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The Potential of Flavonoid Antioxidants in Dragon Fruit Skin (*Selenicereus Undatus*) for Cardiovascular Health

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This study aims to examine the potential of flavonoid antioxidants found in dragon fruit peel (*Selenicereus undatus*) in supporting cardiovascular health. Flavonoids, as bioactive compounds with antioxidant properties, have an important role in protecting the body from oxidative stress that can damage cells and tissues, including the cardiovascular system. With a qualitative approach through literature studies and library research, this study analyzes secondary data from various scientific sources to explore the effects of flavonoids on reducing the risk of cardiovascular disease. Studies show that the flavonoid content in dragon fruit peel is able to suppress the lipid oxidation process, lower cholesterol levels, and inhibit inflammation which is a major risk factor for cardiovascular disease. In addition, the high antioxidant activity of these flavonoids has the potential to strengthen the walls of blood vessels and improve blood circulation, so that it can prevent atherosclerosis and hypertension. The results of this study support the use of dragon fruit peel as a source of natural antioxidants that have the potential to be used as a supplement in the prevention of cardiovascular diseases. A further recommendation is to conduct clinical research to test the effectiveness of flavonoids from dragon fruit peel in cardiovascular health applications in more depth.

1. Introduction

Cardiovascular disease is one of the leading causes of death in the world, which is characterized by disturbances in the blood circulation system and has the potential to cause serious complications, such as heart attacks and strokes (World Health Organization [WHO], 2021). One of the main factors in the development of this disease is oxidative stress, which is caused by the accumulation of free radicals in the body and plays a role in the inflammatory process and tissue damage (Halliwell & Gutteridge, 2015). Recent studies have shown that antioxidants can help reduce the impact of oxidative stress, especially by inhibiting lipid oxidation and preventing the formation of atherosclerotic plaques (Rahman et al., 2019; Shahidi & Ambigaipalan, 2015).

Flavonoids are a group of naturally occurring polyphenol compounds found in fruits, vegetables, teas, and red wines, which are known to have powerful antioxidant properties. Antioxidants are compounds that play a role in protecting cells from oxidative damage caused by free radicals, unstable molecules that are formed as a result of metabolic processes and environmental exposure, such as pollution and ultraviolet radiation (Halliwell & Gutteridge, 2015). Free radicals can cause damage to DNA, proteins, and lipids, potentially triggering a variety of degenerative diseases, including cardiovascular disease, cancer, and neurodegenerative disorders (Rahman et al., 2019). Flavonoids work by neutralizing free radicals before they can damage cells, as well as strengthening the body's endogenous antioxidant defense system, thereby lowering the risk of tissue damage caused by oxidative stress.

In the context of cardiovascular health, flavonoids play an important role by preventing the oxidation of LDL (Low-Density Lipoprotein) cholesterol, which is the initial step in the formation of atherosclerotic plaques in blood vessels (Geleijnse et al., 2012). This plaque can narrow blood vessels and block blood flow, which if left untreated can lead to coronary heart disease or stroke. Some studies have also shown that flavonoids have a vasodilating effect, which is the ability to widen blood vessels, so that they can lower blood pressure and improve blood flow (Middleton et al., 2000). The anti-inflammatory effects of flavonoids also contribute to reducing the risk of chronic inflammation which is often a contributing factor to the occurrence of cardiovascular disease (Shahidi & Ambigaipalan, 2015).

In addition, flavonoids can improve endothelial function, which is a thin layer on the walls of blood vessels that regulates various vascular functions, including blood pressure regulation and coagulation (Kumar & Pandey, 2013). By increasing nitric oxide production, flavonoids help regulate blood vessel relaxation and prevent excessive blood clots, an important factor

in maintaining healthy blood circulation (Rohman & Riyanto, 2015). Recent studies have also shown that flavonoids may inhibit enzymes that contribute to tissue damage in chronic diseases, adding to the evidence regarding the benefits of these antioxidants for long-term health (Yusoff et al., 2018). With these various mechanisms, flavonoids not only function as antioxidants but also as potential therapeutic agents in the prevention and management of cardiovascular diseases.

Flavonoids, as one of the natural antioxidant compounds, are widely found in various plants and have been shown to have high antioxidant activity (Kumar & Pandey, 2013). The skin of dragon fruit (*Selenicereus undatus*), which is often just waste, turns out to contain significant amounts of flavonoids (Sari et al., 2020). Although there have been many studies on the benefits of flavonoids in various plants, research specifically exploring the flavonoid potential of dragon fruit peel for cardiovascular health is still limited (Yusoff et al., 2018). This shows that there is an important research gap to be filled to expand knowledge about potential sources of natural antioxidants.

The urgency of this research is also driven by the increasing need for natural antioxidants as a safer and more affordable alternative to synthetic supplements, especially in the prevention of chronic diseases (Rohman & Riyanto, 2015). Some previous studies have shown that flavonoid compounds are able to improve blood vessel function and reduce the risk of hypertension, but specific studies on the effects of flavonoids in dragon fruit peel on cardiovascular health are still very limited (Geleijnse et al., 2012; Middleton et al., 2000). Therefore, this study has a novel contribution by revealing the specific potential of dragon fruit peel as a source of flavonoids that support cardiovascular health.

The main goal of this study is to explore the potential of flavonoid antioxidants in dragon fruit skin in supporting cardiovascular health, especially in preventing atherosclerosis and lowering the risk of hypertension. The expected benefit of this study is to provide a scientific basis for the use of dragon fruit peel as a source of natural antioxidants, as well as encourage the use of local resources that have been underutilized. The results of this study can also open up opportunities for the development of flavonoid-based health products from dragon fruit peel, which not only function as a natural supplement but also support the management of cardiovascular health holistically.

2. Method

This study uses a qualitative approach with the type of literature study research or library research. The literature study was selected to examine the potential of flavonoid antioxidants in the skin of dragon fruit (*Selenicereus undatus*) related to its benefits for cardiovascular health. This approach is considered appropriate because it allows researchers to collect and analyze information from a variety of relevant scientific sources without directly collecting primary data (Creswell, 2014). Through this method, the study gained a thorough understanding of the characteristics and benefits of flavonoids and their effects in reducing the risk of cardiovascular disease.

The data sources used in this study are secondary data from various scientific journal articles, books, research reports, and other reliable sources that discuss flavonoids, antioxidants, and the role of bioactive compounds in heart and blood vessel health. Articles used as references are articles published in the last five to ten years to ensure that the information obtained is still relevant and in accordance with the latest research developments (Ridley, 2012). These sources were selected considering their level of credibility and relevance to the topic discussed, as well as the availability of data on the composition and activity of flavonoids in dragon fruit peels.

The data collection technique in this study involves searching, selecting, and reviewing literature in accordance with the research topic. The search process was conducted using keywords such as "flavonoids," "antioxidants," "dragon fruit skin," and "cardiovascular health" on scientific databases such as Google Scholar, PubMed, and ScienceDirect (Bowling, 2014). Each relevant literature is then evaluated based on predetermined inclusion criteria, namely literature that focuses on the content of flavonoids and their benefits for cardiovascular health.

The data that has been collected is analyzed using the content analysis method, which involves the process of interpreting and classifying information from various sources based on themes or concepts related to the potential of flavonoids as antioxidants for heart health (Krippendorff, 2018). This technique allows researchers to identify key patterns as well as discover new findings that may not have been revealed in previous studies. The analysis process is carried out systematically to avoid bias and ensure accurate interpretation of data, so that the results of the study can contribute in-depth knowledge about the benefits of flavonoids on dragon fruit peels in supporting cardiovascular health.

3. Result and Discussion

The following is a table of literature data containing findings from 10 articles selected as the main reference in this study. These articles were selected through a rigorous selection process from various literature relevant to the research topic, namely regarding the potential of flavonoid antioxidants in dragon fruit peel (*Selenicereus undatus*) for cardiovascular health. Each article was analyzed based on the main focus of the study, the type of antioxidant studied, the method of analysis, as well as key findings related to the benefits of flavonoids in supporting cardiovascular health.

Author	Year	Title	Findings
Geleijnse et al.	2012	Tea flavonoids may protect against atherosclerosis: the Rotterdam Study	Tea flavonoids help prevent atherosclerosis through antioxidant effects
Yusoff et al.	2018	Flavonoid content and antioxidant properties of selected tropical fruits	Dragon fruit has a high content of flavonoids that are useful as antioxidants
Sari et al.	2018	The use of red dragon fruit peel as a natural antioxidant	Dragon fruit peel is effective as a natural source of antioxidants containing flavonoids
Rohman & Riyanto	2015	Antioxidant potential and functional value	Dragon fruit peel has high

		of dragon fruit peel	antioxidant activity
Halliwell & Gutteridge	2015	Free radicals in biology and medicine	Flavonoids have an important role in fighting free radicals
Shahidi & Ambigaipalan.	2015	Phenolics and polyphenolics in foods, beverages and spices	Flavonoids contribute to high antioxidant effects
Kumar & Pandey	2013	Chemistry and biological activities of flavonoids: an overview	Flavonoids are effective as antioxidants and have health benefits.
Middleton et al.	2000	The effects of plant flavonoids on mammalian cells: Implications for inflammation, heart disease, and cancer	Flavonoids are able to reduce inflammation and support heart health.
Rahman et al.	2019	In vitro antioxidant and free radical scavenging activity of different parts of Santalum album	Flavonoids show high activity in warding off free radicals

World Health Organization	2021	Cardiovascular diseases (CVDs)	Cardiovascular disease is related to oxidative stress, which can be reduced by antioxidants.
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This table provides a comprehensive view of the literature that supports the study of the potential of flavonoids in dragon fruit peels in helping to maintain cardiovascular health, especially through the antioxidant properties of flavonoids. These articles illustrate the important role of flavonoids in fighting free radicals, lowering the risk of atherosclerosis, and supporting heart health holistically.

Interpretation of the data from the literature table above shows that flavonoids, bioactive compounds with high antioxidant properties, have an important role in supporting cardiovascular health. The reviewed articles revealed that flavonoids found in various plant sources, including dragon fruit peel (*Selenicereus undatus*), can help protect the body from damage caused by free radicals. Free radicals are known to be the main trigger for various degenerative diseases, especially heart and vascular diseases (Halliwell & Gutteridge, 2015). Based on existing literature studies, the antioxidant potential of flavonoids in dragon fruit peel can help reduce the risk of cardiovascular disease through various mechanisms that support heart health.

From the table, several studies highlight that the flavonoids in dragon fruit peels have high antioxidant activity, as revealed by Sari et al. (2020) and Rohman & Riyanto (2015). Both studies showed that dragon fruit peels contain significant amounts of flavonoids, which have the ability to ward off free radicals. These findings are supported by other studies that show that flavonoids in food and beverages in general can lower oxidative stress in the body, thus helping to prevent cell damage due to oxidation (Shahidi & Ambigaipalan, 2015). Thus, dragon fruit peel can be one of the potential natural sources of antioxidants to be developed in supporting cardiovascular health.

Furthermore, some of the articles in the table also show that flavonoids can inhibit the oxidation of LDL (Low-Density Lipoprotein), which is one of the key processes in the formation

of atherosclerotic plaques (Geleijnse et al., 2012). Atherosclerotic plaques are the main cause of coronary heart disease and stroke, so prevention of LDL oxidation is important in maintaining healthy blood vessels. With the ability of flavonoids in dragon fruit peel to prevent this process, there is a significant opportunity for dragon fruit peel to be utilized as an ingredient in supplements or functional foods that support heart health.

In addition to preventing LDL oxidation, some literature also highlights the anti-inflammatory effects of flavonoids. Chronic inflammatory in blood vessels is often associated with a high risk of cardiovascular disease (Middleton et al., 2000). Through these anti-inflammatory effects, flavonoids have the potential to reduce swelling and inflammation in blood vessels, thereby reducing the risk of blockage of blood flow that can lead to conditions such as hypertension or high blood pressure. This shows that dragon fruit peel not only functions as an antioxidant, but also has benefits in regulating blood pressure and preventing chronic inflammation.

From the vasodilation aspect, flavonoids also have the ability to widen blood vessels, which supports increased blood circulation in the body (Kumar & Pandey, 2013). This vasodilating effect is crucial in controlling blood pressure and preventing hypertension, which is one of the main risk factors for cardiovascular disease. Dragon fruit peel, which is rich in flavonoids, can be a potential source in supporting healthy vascular function. In addition, these findings also support the use of flavonoids in natural therapies to improve vascular elasticity and reduce the risk of hypertension.

Overall, the results from the reviewed literature emphasize the importance of flavonoid antioxidants on dragon fruit peel in various mechanisms that support heart and blood vessel health. From preventing LDL oxidation, reducing inflammation, to dilating blood vessels, flavonoids in dragon fruit peels show potential to contribute to the prevention and management of cardiovascular diseases. Thus, dragon fruit peel can be used as a natural ingredient that has the potential to be developed in the formulation of cardiovascular health products. This not only provides an alternative to natural remedies but also supports the utilization of local resources rich in antioxidants.

Discussion and Analysis

This study reveals that the flavonoids found in the skin of dragon fruit (*Selenicereus undatus*) have great potential as antioxidants that support cardiovascular health. Flavonoid compounds basically function as natural antioxidants that are able to ward off free radicals, which are known to be the main cause of oxidative stress in the body. This oxidative stress triggers

various health disorders, including cardiovascular disease, which is currently the leading cause of death worldwide (WHO, 2021). Therefore, this finding is significant, given the need for an approach to heart disease prevention through natural and potential sources that are still underutilized, such as dragon fruit skin.

From a theoretical perspective, the role of flavonoids as antioxidants has been widely studied in the literature. Flavonoids are able to inhibit the oxidation process, especially in LDL (Low-Density Lipoprotein) cholesterol, which when oxidized will trigger the formation of atherosclerotic plaques on the walls of blood vessels (Geleijnse et al., 2012). The fact that the flavonoids in dragon fruit peels have similar abilities makes an important contribution to the prevention of coronary heart disease, which is caused by blockage of blood flow due to atherosclerosis. In this context, flavonoids act as a natural protector for the walls of blood vessels, maintaining elasticity and reducing the risk of blockages.

In addition, studies have also shown that flavonoids have anti-inflammatory effects that are important in preventing chronic inflammation of blood vessels. Chronic inflammatory disease is one of the main factors that cause vascular tissue damage and contributes to the development of cardiovascular disease (Middleton et al., 2000). Dragon fruit peels that are rich in flavonoids have the potential to prevent this inflammatory process, thus helping to reduce the risk of heart disease. It is also relevant to the need for natural ingredients that support preventive treatment to lower inflammation without the side effects that usually occur with synthetic drugs.

Another interesting fact found in this study is the ability of flavonoids to widen blood vessels through the vasodilating effect. This vasodilation is important in improving blood circulation and lowering blood pressure, which is a major risk factor for hypertension and heart disease (Kumar & Pandey, 2013). Dragon fruit skin, with its flavonoid content, can be a natural alternative option in controlling blood pressure and preventing hypertension, which is currently a common health problem due to modern lifestyles and unhealthy diets.

Empirically, the results of this study are relevant to efforts to reduce dependence on synthetic supplements. Currently, people's interest in natural antioxidants continues to increase as awareness of the importance of maintaining health through a more natural and safe way. The use of dragon fruit peel as a source of natural antioxidants rich in flavonoids is also in line with the principles of sustainability and the use of local food ingredients that are often not optimized. In this context, the results of this study make a real contribution in expanding the choice of natural ingredients that can be used to support cardiovascular health holistically.

In terms of economy, the use of dragon fruit skins also provides added value for the food and agricultural industries. Dragon fruit peels, which are usually only considered waste, can be processed into materials with high economic value, especially for supplements or functional foods. This utilization not only reduces waste but also increases the economic value of dragon fruit as a commodity that has great potential in the health industry. Thus, this research has a positive impact on economic development and sustainable waste management.

The authors argue that, although the results of this study show great potential, further research is needed to confirm the effectiveness of flavonoids in dragon fruit peels through clinical trials in humans. Many studies are still based on laboratory experiments, which while providing strong preliminary evidence, still require verification through more comprehensive clinical trials. With empirical evidence from clinical trials, the benefits of flavonoids in dragon fruit peel can be better accepted and applied in medical practice.

Overall, this study opens up opportunities for the development of flavonoid-based health products from dragon fruit peels, which serve as natural supplements for the prevention of cardiovascular disease. This potential is not only important for individual health but also for the wider community, especially in supporting preventive approaches to degenerative diseases. The flavonoids in dragon fruit peels have the potential to fill the need for natural antioxidants that are safer and more affordable compared to synthetic alternatives.

Finally, this study enriches the literature on the benefits of flavonoids for cardiovascular health, particularly from underutilized sources such as dragon fruit skin. By combining scientific data and its practical relevance, the research not only contributes to the theoretical aspect, but also encourages the innovative use of local food ingredients for public health benefits. In the future, further research is expected to develop the application of flavonoids in health products and nutrition-based therapies for the prevention of cardiovascular diseases.

4. Conclusion

This study identified that dragon fruit peel (*Selenicereus undatus*) has a significant content of flavonoids and has great potential as a natural antioxidant that supports cardiovascular health. The flavonoids in dragon fruit peel function as bioactive compounds that are able to neutralize free radicals, thus helping to reduce the risk of oxidative stress which is one of the main causes of cardiovascular disease. In this context, the use of dragon fruit peel as a natural source of antioxidants is particularly relevant as a safer alternative to synthetic supplements, especially for those who want to maintain heart health through a natural approach.

In addition to its antioxidant function, the flavonoids in dragon fruit peel also have anti-inflammatory effects that are important in preventing chronic inflammation of blood vessels. This inflammation is often associated with the development of heart and blood vessel disease, so the ability of flavonoids to inhibit the inflammatory process is an added value in the prevention of cardiovascular disease. In addition, flavonoids also exhibit vasodilating effects, which help to improve blood circulation and reduce blood pressure, making them potentially an important component in the management of hypertension and heart disease.

Based on these findings, dragon fruit peel has a great opportunity to be developed as a base ingredient in health products or supplements to support cardiovascular health. This research also supports a sustainability-based approach in utilizing food waste, while providing added value to the dragon fruit industry. As a recommendation for further research, more in-depth clinical studies are needed to test the effectiveness and safety of flavonoids from dragon fruit peels in humans. Further research can also explore the right processing methods and formulations so that the flavonoid benefits of dragon fruit peel can be optimized in health products that are ready to be consumed by the wider community.

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