidant genes via Nrf2 activation. Anthocyanins neutralize free radicals through single electron transfer and hydrogen atom transfer, bind to transition metal ions, and activate Nrf2 and antioxidant enzymes. Betacyanins and betanin also exhibit antioxidant activity by increasing Nrf2 expression and donating electrons and hydrogen (Rustanti et al., 2025).

Administration of synbiotic yogurt containing whole red dragon fruit (0.018 mL/g body weight/day, equivalent to 200 mL/day for humans) for 4 weeks significantly reduced fasting blood glucose and plasma MDA levels in Sprague Dawley rats with metabolic syndrome. These findings suggest that human trials are warranted to investigate the effects of synbiotic

yogurt containing 200 mL/day of whole red dragon fruit for 4 weeks. Consumption of this synbiotic yogurt may help reduce fasting blood glucose levels and oxidative stress, making it a potential functional food alternative for individuals with metabolic syndrome to improve metabolic health and reduce complication risks (Rustanti et al., 2025).

Hypoglycemic effect

The presence of bioactive compounds in dragon fruit, such as polyphenols, may contribute to its beneficial effects on health. These compounds have been shown to improve insulin sensitivity, reduce oxidative stress, and inhibit glucose absorption. The study's findings suggest that incorporating dragon fruit into a healthy diet may be beneficial, particularly for individuals at risk of T2D. However, further research is necessary to confirm these results and compare the effects of dragon fruit consumption with established healthy eating guidelines (Flores-Verastegui et al., 2025; Rustanti et al., 2025).

Figure 1. Red dragon fruit (Lim et al., 2025)

Hepatoprotective property

To evaluate the bioactivity of functional foods and nutraceuticals, including those containing betacyanins, it's essential to assess their effects after exposure to gastrointestinal conditions. Betacyanins have demonstrated various biological activities, such as antioxidant, anti-inflammatory, and gene regulatory effects, making them promising bioactive compounds for functional foods and drinks. Various in vitro antioxidant assays have been developed to evaluate the antioxidant potential of betacyanins regarding the ability to scavenge free radicals and induce antioxidant enzymes (Ramírez-Melo et al., 2022).

The liver plays a crucial role in detoxification and is susceptible to oxidative stress caused by free radicals. Dietary antioxidants like betacyanins can help counterbalance oxidative insults and support liver detoxification by upregulating antioxidant enzymes and

interacting with redox cell signaling. Hepatoprotection involves restoring the function of antioxidant enzymes like superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) to normal levels (Mitra et al., 2022). While liver function tests measure biomarkers like alanine transaminase (ALT), aspartate transaminase (AST), and bilirubin, these enzymes aren't directly involved in antioxidant mechanisms. Hepatoprotection involves restoring antioxidant enzyme function, and cellular-based bioassays study this effect. While some in vivo studies show beetroot betanin's antioxidant effects, more research is needed on red dragon fruit betacyanins' mechanisms in liver cells (Lim et al., 2025).

Cellular-based antioxidant bioassays, including direct effect measurements and indirect effect assessments, are used to study hepatoprotective effects. Some in vivo studies have shown that beetroot betanin intake can increase antioxidant enzyme activities and gene expressions in rats' livers. However, more research is needed on the antioxidant mechanisms of betacyanins from red dragon fruit pulp/flesh in liver cells (Lim et al., 2025).

Bio-accessibility is a crucial factor determining the bioavailability of betacyanins, as these compounds are prone to degradation and modification during gastrointestinal digestion. Research has shown that over 50% of betacyanins are lost during digestion, regardless of the fruit source. The stability of betacyanins is affected by factors like temperature, pH, light, and oxygen, which can lead to chromatic and functional changes. Understanding these factors is essential for optimizing pigment retention and commercial applications. Various extraction methods, including conventional and non-conventional approaches, have been developed to extract and concentrate betacyanins. Fermentation is an emerging cheaper alternative that can concentrate and stabilize betacyanins, with the added benefit of lowering pH and limiting enzymatic activity (Calva-Estrada et al., 2022; Nicolescu et al., 2023; Sadowska-Bartosz & Bartosz, 2021).

The fermented red dragon fruit drink (FRDFD) contains high levels of bioactive betacyanins and has potential as a functional drink and natural colorant. However, further processing efforts are needed to preserve betacyanins stability during storage. Red dragon fruit (RDF) is a good source of betacyanins, but it is undervalued and understudied compared to red beetroot. More research is needed to explore RDF's hepatoprotective activity and clinical value, and to stimulate industry investment in RDF cultivation and application as a functional ingredient (Lim et al., 2025).

D. CONCLUSION

In conclusion, the role of red dragon fruit in protecting against oxidative stress is by enhancing antioxidant enzyme activity and minimizing the production of reactive oxygen species. Red dragon fruit contains flavonoids, anthocyanins, betalains, betacyanins, and betanin. Those antioxidants could exert hyperglycemic and hepatoprotective properties.

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