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Revealing the Antioxidant Content in Banana Plants: A Nutritional Perspective and Health Benefits

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ABSTRACT: The banana (*Musa paradisiaca* L.) is a fruit widely consumed across tropical regions and recognized for its rich nutritional value and diverse bioactive compounds that contribute to human health. This study aims to evaluate the antioxidant content of banana plants from both nutritional and pharmacological perspectives through a comprehensive literature review. The review was conducted using scientific articles and official guidelines published between 2015 and 2025. The findings indicate that the banana pulp contains essential nutrients such as carbohydrates (27%), proteins (1%), and a variety of vitamins and minerals including calcium, potassium, and iron. In contrast, the banana peel, often considered agricultural waste, is abundant in bioactive phytochemicals such as flavonoids, polyphenols, tannins, saponins, and terpenoids, which contribute to its antioxidant potential. Antioxidant activity in banana extracts has been reported using various analytical methods, including DPPH (IC_{50} = 439.12 µg/mL), FRAP (26.5828 mg QE/g extract), ABTS (IC_{50} = 60.50–95.85 ppm), CUPRAC (EC_{50} = 101–150 µg/mL), and CAA (397 ± 5 µmol TE/100 g) assays. Moreover, fruit maturity influences antioxidant capacity, with unripe banana peels generally exhibiting higher antioxidant activity than ripe ones. These results highlight that banana plants, particularly their peels, possess considerable potential as natural antioxidant sources for use in food, nutraceutical, and pharmaceutical applications. Furthermore, the valorization of banana peel aligns with the circular economy concept, promoting sustainable agricultural waste management and environmental conservation.

KEYWORDS: Antioxidant; nutritional; phytochemical; spectrophotometry; fruit.

1. INTRODUCTION

Antioxidants are bioactive compounds that play a crucial role in maintaining physiological balance by counteracting the harmful effects of oxidants or free radicals in the body (Fawwaz et al., 2023). These compounds possess molecular structures capable of donating electrons or hydrogen atoms to unstable free radical molecules, thereby stabilizing them and interrupting chain oxidation reactions that may lead to cellular damage. Antioxidants can, therefore, reduce or neutralize free radicals, preventing oxidative stress that contributes to the onset of chronic diseases such as cancer (Fawwaz et al., 2025), diabetes, atherosclerosis, and neurodegenerative disorders (Ummum & Abidin, 2024).

Among various natural sources of antioxidants, banana plants (*Musa paradisiaca* L.) hold great promise for development in both nutritional and medicinal contexts. Bananas are one of the most widely cultivated tropical fruits due to their high productivity, adaptability to diverse environments, and rich nutritional composition (Blandina, Siregar & Setiado, 2019). Every part of the banana plant—including the fruit pulp, peel, flower, stem, and leaves—contains valuable bioactive compounds that have been traditionally and scientifically recognized for their therapeutic properties. Despite their potential, banana peels are often discarded as agricultural waste after fruit consumption, although they contain numerous phytochemicals beneficial to human health (Pusmarani et al., 2022).

Globally, bananas have evolved from a supplementary food to an important staple in many regions, particularly in America, Africa, and Southeast Asia. Nutritionally, the fruit pulp provides 116–128 kcal of energy per 100 grams, consisting of approximately 1% protein, 0.3% fat, and 27% carbohydrates, along with essential minerals such as calcium (15 mg), potassium (380 mg), iron (0.5 mg), and sodium (1.2 mg). Moreover, bananas are rich in vitamins A, B1, B2, B6, and C, which contribute to immune function, nerve health, and antioxidant defense. Calcium in bananas helps neutralize the adverse effects of excessive salt and MSG intake, while potassium regulates fluid balance, blood pressure, cardiac rhythm, and muscle contraction. Vitamin B6 and folate also support brain development and may play a preventive role against colorectal cancer (Blandina, Siregar & Setiado, 2019).

Banana peels, in particular, have gained attention as a natural source of antioxidants. Research by Pusmarani et al. (2022) demonstrated that banana peels contain diverse secondary metabolites, including flavonoids, polyphenols, tannins, saponins, and terpenoids, all of which contribute to high antioxidant activity. Similarly, Kim et al. (2022) reported that banana pulp possesses bioactive antioxidant compounds that play an essential role in cellular defense mechanisms against oxidative damage. In addition to antioxidant effects, banana peel extracts have shown hepatoprotective, anti-inflammatory, and anticancer properties, as well as the potential to prevent coronary heart disease (Pusmarani et al., 2022).

Given these findings, this article aims to examine the antioxidant content of banana plants (*Musa paradisiaca* L.) from nutritional and health perspectives through a comprehensive review of scientific literature. Understanding the bioactive potential of banana components, particularly the peel, may contribute to greater utilization of banana by-products, promoting their development as functional food ingredients or natural antioxidants in pharmaceutical and nutraceutical applications. Furthermore, valorizing banana plant waste supports the principles of circular economy and sustainable agricultural management, aligning health benefits with environmental sustainability.

2. METHODS

This article is a review study compiled based on an extensive literature analysis of scientific publications and relevant guidelines. The primary sources used in this study include peer-reviewed journal articles, research reports, and scientific reviews that discuss the nutritional composition, bioactive compounds, and antioxidant potential of banana plants (*Musa paradisiaca* L.) in relation to health benefits and functional applications.

The literature search was conducted across several major scientific databases, including Google Scholar, PubMed, ScienceDirect, and Semantic Scholar. To ensure the inclusion of the most up-to-date and relevant studies, the search was limited to publications from the last ten years (2015–2025). The keywords used in the search process were "antioxidant content of banana plants in health utilization", along with supporting terms such as "banana phytochemicals," "banana peel antioxidants," "Musa paradisiaca bioactivity," and "banana nutritional composition."

The selection of literature was based on inclusion criteria such as (1) articles written in English or Indonesian; (2) studies providing quantitative or qualitative data on the antioxidant content or health-related properties of banana plant components; and (3) publications available in full-text format. Duplicate studies, non-scientific sources, and articles lacking relevant data were excluded from the analysis.

The collected literature was then analyzed descriptively by comparing findings across various studies to identify common trends, variations in antioxidant activity, and potential applications of banana-derived compounds in nutrition, medicine, and sustainable resource management.

3. RESULTS AND DISCUSSION

Banana (*Musa paradisiaca* L.) is one of the abundant plants in Indonesia; however, the utilization of its fruit peels as waste is still not optimal (Rahmi and Hardi, 2021). In fact, banana peels contain various bioactive compounds that are beneficial for health. According to research (Aboul-Enein *et al.*, 2016), Banana peel contains carbohydrates, magnesium, protein, calcium, phosphorus, iron, sodium, and flavonoids. As a fruit with high nutritional value, bananas have long been recognized for their health benefits. **Table 1** shows the nutritional content in 100 g of banana pulp that contributes to various biological functions in the body.

Table 1. Nutritional Content of Bananas per 100 g (Blandina, Siregar and Setiado (2019)

Nutritional	Information
Energy	116-128 kcal
Protein	1%
Fat	0.3%
Carbohydrate	27%
Calcium	15 mg
Potassium	380 mg
Iron	0.5 mg
Sodium	1.2 mg
Vitamin A	0.3 mg
Vitamin B1	0.1 mg
Vitamin B2	0.1 mg
Vitamin B6	0.7 mg
Vitamin C	20 mg

The complete nutritional content makes bananas not only a source of energy but also offers various health benefits. The calcium in bananas can help neutralize the effects of salt and MSG, while potassium plays a crucial role in maintaining body fluid balance, normalizing blood pressure, heart function, and muscle work. Vitamin B6 and folic acid also contribute to brain development and play a role in the prevention of colon cancer. Furthermore, the content of these bioactive compounds makes bananas a source of natural antioxidants that have the potential to replace synthetic antioxidants. *Butylated Hydroxy Toluene* (BHT), that is carcinogenic (Susmayanti and Rahmadani, 2021).

Various methods have been developed to measure total antioxidant activity; however, to date, no truly ideal method exists. Each method has a specific mechanism for detecting antioxidant characteristics in a sample. Therefore, the use of more than one method is often employed to obtain more accurate results (Ummum and Abidin, 2024). The testing of nonenzymatic antioxidant activities such as polyphenols can be conducted through the mechanism of free radical reduction or the chelation of free radical ions through complex formation. Several common methods used in antioxidant activity testing include DPPH (*1,1-diphenyl-2-picrylhydrazyl*), FRAP (*Ferric Reducing Antioxidant Power*), ORAC (*Oxygen Radical Absorbance Capacity*), ABTS (*2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid*), CUPRAC (*Cupric Reducing Antioxidant Capacity*), serta TEAC (*Trolox Equivalent Antioxidant Capacity*) (Aryanti, Perdana and Syamsudin, 2021; Fawwaz et al., 2024; Arifin et al., 2025; Ainunnisa et al., 2025).

The testing of antioxidant activity on banana peel extract has been conducted by Ghozaly & Utami (2017) using the DPPH method. The selection of this method is based on the simplicity of the procedure, rapid analysis, and efficiency in chemical usage. A UV-Vis spectrophotometer was utilized for measurement at a wavelength of 515.5 nm. The test results indicated an IC_{50} value of 439.12 µg/mL. A lower IC_{50} value indicates a higher antioxidant activity. According to Molyneux's classification (2004), extracts with an IC_{50} value below 200 µg/mL are categorized as very active, while extracts with an IC_{50} between 200-1000 µg/mL are categorized as active (Ghozaly and Utami, 2017).

Furthermore, the antioxidant activity test using the FRAP method shows that the ethanol extract of banana peels (*Musa paradisiaca* L.) has an average antioxidant activity of 26.5828 mg QE/g of extract with a standard deviation of 0.4402. The obtained standard deviation is still within an acceptable limit (<0.5), thus this measurement result is considered valid. The principle of the FRAP method is based on the ability of antioxidant compounds to reduce Fe^{3+} ions to Fe^{2+}, which can be observed through the change in color of the blue-green complex (Ummum and Abidin, 2024).

In addition, another study utilized the ABTS method to measure the antioxidant activity of water extracts from cooking banana peels at various ripeness levels (Saputri, Augustina and Fatmaria, 2020). This method measures the absorption of the ABTS cation radical reduction at a wavelength of 734 nm. The results indicate that raw klutuk banana peel has an IC_{50} value of 60.50 ppm, while ripe klutuk banana peel has an IC_{50} value of 95.85 ppm. The lower IC_{50} value in raw klutuk banana peel suggests that its antioxidant activity is higher compared to that of the ripe banana peel.

The difference in antioxidant activity among various banana peel samples is closely related to the content of bioactive compounds such as polyphenols, flavonoids, and tannins. Research by Pantria Saputri *et al.* (2020) indicates that the maturity level of the fruit affects the concentration of these compounds, with raw banana peels generally containing higher levels of polyphenols compared to ripe banana peels. This correlates with stronger antioxidant activity, as evidenced by lower IC_{50} values obtained from the ABTS method. This explains why raw kepok banana peel (IC_{50} = 60.50 ppm) exhibits higher antioxidant activity than ripe kepok banana peel (IC_{50} = 95.85 ppm) (Saputri, Augustina and Fatmaria, 2020). A summary of the results of antioxidant activity testing from various studies on banana plants is presented in **Table 2**. The data show variations in antioxidant activity based on testing methods, banana types, and fruit ripeness.

Table 2. Results of Antioxidant Activity Testing on Banana Plant Extract

Method of Testing	Sample	Result	Interpretation	Reference
DPPH	Banana peel ectract	IC_{50} = 439,12 µg/mL	Included in the active category (200-1000 µg/mL)	Ghozaly & Utami (2017)
FRAP	Ethanol extract of Raja banana peel	26,5828 mgQE/g ekstrak (SD = 0,4402)	The antioxidant activity is quite good	Andi Ummum, Zainal Abidin (2024)
ABTS	Water extract of raw Kepok banana	IC_{50} = 60,50 ppm	The antioxidant activity is higher compared to ripe bananas	Pantria Saputri, Augustina & Fatmaria (2020)
ABTS	Water extract of ripe Kepok banana pelel	IC_{50} = 95,85 ppm	Antioxidant activity is lower compared to raw bananas	Pantria Saputri, Augustina & Fatmaria (2020)
CUPRAC	Banana peel ectract	EC_{50} = 101-150 µg/mL	Indicating antioxidant potential	Insanu, (2018)
CAA	Banana peel ectract	397 ± 5 µmol TE/100 g	The antioxidant activity is relatively low under biological conditions	Wan *et al.* (2015)

IC_{50} : The concentration of the sample that can inhibit 50% of free radicals
EC_{50} : The effective concentration of the sample that produces 50% antioxidant activity
DPPH : *1,1-diphenyl-2-picrylhydrazyl*
FRAP : *Ferric Reducing Antioxidant Power*
ABTS : *2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)*
CUPRAC : *Cupric Reducing Antioxidant Capacity*
CAA : *Cellular Antioxidant Activity*
mgQE/g : miligram Quercetin Equivalent per gram
µmol TE/100 g : mikromol Trolox Equivalent per 100 gram

Based on the data in **Table 2**, it is evident that banana peel extract exhibits significant antioxidant activity, albeit at varying levels. These results confirm the potential of banana peels as a source of natural antioxidants that can be further developed for food and pharmaceutical applications.

The CUPRAC method is also used to evaluate antioxidant activity based on its ability to reduce copper (II) ions (Cu^{2+}) to copper(I) ions (Cu^{+}) under neutral pH conditions. The test results indicate that the EC_{50} value ranges from 101-150 µg/mL, which signifies the antioxidant potential of banana peel extract (Insanu, 2018).

In addition to chemical methods, the measurement of antioxidant activity under biological conditions is conducted using the *Cellular Antioxidant Activity* (CAA) method. This method assesses antioxidant activity in living cells, which is more relevant to physiological conditions compared to chemical methods such as ORAC. Based on research (Wan *et al.*, 2015), The obtained CAA value is 397 ± 5 µmol TE/100 g, indicating a relatively low category of antioxidant activity. Factors influencing the CAA value include the content of phenolic compounds, flavonoids, and vitamin C in the extract, as well as its ability to penetrate cell membranes and interact with the enzymatic system within the cells.

The results of the study as a whole indicate that the ethanol extract of banana peel (*Musa paradisiaca* L.) possesses considerable antioxidant activity based on the DPPH and FRAP methods. The antioxidant activity is also dependent on the ripeness of the banana fruit, as demonstrated in studies using the ABTS method. Additionally, the CUPRAC and CAA methods provide further insights into the antioxidant potential of banana peel extract under chemical and biological conditions. Overall, these findings affirm that banana peels, which have long been considered waste, hold significant potential as a source of natural antioxidants that can be utilized in the food and pharmaceutical sectors.

The antioxidant potential of banana peels opens up opportunities for further utilization, particularly in the development of functional food products, supplements, and cosmetics. Banana peel extracts may be considered as an alternative to synthetic antioxidants such as BHT, which is known to have carcinogenic side effects when used over a long period. Utilizing banana peels as a source of natural antioxidants also aligns with sustainable agricultural waste management efforts, where materials previously regarded as waste can be converted into value-added products with health benefits. This supports the concept of a circular economy in the food and pharmaceutical industries.

4. CONCLUSION

Based on the results of this literature review, banana plants (*Musa paradisiaca* L.) are a rich source of bioactive antioxidant compounds, including flavonoids, phenolics, tannins, saponins, and terpenoids, which play an essential role in combating oxidative stress and preventing various degenerative diseases. These compounds contribute to multiple health benefits such as anti-inflammatory, cardioprotective, hepatoprotective, and anticancer activities, supporting the potential of banana-derived materials as natural therapeutic agents. In addition to their nutritional value, the banana peel, often discarded as waste, demonstrates particularly high antioxidant activity, highlighting its potential for value-added applications in food, nutraceutical, and pharmaceutical industries.

The increasing global demand for natural antioxidants emphasizes the importance of further research to optimize the extraction, formulation, and application of bioactive compounds from banana plants. Future studies should focus on developing eco-friendly processing technologies, standardizing antioxidant activity assays, and exploring clinical efficacy to ensure safe and effective utilization. Overall, the comprehensive utilization of banana plants not only enhances human health but also promotes sustainable agricultural practices and contributes to the circular economy through the valorization of agricultural by-products.

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