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Screening of Antioxidant Activity of Fruit Peel and Stem Bark Extracts of *Garcinia mangostana* L Using the 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) Method

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Abstract
Mangosteen stem bark and rind are known to contain various bioactive compounds such as xanthones, flavonoids, and polyphenols, which can function as antioxidants. To measure the level of antioxidant ability in stem bark and mangosteen fruit peel extracts, one method often used is the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. The purpose of this study was to determine the antioxidant activity of stem bark and fruit peel extracts of Garcinia mangostana L using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. Samples of stem bark and fruit peel were extracted using the maceration method, followed by antioxidant activity testing with the DPPH method. The results showed that the stem bark extract of G. mangostana L. had an IC50 value of 42,95 ppm, while the fruit peel extract showed a lower IC50 value of 12,13 ppm, indicating that both had very strong antioxidant activity. The content of bioactive compounds such as phenolics, flavonoids, and xanthones is the main cause of the high antioxidant activity, making G. mangostana L. stem bark and fruit peel extracts potential therapeutic agents in the prevention and treatment of oxidative stress-related diseases.

INTRODUCTION

Free radicals are highly reactive oxygen-containing compounds with one or more unpaired electrons (Yunita, 2021; Maulydya et al., 2023). They are also defined as stable molecules capable of existing independently, possessing one or more unpaired electrons in their outer orbitals (Faradiba et al., 2024). According to Theafelicia & Wulan (2023), the unpaired electrons in free radicals tend to capture electrons from other molecules in the body due to their high reactivity, which can lead to an increased level of free radicals. They can damage various cellular components such as proteins and lipids, potentially leading to the onset of numerous diseases when these levels exceed the physiological threshold (Putri et al., 2017).

Arista & Siregar (2024) noted that under normal physiological conditions, free radicals serve beneficial functions such as combating inflammation and invading pathogens, as well as modulating smooth muscle tone. However, excessive exposure to free radicals resulting from ultraviolet (UV) radiation, cigarette smoke, air pollution, certain foods, pesticides, and stress may contribute to various degenerative diseases, including cancer, cardiovascular disorders,

cataracts, and premature ageing (Pratama & Busman, 2020). Therefore, the human body requires essential substances, such as antioxidants, to neutralize these free radicals (Pratama et al., 2015).

Antioxidants are compounds that inhibit autoxidation processes (Jayanto, 2024). Faradiba et al. (2024) describe antioxidants as electron-donating molecules with low molecular weight, capable of halting oxidative reactions by preventing the formation of radicals. Although the human body is naturally equipped with endogenous antioxidant systems to counteract physiologically generated free radicals, under certain conditions, these systems may become insufficient to protect against oxidative stress. Consequently, exogenous antioxidants are required to prevent excessive oxidative stress (Widiasriani et al., 2024).

Based on their origin, antioxidants are categorized into two types: synthetic and natural. The use of synthetic antioxidants has become increasingly restricted due to their associated health risks. For example, Butylated Hydroxy Toluene (BHT), a widely used synthetic antioxidant, is carcinogenic and toxic to experimental animals (Samodra et al., 2023). Growing concerns over the adverse effects of synthetic antioxidants have prompted a shift towards natural antioxidants as safer alternatives (Asrifaturofingah et al., 2024).

The exploration of natural antioxidants as free radical scavengers has garnered significant interest due to their accessibility and minimal side effects (Mudjiran & Karneli, 2024; Ukratalo, 2025; Tuhumuri et al*.,* 2025). According to Satriyani (2021), natural antioxidants can be sourced from plants, which represent a promising avenue for discovering novel antioxidant compounds, particularly in biodiversity-rich countries such as Indonesia (Kumalasari et al., 2019). Several studies have demonstrated the antioxidant potential of various plant species, including medicinal herbs (Dewi et al., 2024; Jayanato, 2024; Masniawati et al., 2024; Ansyori et al., 2024; Arista & Siregar, 2024).

One potential source of natural antioxidants is the mangosteen fruit (*Garcinia mangostana* L.), a tropical fruit widely used in traditional medicine across Southeast Asia (Rizaldy et al., 2021). According to Udin et al. (2023), *G. mangostana* possesses numerous health benefits, notably its potent anti-inflammatory and antioxidant properties. The fruit peel contains a variety of xanthones, including mangostin, mangosterol, mangostinone A and B, trapezifolixanthone, tovophyllin B, α- and β-mangostin, garcinone B, mangostanol, the flavonoid epicatechin, and gartanin (Ukratalo, 2025a). Meanwhile, the stem bark has also been reported to contain phenolic and flavonoid compounds that exhibit potential antioxidant activity (Jamila et al., 2016; Mursal et al., 2024).

Sholihah et al. (2017) reported that the peel of *G. mangostana* L. demonstrated potent antioxidant activity, with an IC_{50} value of 8.667 ppm. Similarly, Helisa et al. (2024), using a sonication extraction method, found that ethanolic extracts of the fruit peel had an IC_{50} of 10.28 ppm, while aqueous extracts had an IC_{50} of 46.52 ppm. Both values fall within the "powerful antioxidant" category, as IC_{50} values below 50 ppm are generally considered indicative of high antioxidant potential.

In this study, the antioxidant activity of *G. mangostana* L. fruit peel and stem bark extracts was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method (Maarisit et al., 2024). The DPPH method is widely used due to its simplicity, speed, cost-effectiveness, and

efficiency (Munteanu & Apetrei, 2021; Wołosiak et al., 2022). According to Sulistyan et al. (2024), DPPH is a stable, colored, and water-insoluble compound that serves as a standard reagent in antioxidant assays. DPPH exhibits a characteristic absorbance in the range of 515–520 nm when dissolved in alcohol. Upon reaction with antioxidant compounds, the solution undergoes a colour change from purple to yellow-orange due to reduction, and the degree of discoloration is proportional to the antioxidant activity of the tested sample.

This study aimed to evaluate the antioxidant activity of fruit peel and stem bark extracts of *Garcinia mangostana* L. using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay.

RESEARCH METHODS

Instruments and Materials

The instruments used in this study included Whatman filter paper, a digital balance, micropipettes, a Milton Roy 501 UV-Visible spectrophotometer, a rotary evaporator, a vacuum system, a vortex mixer, a water bath, a desiccator, and a 65-mesh sieve. The materials used consisted of fresh and dried samples of *Garcinia mangostana* L. fruit peel and stem bark, petroleum ether, 1,1-diphenyl-2-picrylhydrazyl (DPPH), 50% Folin-Ciocalteu reagent, a 2% sodium carbonate (Na_2CO_3) solution, and distilled water (aquadest).

Sample Preparation

The fresh (wet) samples of *G. mangostana* L. stem bark and fruit peel were washed, chopped into small pieces, and air-dried for two weeks. The dried materials were ground using a blender and sieved through a 65-mesh sieve to obtain a fine powder.

Extraction Procedure

A total of 50 grams of powdered sample was macerated in 200 mL of petroleum ether for 24 hours with intermittent stirring. The mixture was filtered using a vacuum filtration setup with Whatman filter paper to separate the residue from the filtrate. The filtrate was then evaporated to remove the solvent, and the resulting concentrated extract was weighed and stored at 40°C.

Determination of Free Radical Scavenging Activity (DPPH Assay)

Each petroleum ether extract (0.5 mL) was mixed with 2 mL of DPPH solution and vortexed for 2 minutes. A colour change from purple to yellow indicated the presence of free radical scavenging activity. After 30 minutes of incubation, the absorbance was measured at 517 nm using a UV-Vis spectrophotometer, within the last 5 minutes of the incubation period.
The radical scavenging activity (%) was calculated using the following equation:

$$\% \text{ inhibition} = \frac{A_{control} - A_{Sample}}{A_{control}} \times 100\%$$

The percentage inhibition values obtained were plotted against sample concentrations to

construct a linear regression curve. The IC_{50} value (the concentration of extract required to inhibit 50% of DPPH radicals) was calculated from the resulting regression equation.

RESULTS AND DISCUSSION

Stem Bark of *Garcinia mangostana* L.

The IC_{50} value was determined based on absorbance measurements and the corresponding percentage of inhibition. The results indicated that higher extract concentrations corresponded to increased free radical inhibition (% inhibition). Table 1 presents the absorbance values and inhibition percentages of the stem bark extract at various concentrations.

Table 1. Absorbance and Percentage (%) Inhibition of *G. mangostana* L. Stem Bark Extract

Concentration (ppm)	Absorbance	% Inhibition
5	0,396	18,85
10	0,372	23,77
15	0,359	26,43
20	0,342	29,92
25	0,312	36,07

Based on the data in Table 1, a linear regression equation of the form Y = aX + b was constructed. The resulting linear relationship is shown in Figure 1.

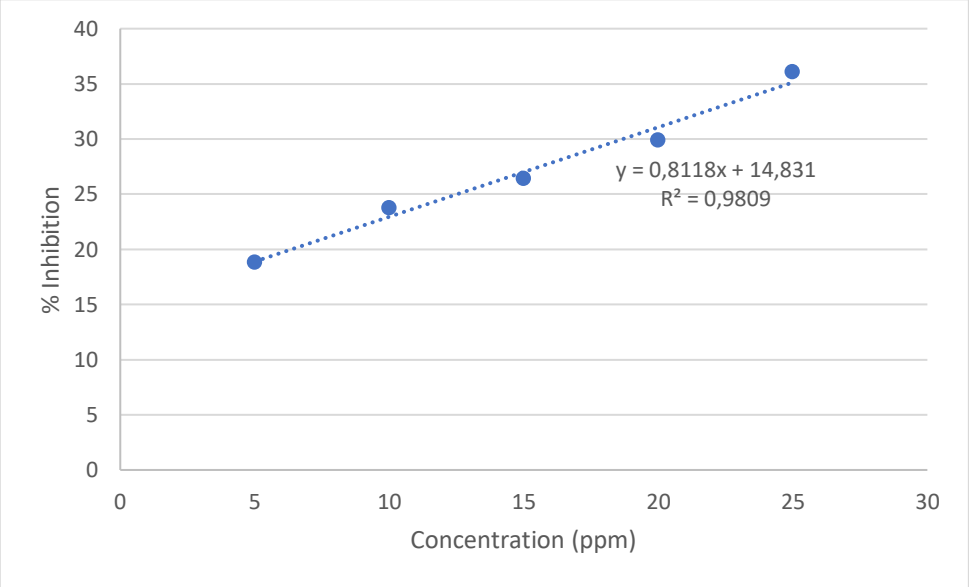

Figure 1. Linear Regression Curve of Antioxidant Activity of *Garcinia mangostana* L. Stem Bark Extract

The IC_{50} value was determined based on the linear regression equation shown in Figure 1. According to the calculated data, the IC_{50} value of the stem bark extract of *G. mangostana* L. was 42.95 ppm, indicating strong antioxidant activity.

Fruit Peel of *Garcinia mangostana* L.

The antioxidant activity of the fruit peel extract, based on the absorbance and inhibition

percentage measurements, is presented in Table 2.

Table 2. Absorbance and Percentage (%) Inhibition of *G. mangostana* L. Fruit Peel Extract

Concentration (ppm)	Absorbance	% Inhibition
5	0,331	32,17
10	0,29	40,57
15	0,208	57,38
20	0,105	78,48
25	0,101	79,30

The data presented in Table 2 were plotted and analyzed using linear regression to obtain a relationship between extract concentration and percentage inhibition. The resulting regression equation is illustrated in Figure 2.

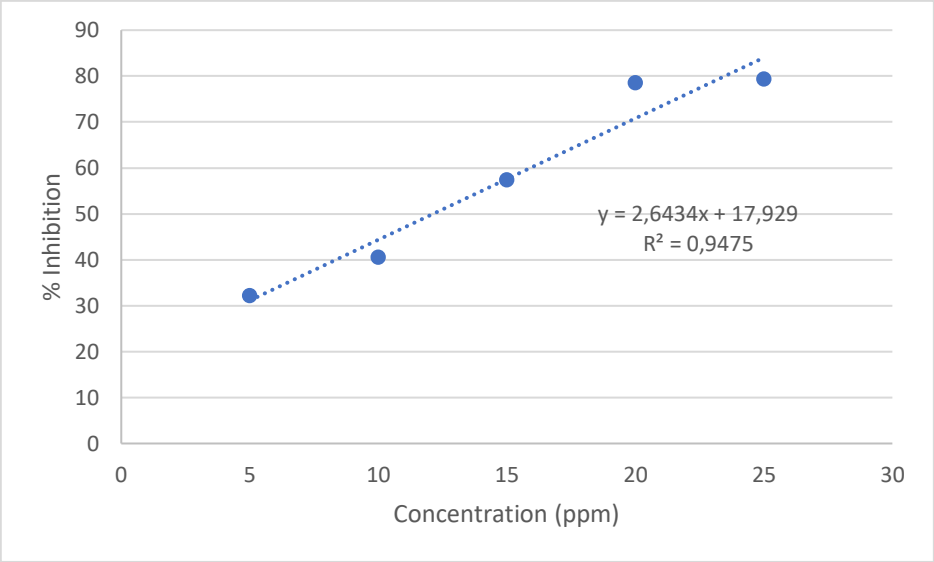

Figure 2. Linear Regression Curve of Antioxidant Activity of *Garcinia mangostana* L. Fruit Peel Extract

The IC_{50} value was determined from the linear regression equation presented in Figure 2. Based on the regression analysis, the IC_{50} value of the *Garcinia mangostana* L. fruit peel extract was calculated to be 12.13 ppm.

IC_{50} is a parameter used to measure the effectiveness of a compound in inhibiting a biological or biochemical function—in this case, the compound's ability to scavenge free radicals. Specifically, IC_{50} represents the concentration of an extract required to reduce free radical activity by 50% compared to an untreated control. This measurement is widely applied in antioxidant research to assess how effectively a substance can mitigate oxidative damage. A lower IC_{50} value indicates stronger antioxidant capacity.

The results of this study revealed that the stem bark extract of *G. mangostana* L. exhibited an IC_{50} value of 42.95 ppm. In comparison, the fruit peel extract demonstrated a significantly lower IC_{50} value of 12.13 ppm. According to Mardawati et al. (2008), compounds with IC_{50} values below 50 ppm are classified as having extreme antioxidant activity, whereas those with IC_{50} values above 200 ppm are considered very weak antioxidants. Based on these criteria, both the stem bark and fruit peel extracts of *G. mangostana* L. meet the threshold for

powerful antioxidant agents. These findings suggest that both plant parts have considerable potential to neutralise free radicals that contribute to cellular, tissue, and organ damage.

The IC_{50} value of the stem bark extract obtained in this study is slightly lower than that reported by Udin et al. (2023), who found an IC_{50} of 47.73 ppm for ethanol extracts of *G. mangostana* L. stem bark. These variations may be attributed to several factors, particularly the type of solvent used during the extraction process. The choice of solvent plays a critical role in determining the composition of bioactive compounds extracted from plant materials, which in turn affects the antioxidant potency of the extract. Different solvents extract produced sets of compounds based on their polarity and the chemical properties of the phytochemicals present in the plant.

The high antioxidant activity observed in both the stem bark and fruit peel of *Garcinia mangostana* L. can be attributed to the presence of various bioactive compounds. One of the primary antioxidant constituents found in both plant parts is xanthone, particularly mangostin, a polyphenolic compound known for its potent antioxidant activity (Putri, 2015; Sumarmin, 2018; Agent, 2018).

In addition to xanthones, both the fruit peel and stem bark of *G. mangostana* L. are rich in flavonoids (Yuliastri et al., 2023), which are well-established antioxidants. Flavonoids act by binding to and neutralising free radicals, thereby effectively reducing oxidative stress in the body (Kaihena et al*.,* 2023; Kaihena et al*.,* 2024). Oxidative stress, resulting from an imbalance between the production of reactive oxygen species and the body's ability to neutralise them, is a major contributor to the pathogenesis of chronic diseases (Ukratalo et al*.,* 2023; Moniharapon et al*.,* 2023). Moreover, flavonoids are known to exhibit anti-inflammatory, anticancer, and cell-protective properties. Several studies have demonstrated that flavonoids can inhibit cancer cell proliferation and invasion, while also supporting tissue repair and regeneration (Sumartini, 2020).

The presence of such potent bioactive compounds made *G. mangostana* L. a promising candidate for the development of healthcare and cosmetic products. Xanthones, for example, help neutralise free radicals that contribute to skin aging, while flavonoids such as quercetin, kaempferol, and rutin help preserve skin elasticity, prevent wrinkles, and promote the regeneration of damaged skin cells. Additionally, the strong antioxidant capacity of these extracts offers protection against UV-induced skin damage, a significant factor in premature aging, pigmentation, and skin cancer. By mitigating oxidative stress triggered by UV radiation, these plant extracts can function as natural skin protectants.

Beyond skincare applications, the bark and peel extracts of *G. mangostana* L. also show potential in preventing degenerative diseases, including cancer, diabetes, and cardiovascular diseases. The antioxidant compounds in mangosteen extracts offer systemic benefits that extend beyond the skin. Xanthones, flavonoids, and phenolic compounds have been shown to suppress cancer cell growth and reduce inflammation, both of which are associated with the development of chronic diseases. With the increasing interest in natural therapeutic agents, mangosteen-based products are expected to gain popularity in the health and wellness industries, offering dual benefits for both aesthetic and preventive healthcare purposes.

CONCLUSION

The IC_{50} value of the fruit peel extract of Garcinia mangostana L. was 12.13 ppm, which was lower than that of the stem bark extract (42.95 ppm). This difference indicates that the fruit peel extract exhibited higher toxic activity, as a lower concentration was required to inhibit 50% of the target activity compared with the stem bark extract.

These findings suggest that mangosteen fruit peel has greater potential to be developed as a source of natural bioactive compounds for pharmaceutical, antioxidant, antimicrobial, and anticancer applications. Furthermore, the utilization of fruit peel as an active material may enhance the added value of agricultural waste and support the development of more economical and environmentally sustainable natural-based products.

DECLARATIONS

Author Contributions

L.E and N. A. P. S. B. K contributed to designing the study, preparing samples and test materials, conducting the study, and preparing the manuscript.

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Declaration of Interest

The authors declare that this research and the data obtained are not related to any party.

Data Sharing Statement

Data supporting this study's findings and conclusions can be provided to other parties upon relevant request.

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