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Phytochemical Profile and Antioxidant Activity of Phenolic and Flavonoid Compounds in Methanol Extracts of the Fruit and Leaves of *Scaevola taccada* (Geartn.) Roxb

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Abstract

The mangrove plant *Scaevola taccada* (Gaertn.) Roxb is known to have potential as a source of natural bioactive compounds that act as antioxidants. The presence of antioxidant compounds can control ROS (Reactive Oxygen Species) and RNS (Reactive Nitrogen Species), which trigger oxidative stress. The purpose of this study is to assess the antioxidant activity and total phenolic and flavonoid content of methanol extracts from the fruits and leaves of *Scaevola taccada* originating from the coastal area of Sikara-kara Village, Mandailing Natal Regency. This study is an experimental study conducted in vitro in a laboratory. The extraction process was performed using the maceration method with 80% methanol as the solvent. Total phenolic compounds were measured using the Folin-Ciocalteu method with gallic acid as the standard, while total flavonoids were measured using the aluminum chloride method with quercetin as the standard. Antioxidant activity was measured using the DPPH method, with the results expressed as IC_{50} values. The findings indicated that the leaf extract possessed elevated concentrations of phenolics and flavonoids relative to the fruit extract, with a total phenolic content of 68.896 mg GAE/g extract and a total flavonoid content of 103.612 mg QE/g extract. The fruit extract exhibited a total phenolic value of 43.916 mg GAE/g extract and a total flavonoid value of 11.287 mg QE/g extract. Leaf extract exhibits superior antioxidant activity, evidenced by an IC_{50} value of 52.832 ppm, in contrast to 342.386 ppm for the fruit extract. This study shows that the leaves of *Scaevola taccada* have greater potential as a source of antioxidants than the fruit, thereby opening up opportunities for their use as raw materials in the production of herbal medicines.

Keywords: Antioxidants; DPPH; Flavonoid; Phenolic; *Scaevola taccada*.

INTRODUCTION

The utilization of mangroves as a natural remedy has been employed for generations in numerous coastal regions. Almost all components of the plant, including the leaves, fruit, bark, and roots, are employed in traditional medicine (Abubakar *et al*., 2019). Various mangrove species are known to help manage degenerative conditions such as gout, rheumatism, high cholesterol, infections, and digestive disorders, as well as boost the immune system (Prasetyo, 2023). This is supported by the presence of bioactive compounds such as alkaloids, tannins, flavonoids, polyphenols, and saponins, which possess various pharmacological activities, including antioxidant properties (Pambudi & Haryoto, 2022).

Free radicals are reactive molecules that can trigger oxidative stress, which contributes to damage to cells, tissues, and DNA, as well as various chronic diseases such as cancer, diabetes, and heart disease (Natzir & Syamsul, 2024; Situmeang *et al*., 2025). Free radical activity can be controlled by antioxidant compounds capable of neutralizing oxidative reactions (Faisal *et al*., 2022; Kurniawati *et al*., 2025). Therefore, the use of natural antioxidants from plants, including mangroves, is becoming increasingly important as they are considered safer than synthetic antioxidants (Winarti *et al*., 2019).

One mangrove species with potential as a source of natural medicine is the sea daisy (*Scaevola taccada* (Gaertn.) Roxb), which belongs to the family *Goodeniaceae* (Gosari *et al*., 2024). This plant has traditionally been used in various countries in Southeast Asia and Australia; for example, in the Philippines, the roots are boiled to treat beriberi, syphilis, and dysentery; in Malaysia, the leaves are used as a compress for headaches; in Indonesia, young leaves are chewed or boiled into tea to relieve coughs, and in northern Australia, the juice from young stems and ripe fruits is applied to insect bites and stings (Valkenburg & Bunyapraphatsara, 2001). Pharmacologically, various laboratory tests have shown that *S. taccada* has been proven to possess diverse biological activities. Leaf

extract of *S. taccada* is known to possess antibacterial activity (Apriandi *et al*., 2023), anti-inflammatory activity (Amirah *et al*., 2014; Sani & Yustimartina, 2016), antihyperglycemic (El-Sayed *et al*., 2020), antihyperlipidemic (Rahmawati *et al*., 2020), antioxidant (Budiana *et al*., 2019), and anticancer (Chandran & Arunachalam, 2015). Meanwhile, the fruit has been found to possess antifungal (Suthiwong *et al*., 2017), antibacterial (Fath, 2023), and antioxidant (Nengsih *et al*., 2021).

The pharmacological benefits of *S. taccada* are supported by its diverse phytochemical content, including alkaloids, flavonoids, phenols, steroids/triterpenoids, saponins, and tannins (Siagian *et al*., 2020; Widati, 2021). These compounds act as natural antioxidants capable of neutralizing free radicals and protecting cells from oxidative damage. Previous studies have demonstrated the antioxidant activity of several extracts from parts of the *S. taccada* plant, such as a leaf extract prepared with chloroform, which yielded an IC50 value of 0.194 ppm, and a fruit extract with a value of 0.464 ppm (Rudianto *et al*., 2019); ethyl acetate-extracted leaves with an IC_{50} value of 476.7 ppm (Ghani *et al*., 2021); water extract of mature fruit had an IC_{50} value of 113.47 ppm, water extract of young fruit 130.71 ppm, and water extract of mixed fruit 164.58 ppm (Apriandi *et al*., 2021); juice from young fruit with an IC_{50} of 19.524 ppm, juice from mature fruit 50.664 ppm, and juice from mixed fruit 35.518 ppm (Fatmawati *et al*., 2021).

Ecologically, the coastal area of Sikara-kara Village, Natal Subdistrict, Mandailing Natal Regency is an open coastal zone directly influenced by tidal fluctuations, high salinity, intense solar radiation, and other coastal environmental stresses. These extreme environmental conditions can trigger mangrove plants, including *S. taccada*, to produce higher amounts of secondary metabolites as an adaptive mechanism against environmental stress (Yang *et al*., 2018). In this context, the levels of phenolic compounds and flavonoids can be increased to enhance their antioxidant properties.

The various secondary metabolites and bioactivities found in *S. taccada* indicate its potential as a source of natural medicines. Although previous studies have described the secondary metabolite profiles and antioxidant potential of the leaves and fruits, information regarding total phenolic content, total flavonoid content, and specific antioxidant activity in methanol extracts remains very limited. For this reason, this study is crucial to evaluate the phytochemical composition and antioxidant capacity of *S. taccada* methanol extracts as natural antioxidant agents.

MATERIALs AND METHODS

Date and Time

This study was conducted from October 2025 to February 2026. Leaf and fruit samples of *S. taccada* were collected in the coastal area of Sikara-kara Village, Natal Subdistrict, Mandailing Natal Regency, as shown in (Figure 1). The extraction process, determination of total phenolic and flavonoid content, and testing of antioxidant activity were conducted at the Samudra University laboratory.

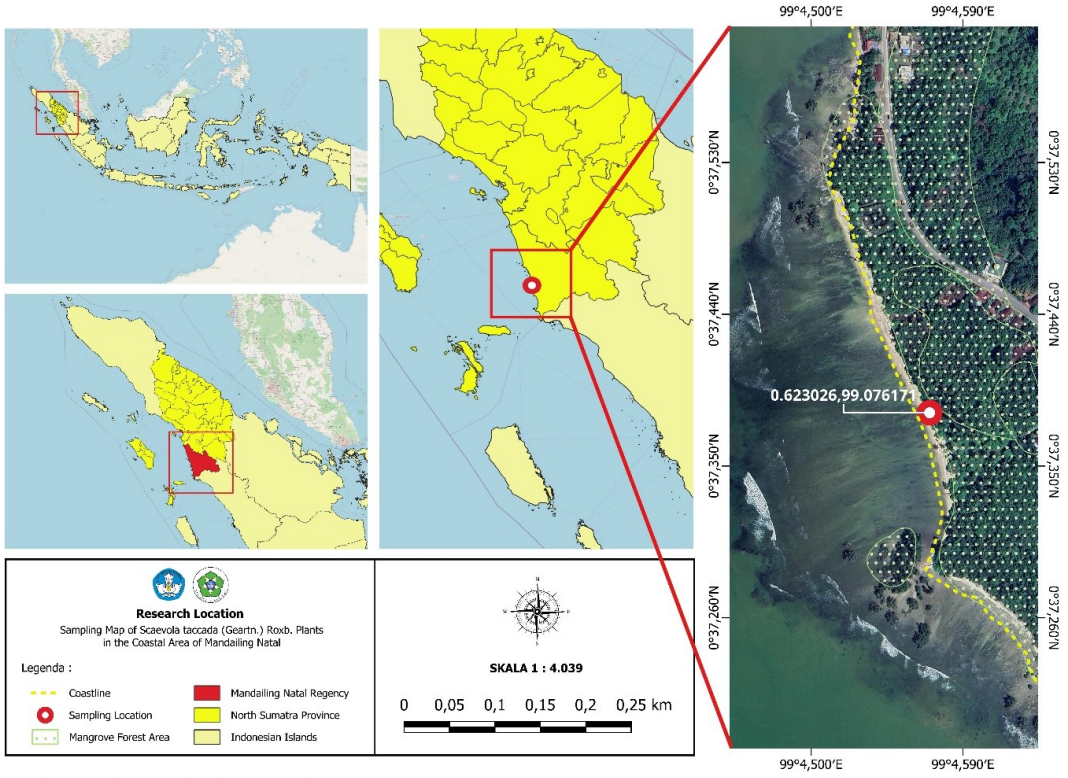

Figure 1. Location of *Scaevola taccada* Plant Sampling.

Figure 2. The plant *Scaevola taccada*; A. Growth Form, B. Leaves, and C. Fruit.

Tools and Materials

This study is an *in vitro* laboratory experiment using a quantitative approach. The samples used were dried leaves and fruits of *S. taccada*, as shown in Figure 2. Other materials used included 80% methanol, p.a. methanol, distilled water, gallic acid, Folin–Ciocalteu reagent, 10% Na_2CO_3, $AlCl_3$, quercetin, 5% dimethyl sulfoxide (DMSO) 5%, potassium acetate, ascorbic acid, and DPPH solution (2,2-diphenyl-1-picrylhydrazyl). The equipment used included a GPS (Global Positioning System), a UV-Vis spectrophotometer, Whatman No. 1 filter paper, vials, an analytical balance, micropipettes, aluminum foil, an incubator, and standard laboratory glassware.

Procedures

Sample Preparation and Extraction

The extract was prepared by collecting leaf and fruit samples from the study site, which were then sorted, cut into small pieces, and dried in the shade until the plant parts became stiff and brittle and their weight had decreased to approximately 80%–90% (Indriaty et al., 2022). Simplisia 100 grams of crude drug were extracted using the maceration method with 80% methanol as the solvent for 72 hours at room temperature (Indriaty et al., 2023). The maceration product was then filtered using Whatman No. 1 filter paper to obtain the filtrate, which was then evaporated by allowing it to stand at room temperature until it became a concentrated extract.

Determination of Total Phenolic Content (TPC)

The total phenolic content was determined using the Folin–Ciocalteu method, with gallic acid used as the reference standard solution. A stock solution of gallic acid standard at a concentration of 500 ppm was prepared by dissolving 5 mg of the substance in 0.625 mL of methanol p.a and diluting it with distilled water to a final volume of 10 mL. This was then diluted to obtain concentrations of 100 ppm, 125 ppm, 150 ppm, 175 ppm, and 200 ppm. For each concentration, 0.1 mL of the solution was taken and mixed with 7.9 mL of distilled water, 0.5 mL of Folin–Ciocalteu reagent, and 1.5 mL of 10% Na_2CO_3 was added to obtain final concentrations of 1 ppm, 1.25 ppm, 1.5 ppm, 1.75 ppm, and 2 ppm. Subsequently, the solutions were incubated in the dark at room temperature for 120 minutes. Absorbance was measured at 765 nm to determine the total phenolic content in mg EAG/g of extract. The test solution was prepared by dissolving 5 mg of the extract sample in a solvent mixture consisting of 0.05 mL of DMSO 5%, 0.250 mL of methanol p.a, and 4.7 mL of distilled water. The solution was then reacted with a reagent similar to the standard solution until a final concentration of 10 ppm was reached. The calculation of total phenolic content was based on formula 1 (Belew et al., 2025).

$$TPC = \frac{C \,.\, V \,.\, fb}{g} \quad (1)$$

Notes: TPC: total phenolic content; C: phenolic concentration (value x); V: volume of extract used; fb: dilution factor; g: sample weight.

Determination of Total Flavonoid Content (TFC)

The total flavonoid content was determined using the aluminum chloride ($AlCl_3$) method with quercetin as the standard solution. A 500 ppm quercetin stock solution was prepared by dissolving 5 mg of the standard substance in 10 mL of methanol p.a. This solution is then diluted with distilled water to concentrations of 20 ppm, 40 ppm, 60 ppm, 80 ppm, and 100 ppm. For each concentration, 1 mL was taken and 3 mL of methanol p.a, 0.2 mL of $AlCl_3$, 0.2 mL of potassium acetate, and 5.6 mL of distilled water were added, resulting in final concentrations of 2 ppm, 4 ppm, 6 ppm, 8 ppm, and 10 ppm. The mixture was incubated at room temperature for 30 minutes, after which the absorbance was measured at a wavelength of 440 nm to determine the total flavonoid content in mg QE/g of extract. The test solution was prepared by dissolving 5 mg of the extract in a mixture of 4.950 mL of methanol p.a and 0.05 mL of DMSO 5%. Next, the same reagent was added as in the standard solution procedure to obtain a final concentration of 100 ppm. The calculation of total flavonoid content was based on formula 2 (Belew et al., 2025).

$$TFC = \frac{C \,.\, V \,.\, fb}{g} \quad (2)$$

Notes: TPC: total phenolic content; C: phenolic concentration (value x); V: volume of extract used; fb: dilution factor; g: sample weight.

Testing Antioxidant Activity Using the DPPH Method

Antioxidant activity was tested using the DPPH method with ascorbic acid as the standard. Take 3 mg of ascorbic acid and dissolve it in 5 mL of methanol p.a to produce a 600 ppm solution, which is then diluted to yield final concentrations of 1 ppm, 3 ppm, 6 ppm, 9 ppm, 12 ppm, and 15 ppm. For the test solutions, 5 mg of extract was dissolved in 9.950 mL of methanol p.a and 0.05 mL of 5% DMSO was added to produce a 500 ppm solution. It was then diluted with methanol p.a to a volume of 4 mL, and 1 mL of DPPH solution was added at various concentrations (6.25 ppm, 12.5 ppm, 25 ppm, and 50 ppm). All mixtures were incubated for 30 minutes at room temperature, after which absorbance measurements were taken at a wavelength of 517 nm. The percentage of inhibition was calculated and used to determine the IC_{50} value via the linear regression equation y = bx + a, where y is set to 50 and x represents the IC_{50} (Khasanah et al., 2025). Notes: y = Percentage of inhibition (%); x = Sample concentration (ppm); a = Slope of the curve; b = Gradient.

Data analysis

All tests were conducted in triplicate. The research data were analyzed quantitatively and presented as mean values to determine the total content of phenolic compounds and flavonoids, as well as the IC_{50} values for the antioxidant activity of the extracts. The test results were analyzed using Microsoft Excel and OriginLab Version 2024.

RESULTS AND DISCUSSION

RESULT

Total Content of Phenolic Compounds and Flavonoids

The total phenolic and flavonoid contents were determined to evaluate the concentrations of these two compounds in the fruit and leaves of *Scaevola taccada* (Gaertn.) Roxb. Phenolic and flavonoid compounds are secondary metabolites that play an important role in plant biological activity, particularly as antioxidants. Total phenolic compounds were measured using the Folin–Ciocalteu method with gallic acid as the standard, while total flavonoids were determined using the aluminum chloride complexation method with quercetin as the standard.

The results of measuring the concentration of the gallic acid standard solution against the absorbance values were used to plot a standard curve, as shown in Figure 3. The quercetin standard solution then illustrates the relationship between concentration and absorbance values, as shown by the standard curve in Figure 4.

The regression equations obtained from the standard curves for gallic acid and quercetin are shown in Table 1. The results of the regression equations obtained show standard curves for each parameter with high values of the coefficient of determination (R^2). This indicates that these equations are suitable for use as a basis for calculating the levels of bioactive compounds in the fruit and leaf extracts of *S. taccada*.

Table 1. Regression Equations for the Standard Curves of Fruit Extract (B-ST) and Leaf Extract (D-ST) from the S. taccada Plant.

Test	Standard	Regression Equation	R^2
TPC	Gallic Acid	y = 0,1241x - 0,0045	R^2 = 0,9946
TFC	Quercetin	y = 0,0443x - 0,009	R^2 = 0,999

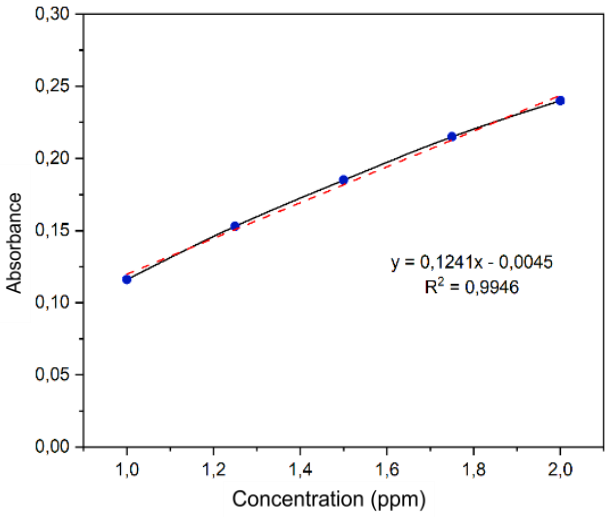

Figure 3. Standard Curve for Gallic Acid.

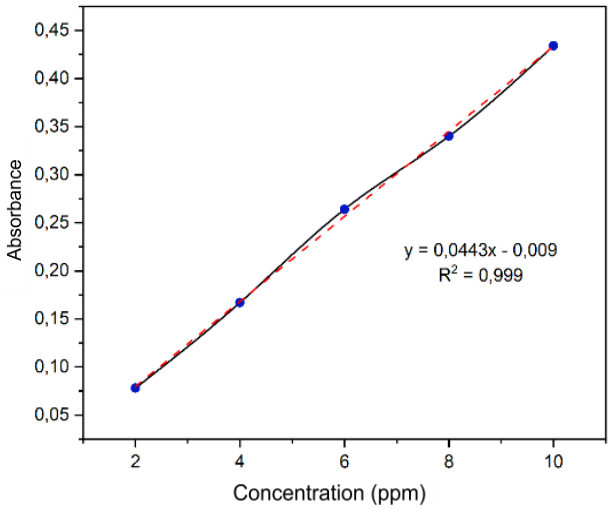

Figure 4. Standard Curve for Quercetin.

Based on calculations using the regression equation of the standard gallic acid curve, the total phenolic content in the fruit extract (B-ST) and leaf extract (D-ST) was determined as shown in Figure 5. The analysis results indicate that the phenolic content in the leaf extract is higher than that in the fruit extract, with total phenolic values of 68.896 mg GAE/g extract for the leaves and 43.916 mg GAE/g extract for the fruit, respectively. In addition, based on calculations of total flavonoid content using a regression equation derived from the quercetin standard curve, the leaf extract also exhibited significantly higher flavonoid levels compared to the fruit extract. The flavonoid content in the leaf extract was 103.612 mg QE/g of extract, whereas that in the fruit extract was 11.287 mg QE/g of extract.

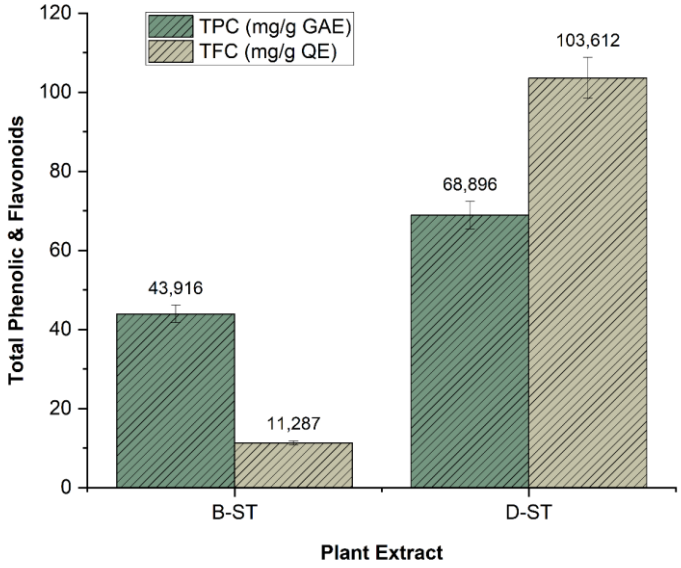

Figure 5. Total phenolic compound (TPC) and total flavonoid (TFC) content in fruit extract (B-ST) and leaf extract (D-ST) of S. taccada.

Antioxidant Activity of *Scaevola taccada* Extract

Antioxidant activity in this study was measured using the DPPH (2,2-diphenyl-1-picrylhydrazyl) reagent. This method is used to evaluate the ability of antioxidant compounds to neutralize free radicals by measuring changes in absorbance at a wavelength of 517 nm. Antioxidant activity testing was conducted using ascorbic acid as a positive control and extracts of the fruit and leaves of *S. taccada* as test samples. The results of the antioxidant activity test, expressed as the percentage of inhibition at various solution concentrations, are shown in Table 2.

Table 2. Testing the Antioxidant Activity of Extracts at a Wavelength of 517 nm.

Solution	Concentration (ppm)	% Inhibition	Linear Equations	IC_{50} (ppm)
Ascorbic Acid (3 mg)	1	5,36	y = 6,1433x + 24,40135 R^2 = 0,68574	4,167
	3	38,79		
	6	95,33		
	9	96,30		
	12	96,39		
	15	96,83		
S. taccada fruit (5 mg)	12,5	0,08	y = 0,1439x - 0,7307 R^2 = 0,816	342,386
	25	4,35		
	50	5,97		
S. taccada leaf (5 mg)	6,25	1,38	y = 0,8676x - 4,1629 R^2 = 0,9996	52,832
	12,5	6,50		
	25	17,59		

Overall, the findings of this study indicate that *S. taccada* leaf extract contains higher levels of phenolic compounds and flavonoids and exhibits stronger antioxidant activity compared to the fruit extract.

Discussion

This study shows that the total content of phenolic compounds in the leaf extract of *S. taccada* was 68.896 mg GAE/g extract, which was higher than that of the

fruit extract at 43.916 mg GAE/g extract. The total content of flavonoid compounds also showed a similar pattern, with the leaf extract having a value of 103.612 mg QE/g of extract, which was significantly higher than that of the fruit extract at 11.287 mg QE/g of extract. The ethanol leaf extract of *S. taccada* in the study by Budiana *et al*., (2019) had a total phenolic compound content of 46.95 mg GAE/g extract and a total flavonoid compound content of 21.60 mg QE/g extract, lower than those obtained in this study. In another report by (Fatmawati *et al*., 2021), the juice extract of *S. taccada* fruit had a total phenolic content of 154.88 mg GAE/g extract, which was higher than in this study, and a total flavonoid content of 6.827 mg QE/g extract, which was lower than the results of this study.

A comparison of these results shows that leaves contain higher levels of phenolic compounds and flavonoids than fruits. A report by Nguyen *et al*., (2021) on the genus *Scaevola* indicates that the leaves of this plant contain higher levels of phenolic compounds than other parts of the plant. Phytochemical studies indicate that the leaves of coastal plants generally have higher concentrations of phenolic compounds than the fruit because leaves are the primary organs involved in plant metabolism and defense, leading to greater accumulation of phenolic compounds which act as antioxidants in the leaves (Nikoli *et al*., 2025).

The high phenolic content in leaves is associated with the physiological function of leaves as a center for the biosynthesis of secondary metabolites and as a mechanism for plant protection against environmental stress (Kumar *et al*., 2023). Similar results were also reported by Del *et al*., (2020), who stated that plants growing in environments with high ecological stress, such as coastal areas or regions with high light intensity, tend to produce greater amounts of phenolic compounds. These compounds act as the plant's natural defense system against ultraviolet radiation and oxidative stress. Furthermore, these differences in flavonoid content indicate that leaves are the plant parts richest in secondary metabolites that act as antioxidants. This finding aligns with research conducted by Ferreyra *et al*., (2021), which states that flavonoids are the primary group of secondary metabolites that accumulate extensively in plant leaves due to their role in protecting photosynthetic tissues from ultraviolet radiation and oxidative damage.

Another study by Mierziak *et al*., (2014) also showed that flavonoids act as a natural filter against ultraviolet radiation that can damage chloroplasts. Therefore, leaves, as photosynthetic organs, tend to produce higher amounts of flavonoids compared to other plant parts (Agati *et al*., 2020). In addition, the report by Zahra *et al*., (2024) explains that flavonoids are bioactive compounds with various important biological activities, such as anti-inflammatory, anticancer, antioxidant, and antimicrobial properties. The antioxidant activity of flavonoids is based on the transfer of hydrogen or electrons to free radicals, a process supported by the compounds aromatic ring systems (Hassanpour & Doroudi, 2023).

In addition, this study also shows that *S. taccada* leaf extract has higher antioxidant activity than its fruit extract, indicating greater potential for neutralizing free radicals. This is evidenced by the leaf extract's IC_{50} value of 52.832 ppm, which is classified as strong antioxidant activity, whereas the fruit extract has an IC_{50} value of 342.386 ppm, which falls into the weak category. These findings are also consistent with previous studies on the antioxidant activity of *S. taccada*. According to a study by Apriandi *et al*., (2021) show that the aqueous extract of *S. taccada* fruit has an IC_{50} value ranging from 113 to 164 ppm based on the DPPH method. Meanwhile, the findings of a study by Rudianto *et al*., (2019) using chloroform as a solvent showed that the leaf fraction of *S. taccada* possesses very strong antioxidant capacity with an IC_{50} value of 0.194 ppm, which is significantly larger than the findings in this study. This indicates that the plant's leaves have greater potential as a source of antioxidants compared to its fruit.

Differences in IC_{50} values obtained in various studies may be influenced by several factors, such as the extraction method, the type of solvent used, the environmental conditions in which the plants grow, and the stage of plant growth at the time of sampling (Skrovankova & Mlcek, 2025). According to Malik *et al*., (2017), the type of solvent used in the extraction process also plays a crucial role in determining the antioxidant activity of an extract, as it relates to the solvent's polarity and its ability to dissolve bioactive compounds particularly phenolic compounds known to play a role in scavenging free radicals. Therefore, the diversity of these factors influences the types and levels of secondary metabolites produced by plants.

These differences in antioxidant activity are related to the high content of phenolic compounds and flavonoids in the leaf extract. The relationship between phenolic compounds and antioxidant activity has also been widely reported in various previous studies. Research by Džarić *et al*., (2025) revealed a strong correlation between the presence of phenolic compounds in plant extracts and antioxidant activity. Another report by Akmalia & Pranatami, (2025), states that the presence of phenolic compounds and flavonoids is closely linked to antioxidant activity in plants. This is due to the role of phenolic compounds as antioxidants through a hydrogen or electron donor mechanism capable of neutralizing free radicals. Additionally, Shahidi & Ambigaipalan, (2015) reported that phenolic compounds are the primary contributors to antioxidant activity in various plant extracts due to their ability to inhibit lipid oxidation reactions.

According to Salhi *et al*., (2024), there is a significant correlation between the total content of phenolic compounds and total flavonoid compounds, as well as

antioxidant activity in various medicinal plants. The higher the phenolic and flavonoid content in a plant extract, the stronger the resulting antioxidant activity. This finding supports the results obtained in this study, where *S. taccada* leaf extract which contains higher phenolic and flavonoid compounds also shows a stronger antioxidant capacity compared to the fruit extract.

Overall, this study demonstrates that the abundance of phenolic compounds and flavonoids in plant extracts significantly contributes to their increased antioxidant activity. These findings confirm that the leaf portion holds the greatest potential for development as a source of natural antioxidants. Thus, the leaves of *S. taccada* hold greater potential as a source of natural antioxidants that can be utilized in the development of herbal medicines based on coastal biological resources.

CONCLUSIONS

The methanol extract of *S. taccada* leaves exhibited higher total phenolic and total flavonoid content compared to the fruit extract, at 68.896 mg GAE/g and 103.612 mg QE/g, respectively, whereas the fruit extract contained 43.916 mg GAE/g and 11.287 mg QE/g. Consistent with this, the leaf extract also exhibited stronger antioxidant activity with an IC_{50} value of 52.832 ppm compared to the fruit extract at 342.386 ppm. Thus, the leaves of *S. taccada* are considered to have greater potential as a source of natural antioxidants and can be utilized in the development of herbal medicinal ingredients.

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Competing Interests: The authors declare that there are no competing interests.

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