JURNAL PERIKANAN
UNIVERSITAS GADJAH MADA
Terakreditasi Ristekdikti No: 158/E/KPT/2021
ISSN: 2502-5066 (Online)
ISSN: 0853-6384 (Print)
Vol. 27 (1), 1-7
DOI 10.22146/jfs.90770

Antioxidant Activity and Phytochemical Screening of *Rhizopora mucronata* Mangrove Leaf Extract from Mangrove Botanical Garden, Surabaya City, East Java

Rahmawati Rahmawati *, Yushinta Aristina Sanjaya, Yunita Satya Pratiwi, Elistiya Putri Nuraini Hendrawan, Zhafa Nesya Salsabila & Tania Amalia

Departmenf of Food Technology, Faculty of Engineering, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, East Java, Indonesia

*Corresponding author, email: rahmawati.tp@upnjatim.ac.id

Submitted: 17 January 2024; **Revised:** 19 February 2024; **Accepted:** 03 June 2024; **Published:** 25 May 2025

ABSTRACT *Rhizophora mucronata* is a type of mangrove plant that acts as a natural antioxidant which is used as a food ingredient and traditional medicine. The aim of this research was to determine the profile of secondary metabolites, antioxidant activity and total phenols of *R. mucronata* leaf extract. *R. mucronata* leaves were obtained from Gunung Anyar District, Surabaya City and then extracted using three solvents with different polarities, namely n-hexane, ethyl acetate, and ethanol. Mangrove leaf extract (*Rhizopora mucronata*) was followed by phytochemical testing using color testing, antioxidant activity testing using the DPPH method, and determining phenol content using the Folin-Ciocalteu method. Phytochemical tests show that all *R. mucronata* mangrove leaf extracts contain secondary metabolites such as flavonoids, saponins, steroids, triterpenoids and tannins with total phenols ranging from 0.04%-6.7%. The antioxidant activity of n-hexane, ethyl acetate, and ethanol extracts were 4.9 mg ± 0.82%, 1.7 mg ± 0.17%, and 0.21 mg ± 1.9%, respectively.

Keywords: Antioxidant; phenol; phytochemicals; *R. mucronata*

INTRODUCTION

Indonesia is an archipelagic country rich in natural resources. One of the natural wealth that can be utilized its natural potential is mangrove plants or commonly known as mangrove plants (Lasabuda, 2013). Mangroves are widespread in tropical and subtropical regions, mostly found along saltwater tidal zones of the Indo-Pacific protected coastline (India to Australia) (Sachithanandam *et al*., 2019). According to Triyatno *et al*. (2019) mangroves are referred to as coastal plants, tidal plants and brackish plants because they grow well on coral beaches or thin sandy coral reef land, or on beaches that have alluvial soil types. Estimated mangrove area in Indonesia is ±3 million hectares (Rahadian *et al*., 2019). Around 202 types of mangrove species in Indonesia have been identified and thrive because the tropical climate is an ideal place for mangrove plant growth (Purwaningsih *et al*., 2013). One type of mangrove that is abundant in tropical rainforests in Indonesia is *Rhizophora mucronata* (Lesdiana & Usman, 2021).

Rhizophora mucronata is a species of mangrove plant belonging to the Rhizophoraceae and has a large distribution in the Indo-Pacific region (Abdi et al., 2019). Rhizophora mucronata Or it can be called tinjang or tanjang has elliptical leaves that expand to an elongated round shape and have a tapered tip. The petioles are green, and the surface of the leaves is textured like bark. R. mucronata fruits have a brownish-green color, are oval or egg-like, and feel rough at the base. The roots have a root system of supporting roots (stilt-roots) (Angio et al., 2022). Morphologically, R. mucronata can grow up to a height of 3-4 meters and can produce cigar-shaped fruit (propagul) (Sadeer et al., 2019). Recent studies have shown that this plant extract acts as an antioxidant, anti-diabetic, antimicrobial (anti-viral, anti-fungal, anti-bacterial), anti-cancer, anti-inflammatory, and analgesic (Setyawan et al., 2022).

Research related to the content of compounds in mangroves *Rhizophora mucronata* has been widely conducted. *Rhizophora mucronata* mangrove leaves contain 2-(2ethoxy ethanol, kau-16-ene and benzophenon, phenolic compounds flavonoid group, phenolic acids, tannins dihydroflavonol, caffeic acid, vanillic acid, p-hydroxy benzoate acid, tannins, alkaloids, coumarins, flavonoids, phenols and polyphenols, quinones, resins, saponins, phytosterols, xanthoprotins, pigments (chlorophyll, carotenoids) and sugars (Ridlo *et al*., 2017). Secondary metabolite compounds contained in R. *mucronata mangrove* leaves consist of phenols, flavonoids, tannins, saponins, terpenoids which are a response to a growing environment that is not ideal (Akasia *et al*., 2021). According to Mile *et al*. (2021), *R. mucronata* macerated with ethanol solvent showed an average total flavonoid content of 19.5095 mg/ml while phytochemical screening results were identified as containing alkaloids, flavonoids, tannins, saponins, and phenolic compounds.

Rhizophoraceae *extract* has high potential as a source of antioxidants that benefit human health by fighting free radicals (Indriaty *et al*., 2023). Antioxidants can play a role in overcoming degenerative diseases. This is evidenced by the increase in antioxidants such as the enzyme catalase which can ward off free radicals. Mangrove plants (*Rhizophora mucronata*) are plants that have the potential as natural antioxidants (Bulan *et al*., 2022). Antioxidant activity can be expressed in Inhibitory Concentration 50 (IC_{50}) (Ridlo *et al*., 2017). The IC_{50} value is the concentration of the extract solution which causes a reduction in DPPH activity by 50% (Usman *et al*., 2022).

The IC_{50} value of the tested extract was obtained from the compounds contained in the extract and fraction, where both the extract and the fraction are a collection of several secondary metabolite compounds that have not been separated (Minarti *et al*., 2021). Based on the potential possessed by *Rhizophora mucronata,* the objective of this research is to evaluate the content of secondary metabolite compounds contained in *R. mucronata mangrove* leaf extract and to determine its potential as a source of natural antioxidants.

MATERIALS AND METHODS

Sample preparation

Samples of *R. mucronata mangrove leaves* were obtained from the Mangrove Botanical Garden, Gunung Anyar District, Surabaya. *R. mucronata* leaves are washed and then dried manually by drying in the sun with the help of sunlight and mashed into powder. The powder sample was weighed 50 grams and extracted using n-hexane, ethyl acetate and ethanol solvents. The extraction method is carried out by putting the powder sample into the Erlenmeyer and added with n-hexane, ethyl acetate and ethanol solvents. Each solvent uses 3 Erlenmeyer and is shaking in a shaker. The filtrate obtained is then evaporated with a *vacuum rotary evaporator* with a temperature of 40°C until a crude extract is obtained.

Phytochemical analysis

Testing of compounds contained in the leaves of *Rhizophora mucronata* can be known by conducting several tests on phytochemical tests, including: Alkaloid compound tests are carried out with Mayer, Wagner and Dragendorff reagents, which if the positive results of alkaloids with Wagner and Dragendorf reagents are characterized by the presence of brown deposits on Wagner reagents and orange deposits on Dragendorf reagents. The alkaloid test is tested using Dragendorf reagents to produce a dark brown solution which means it is positive for alkaloids. The flavonoid compound test was carried out with concentrated Mg + HCl + ethanol reagent characterized by the presence of a red precipitate. The saponin test is performed without the use of reagents and is tested positive if the foam does not disappear at the time of addition of HCl. Steroid compound tests using Libermann-burchard reagents obtained positive results characterized by the presence of bluish-purple / forage deposits. Test of triterpenoid compounds using chloroform + H_2SO_4 concentrated reagent obtained positive results characterized by the presence of brownish-red precipitates. The phenolic test uses a 10% NaCl reagent + 1% gelatin and obtained positive results characterized by the presence of white precipitates. The tannin compound test using a 1% $FeCl_3$ reagent obtained positive results characterized by the presence of greenish-brown deposits.

Analysis of antioxidant activity

Antioxidant activity was measured using the method (DPPH) by making several concentrations of ethanol solvent extract and pipettes of 1 ml each, adding 3 ml of DPPH solution (40 ppm in ethanol), the solution was allowed to stand at room temperature for 30 minutes. The manufacture of the control was carried out with 1 ml of ethanol and 3 ml of DPPH 40 ppm. The absorbance value was measured at a wavelength of 519 nm using visible light spectrophotometry.

The percentage of free radical inhibition determines antioxidant activity. Quantitative analysis of the activity of radical inhibitors or DPPH, is carried out using the following formula:

$$\% \text{ inhibition} = \frac{\text{Control Absorbance} - \text{Sample Absorbance}}{\text{Control Absorbance}} \times 100$$

After the percentage of antioxidant activity is obtained, the linear regression curve between the sample concentration and the average inhibitory percent is determined by calculating the inhibitor concentration value (IC_{50}), which is obtained from the equation y = ax + b on the linear regression curve of the concentration relationship (x) and the percentage of attenuation (y).

Analysis of total phenolic content

Total phenol levels are measured using spectrophotometric methods by making a standard curve first by making a standard solution of gallic acid with a content of 5 to 40 ppm (H_2O solvent), then each pipette content of 1.0 mL put into a vial bottle and then added 0.5 mL Folin-Ciocalteu after that let stand for 5 minutes, then added 2 mL 10% sodium carbonate solution, and allowed to stand again for 10 minutes before measuring the absorbance (at λ = 770 nm).

After making the standard curve is complete, proceed with sample preparation by weighing 20 mg of sample in 20 mL H_2O, then pipette 5 ml and 10 mL H_2O, then pipette again 1.0 mL aliquot and put into a vial, then added 0.5 mL Folin-Ciocalteu, then let stand 5 minutes, then added 2 mL 10% sodium carbonate solution and let stand 10 minutes before measuring the absorbance (at λ = 770 nm). The test results of total phenol content on total phenolic content are expressed in milligrams of gallic acid equivalent (mg GAE/g extract) which is used as standard.

RESULTS AND DISCUSSION

Yield of extraction

Yield is a calculation of the weight of the extract compared to the initial weight of the sample used (Manuhuttu & Saimima, 2021). The calculation of the percentage of yield aims to find out the number of samples needed for extraction in order to obtain the desired amount of extract (Egra *et al*., 2023). The results of the extraction process in each sample are carried out through the maceration method and are presented on Table 1.

Table 1. The yield of *R. mucronata* leaves extract.

Solvent	Yield (%)
n-Hexane	0.83
Ethyl acetate	3.73
Ethanol	7.86

The yield calculation results in table 1 show that the highest yield was obtained using a polar solvent, namely

Table 2. Bioactive compounds from leaves extract of *Rhizophora mucronata*.

Bioactive compounds	Reagent	Solvent		
		Ethanol	Ethyl acetate	n-hexane
Alkaloid	Mayer	+	+	-
	Wagner	+	+	+
	Dragendorff	+	+	+
Flavonoid	Mg + HClpekat + etanol	+	+	+
Saponin	-	+	+	+
Steroid	Libermann-Burchard	+	+	+
Triterpenoid	Chloroform + H2SO4 concentrated	+	+	+
Phenolic	NaCl 10% + Gelatine 1%	+	+	-
Tannin	FeCl3	+	+	+

Notes : (+) detected; (-) not detected

ethanol of 7.86% while the smallest yield was obtained by treatment using a non-polar solvent, n-Hexane of 0.83%. This shows that the compounds that can be extracted in *Rhizophora mucronata* mangroves are tend to be polar so as to produce the highest yield compared to non-polar solvents. This is in accordance with the research conducted by Egra *et al*. (2023) which depicted that extraction of *R. mucronata* leaves using n-Hexane solvent yielded the smallest yield of 0.19% compared to ethyl acetate solvent of 1.87%. According to Maulana & Sasmito (2021), extraction of *Rhizophora apiculate* using ethanol solvent (5.91%) produces the highest yield of ethyl acetate (1.31%) and n-hexane (1.18%) solvents, indicating that the compounds contained in mangrove leaves tend to be polar.

The yield percentage is influenced by the bioactive content contained in the material and the type of solvent used. During maceration, the cell wall and cell membrane will rupture due to the pressure difference between the outer and inner cells. Secondary metabolites are released in the cytoplasm and dissolved in the solvent (Li *et al*., 2019). Based on Hardiningtyas *et al*. (2014), The selection of solvents based on their solubility and polarity will affect the extraction yield because solvents, the ease of separation of natural materials in the sample depends on the type of solvent and the bioactive content contained in the sample is related to the amount of yield value produced. Different yield percentages are also due to different physiological adaptation patterns to the environment. Yang *et al*. (2018) stated that bioactive compounds that plants are responding to extreme environmental conditions especially light irradiation, temperature, nutrient supply, salinity, etc.

The color of n-hexane extract was brownish yellow, while the ethyl acetate and ethanol extract were dark green. According to Indriaty *et al*. (2023) stated that *Rhizophora* mangrove extracts generally have a solid form and are reddish-brown in color. Reddish-brown color indicates the presence of tannins, which have chromophore groups in the conjugated C=C and C=O bonds, which absorb and produce color in a compound. In addition, there are also plant pigments that affect other colors in Rhizophoraceae extracts derived from chlorophyll a, chlorophyll b, beta carotene, lutein, neoxanthin, pheophytin a, and violaxanthin (Rumengan *et al*., 2021)

Phytochemical testing

Phytochemical tests in this study aim to identify secondary metabolites produced by plants (Egra *et al*., 2023). The phytochemical testing of this study includes assays of alkaloids, flavonoids, saponins, steroids, triterpenoids, phenolics, and tannins. Based on the results of phytochemical tests in Table 2, it shows that all *R. mucronata* mangrove leaf extracts contain secondary metabolites such as flavonoids, saponins, steroids, triterpenoids, and tannins. Alkaloid and phenolic compounds were found in ethanol and ethyl acetate extracts of *R. mucronata* leaves, but not in n-Hexane extracts of *R. mucronata* leaves. In previous studies, phytochemical screening of *R. mucronata* ethanol extract identified the presence of alkaloids, flavonoids, tannins, saponins and phenolics (Mile *et al*., 2021). Ethyl acetate extract of *R. mucronata mangr* ayer's reagent, the formation of brown deposits in Wagner's reagent and the formation of orange deposits in Dragendorff reagents (Aji *et al*., 2023). Alkaloids are not found in n-hexane extracts of *R. mucronata* leaves allegedly because n-hexane solvents are nonpolar solvents unable to dissolve alkaloid compounds. This is in accordance with the statement Manteu *et al*. (2018), that Alkaloids are chemical compounds that can dissolve in organic solvents and are widely found in extracts that use polar solvents.

Flavonoids showed positive reactions in all *R. mucronata* leaves extracts characterized by the formation of red color when reacted with concentrated Mg + HCl + ethanol reagents. Flavonoids act as antioxidants because they can capture reactive oxygen species (ROS) and prevent ROS regeneration while indirectly increasing enzymatic and cellular antioxidants. Prevention of ROS formation by flavonoids is done in several ways, such as inhibiting the enzymes xanthine oxidase and nicotinamide adenine dinucleotide phosphate (NADPH) and preventing redox reactions that can produce free radicals (Liu *et al*., 2018).

Other metabolic compounds detected in the leaves of *Rhizophora mucronata* are saponins, steroids, triterpenoids, and tannins. Samples that tested positive for saponin compounds were characterized by foam that did not disappear upon addition of HCl (Sari *et al*., 2019). Saponins can dampen superoxide through hydroperoxide intermediates, which prevent

biomolecular damage due to free radicals (Liu *et al*., 2018). R. *mucronata* leaves containing steroid compounds are evidenced by the formation of purple to blue / green colors. According to Egra *et al*. (2023), *R. mucronata* leaf extract has a high steroid content, while alkaloids, saponins, tannins, phenols, and flavonoids tend to be low. Steroids can increase body stamina (aphrodisiac) and act as anti-inflammatory (Permana *et al*., 2016). The detection of triterpenoid compounds is thought to be caused by the ability of ethanol solvents to extract polar compounds (Dia *et al*., 2015). The positive reaction of triterpenoids in the sample is indicated by the formation of a reddish-brown color (Manteu *et al*., 2018).

The tannin compound test using a 1% $FeCl_3$ reagent obtained positive results as evidenced by the formation of a brownish-yellow color due to a solution of tannin compounds containing many OH groups in the solvent, both of which are polar (Acacia *et al*., 2021). Tannins as antioxidants can act as H atom donors to dampen DPPH radicals, which occur as tannin radical stabilizers due to resonance (Liu *et al*., 2018). Tannins have several properties, such as astringent, anti-diarrheal, antibacterial, and antioxidant. Flavonoids have anti-inflammatory, antibacterial and antioxidant properties (Egra *et al*., 2023).

Phytochemical testing with n-hexane solvent gave positive results of *R. mucronata* mangrove leaves not positive for phenolic compounds while phytochemical testing using ethyl acetate and ethanol solvents showed that *R. mucronata* mangrove leaves were positive for phenolic compounds. The use of solvents that have different polarity levels can be one of the factors for the non-detection of phenolic compounds in extracts that use nonpolar solvents such as n-hexane. Phenolic compounds contained in the leaves of *R. mucronata* are characterized by the presence of white precipitate using NaCl 10% + gelatin 1%. The research conducted by (Syamsudin *et al*., 2022) revealed that a different final result, namely the color of the sample becomes blue-black because it uses a 5% $FeCl_3$ reagent. The use of solvents with increased or high polarity aims so that each solvent can dissolve compounds based on their level of polarity (Haryoto & Frista, 2019).

Antioxidant activity

The body needs compounds known as antioxidants to stop oxidation reactions consisting of free radicals (Loho *et al*., 2021). The DPPH test is widely used to evaluate the potential of plant extracts to neutralize free radicals, especially organic radicals. The ability of the extract or vitamin C (as a positive control) to donate hydrogen electrons and bind with the nitrogen radical in DPPH causes the purple color solution of the DPPH radical to turn light yellow (Bulan *et al*., 2022). The ability of the extract to inhibit antioxidants is determined based on the value of IC_{50} (Gazali *et al*., 2020). This value indicates the sample concentration required to reduce free radical activity. Test of antioxidant activity of *R. mucronata* leaf extract showed that DPPH solution turned yellow, from the previous concentrated unggu. Based on Table 3, the ethanol, ethyl acetate, and n-hexane extracts of *R. mucronata* leaves showed high antioxidant activity. This is in accordance with the statement Leksono *et al*. (2018) which indicated that a compound is considered a very strong antioxidant if its IC_{50} value is less than 50 ppm (IC50 < 50 ppm), strong (50 ppm < IC_{50} < 100 ppm), medium (100 ppm < IC_{50} < 150 ppm), and very weak (IC_{50} > 200 ppm).

Table 3. The IC_{50} value of *R. mucronata* leaves extract.

Solvent	IC_{50} value
n-hexane	4.90 mg ± 0.82%
Ethyl acetate	1.70 mg ± 0.17%
Ethanol	0.21 mg ± 1.90%

Antioxidant activity in samples with ethanol solvent had the highest antioxidant levels with the smallest IC_{50} value compared to other solvents at 0.21 mg ± 1.9%. Inhibitory Concentration (IC_{50}), which is the concentration of an antioxidant that stops free radical activity by 50% (Leksono *et al*., 2018). If the resulting IC_{50} value is lower, it indicates that the ability of antioxidant activity is getting better (Filbert *et al*., 2014). According to Rumengan *et al*. (2021) states that the leaf extract of *Rhizophora mucronata* has very strong antioxidant activity. The IC_{50} value of ethanol extract of *Rhizophora mucronata* leaves from Lembeh Island, North Sulawesi, Indonesia with DPPH method showed IC_{50} 20.99 ± 0.33 µg/mL. R. *mucronata* leaf extract has antioxidant activity because hydrogen atoms or electrons are donated to react with DPPH radicals. Increased extract concentration also increases the percentage of DPPH free radical inhibition (Rumengan *et al*., 2021). This suggests that *R. mucronata leaf extract has strong* scavenging abilities in its role as a hydrogen atom donor.

The antioxidant ability of mangrove plants is influenced by the content of secondary metabolites, which function as antioxidant supporting compounds, such as tannins, phenolics, and flavonoids (Moito *et al*., 2023). The higher the amount of phenol compounds and flavonoid compounds in a sample will provide higher antioxidant activity so that the IC_{50} value will be lower (Safithri *et al*., 2020). This is proven in phytochemical tests of n-hexane extract showing fewer secondary metabolite compounds hence that the antioxidant ability possessed is smaller than ethanol and ethyl acetate extracts. The difference in metabolite content in mangroves is caused by differences in age, geographical location and climate which will affect the content of bioactive compounds in mangrove plants. Extreme environmental conditions (especially light irradiation, temperature, nutrient supply, salinity, etc.), plants are able to adapt to changing circumstances through the release and accumulation of various secondary metabolites including phenolic compounds, triterpenoids and flavonoids, and many of these have high economic value and utilization due to antioxidant properties (Yang *et al*., 2018).

Total phenolic content

Total phenol testing is usually used to determine the content or antioxidant activity of a sample used. One sample that can be used to determine the content or activity of antioxidants is usually found in the leaves of the mangrove *Rhizophora mucronata* which is known as

one of the good sources of antioxidant production. Total phenol is the main component that is closely related to antioxidant activity which further to obtain the total phenolic concentration in the extract can be determined by testing using Folin-Ciocalteu reagent (Sopalun *et al*., 2021).

Table 4. Total phenolic content from *Rhizophora mucronata* leaves extracts.

Solvent	Total Phenolic Content
n-hexane	0.04% w/w ± 0.01%
Ethyl acetate	0.09% w/w ± 0.01%
Ethanol	6.70% w/w ± 0.02%

Table 4 depicted that the total phenol content is different for each solvent. The highest total phenol content was obtained from extraction with ethanol, which was 6.7% w/b ± 0.02%. The lowest total phenol content was obtained from extraction with n-hexane of 0.04% w/b ± 0.01%. According to research conducted by Permana *et al*. (2016), The presence of phenol compounds in a material indicates the presence of antioxidant content in the material. Research by Prasedya *et al*. (2019) indicates that higher phenol content indicates stronger antioxidant activity, as evidenced by lower IC_{50} values. It is proven that the antioxidant content of *R. mucronata* ethanol extract is higher because it contains the highest total phenol. Ethanol is a solvent that can dissolve compounds from less polar to polar, one of the compounds that can be dissolved by ethanol is phenolic compounds. Ethanol can dissolve phenolic compounds because it is able to degrade the cell wall so that bioactive compounds more easily come out of plant cells. Ethanol has a hydroxyl group that can bond to the hydrogen group of the hydroxyl group of the phenolic compound leading to an increase in the solubility of phenolic compounds in ethanol. Differences in ethanol concentration can affect the solubility of phenolic compounds in solvents (Prayitno *et al*., 2016).

Total phenols in *R. mucronata* have previously been studied by Hastuti *et al*. (2023) which states that the total phenolic leaves *of R. mucronata* in Tugu District, Semarang, Central Java 3.90 ± 1.11 (%w/w). Moreover, Suhendra *et al*. (2019), stated that ethanol concentration affects total phenol levels, yield, total flavonoids and DPPH radical inhibitor activity which also produces the highest content obtained from 70% ethanol extract. Maria *et al*. (2020) states that 48.2% phenol content is present in *R. mucronata*. The total phenolic content is expressed in milligrams of gallic acid equivalent (mg GAE/g extract) used as standard. Phenolic compounds such as flavonoids can act as antioxidants because they contain hydroxyl groups bonded to the aromatic carbon ring so that they can capture free radicals (Saxena *et al*., 2013). Phenolic compounds can react with free radicals because they have the ability to donate electrons (reducing agents) to produce more stable products and inhibit free radical chain reactions (Plaza *et al*., 2014).

CONCLUSIONS AND RECOMMENDATION

Conclusions

The results of antioxidant tests show that *R. mucronata* mangroves can function as natural antioxidants because of the content of secondary metabolites and phenolic compounds in the leaves. The compounds that can be extracted in the leaves of *Rhizophora mucronata mangroves* are semi-polar because they produce the highest yield (0.0748%) in ethyl acetate extract. Phenolic compounds contained in all mangrove leaf extracts (*Rhizophora mucronata*) include flavonoids, saponins, steroids, triterpenoids, and tannins with total phenols ranging from 0.04-6.7%. The magnitude of antioxidant activity, *R. mucronata* is included in the strong antioxidant because the IC_{50} value in each sample was 4.9 mg ± 0.82% in n-Hexane extract, 1.7 mg ± 0.17% in ethyl acetate extract, and 0.21 mg ± 1.9% in ethanol extract.

Recommendation

Research on antioxidant activity and phytochemical screening of *Rhizophora mucronata* mangrove leaf extract needs further research, especially related to the characterization of specific compounds that act as a of antioxidants. In additioin, potential bioactive compounds function as antioxidant could be further developed as natural preservatives in foood commodities or therapeutic agents.

AUTHORS' CONTRIBUTIONS

In preparing this article, RR, YAS, YSP, EPNH, and ZNS contributed in several activities, starting from conducting research activities to preparing manuscript, while TA specifically involved in data analysis and preparing manuscript.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Institute for Research and Community Services (LPPM), Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, for providing financial support in the implementation of research activities Indonesia. The authors also expressed the gratitude to

REFERENCES

Abdi, V., I. Sourinejad, M. Yousefzadi & Z. Ghasemi. 2019. Biosynthesis of silver nanoparticles from the mangrove *Rhizophora mucronata*: Its characterization and antibacterial potential. Iranian Journal of Science and Technology, Transaction A: Science. 43 (5): 2163-2171. https://doi.org/10.1007/s40995-019-00739-9.

Aji, A.P., E. Issusilaningtyas, A.R. Fauziah & D.R. Nugraheni. 2023. Pengaruh metode ekstraksi terhadap kandungan metabolit sekunder ekstrak daun bakau hitam (*Rhizopora mucronata*). Sains Indonesiana. 1 (3): 173-181.

Akasia, A.I., I.D.N.N. Putra & I.N.G. Putra. 2021. Skrining fitokimia ekstrak daun mangrove *Rhizophora mucronata* dan *Rhizophora apiculata* yang dikoleksi dari kawasan mangrove Desa Tuban, Bali. JMRT. 4 (1): 16-22. https://doi.org/10.24843/JMRT.2021.v04.i01.p03.

Angio, M.H., E. Renjana, L.W. Ningrum, E.R. Firdiana & R. Irawanto. 2022. Inventory of plants in the Mangrove Botanic Garden of

Gunung Anyar and their potential as medicinal plants. Jurnal Penelitian Kehutanan Wallacea. 11 (1): 53-70. https://doi.org/10.18330/jwallacea.2022.vol11iss1pp53-70.

Bulan, D.E., N. Nurfadilah, M.R. Syahrir, A. Mismawati, A.K. Torambung & M. Rachmawati. 2022. Phytochemical composition and antioxidant activity of leaf extracts from three *Rhizophora* species from Bontang Waters, Indonesia. Tropical Journal of Natural Product Research. 6 (8): 1178-1182. https://doi.org/10.26538/tjnpr/v6i8.2.

Dia, S.P.S., N. Nurjanah & A.M. Jacoeb. 2015. Chemical composition, bioactive components and antioxidant activities from root, bark and leaf lindur. Jurnal Pengolahan Hasil Perikanan Indonesia. 18 (2): 205-219. https://doi.org/10.17844/jphpi.2015.18.2.205.

Egra, S., H. Kuspradini, I.W. Kusuma, I. Batubara, I. Imra, N. Nurjannah, E. Wahyuni, K. Yamauchi & T. Mitsunaga. 2023. Potential of prospective medicinal plants of Rhizophoraceae from North Kalimantan, Indonesia. Biodiversitas. 24 (3): 1346-1355. https://doi.org/10.13057/biodiv/d240303.

Filbert, F., H.S.J. Koleangan, M.R.J. Runtuwene & V.S. Kamu. 2014. Penentuan aktivitas antioksidan berdasarkan nilai LC_{50} ekstrak metanol dan fraksi hasil partisinya pada kulit biji pinang yaki (*Areca vestiaria* Giseke). Jurnal MIPA UNSRAT. 3 (2): 149-154. https://doi.org/10.35799/jm.3.2.2014.6002.

Hardiningtyas, S.D., S. Purwaningsih & E. Handharyani. 2014. Antioxidant activity and hepatoprotective effect of green mangrove leaves. JPHPI. 17 (1): 80-91. https://doi.org/10.17844/jphpi.v17i1.8140.

Haryoto, H & A. Frista. 2019. Aktivitas antioksidan ekstrak etanol, fraksi polar, semipolar dan non polar dari daun mangrove kacangan (*Rhizophora apiculata*) dengan metode DPPH dan FRAP. J. Sains Kes. 2 (2): 131-138.

Hastuti, E.D., M. Izzati & S. Darmanti. 2023. Usability of planted mangroves in the Coastal Area of Semarang, Indonesia, as the source of secondary metabolite extracts. Biodiversitas. 24 (4): 2409-2415. https://doi.org/10.13057/biodiv/d240456.

Indriaty, I., D. Djufri, B. Ginting & K. Hasballah. 2023. Phytochemical screening, phenolic and flavonoid content, and antioxidant activity of rhizophoraceae methanol extract from Langsa, Aceh, Indonesia. Biodiversitas. 24 (5): 2865-2876. https://doi.org/10.13057/biodiv/d240541.

Lasabuda, R. 2013. Pembangunan wilayah pesisir dan lautan dalam perspektif Negara Kepulauan Republik Indonesia. Jurnal Ilmiah Platax. 1 (2): 92-101. https://doi.org/10.35800/jip.1.2.2013.1251.

Leksono, W. B., R. Pramesti, G.W. Santosa & W.A. Setyati. 2018. Jenis pelarut metanol dan N-Heksana terhadap aktivitas antioksidan ekstrak rumput laut *Gelidium* sp. dari Pantai Drini Gunung kidul - Yogyakarta. Jurnal Kelautan Tropis. 21 (1): 9-16. https://doi.org/10.14710/jkt.v21i1.2236.

Lesdiana, L & U. Usman. 2021. Uji toksisitas dan uji fitokimia ekstrak metanol daun mangrove *Rhizophora mucronata*. Prosiding Seminar Nasional Kimia. 94-98.

Li, H.F., L.J. Li., L.M. Ji, X.W. Peng & W. Li. 2019. The extraction ability and mechanism in extraction lithium by several organic extractants. Chemical Physics Letters. 733. https://doi.org/10.1016/j.cplett.2019.136668.

Liu, Z., Z. Ren, J. Zhang, C.C. Chuang, E. Kandaswamy, T. Zhou & L. Zuo. 2018. Role of ROS and Nutritional Antioxidants in Human Diseases. Frontiers in Physiology. 9 (477): 1-14. https://doi.org/10.3389/fphys.2018.00477.

Loho, R.E.M., M. Tiho & Y.A. Assa. 2021. Kandungan dan aktivitas antioksidan pada rumput laut merah. Medical Scope Journal. 3(1): 113-120. https://doi.org/10.35790/msj.3.1.2021.34986.

Manteu, S.H., N. Nurjanah & T. Nurhayati. 2018. Characteristics of brown seaweeds *Sargassum policystum* and *Padina minor* from Pohuwato Water, Gorontalo. Jurnal Pengolahan Hasil Perikanan Indonesia. 21 (3): 296. https://journal.ipb.ac.id/index.php/jphpi/article/view/24709.

Manuhuttu, D & N.A. Saimima. 2021. Potensi daun mangrove (Sonneratia alba) sebagai antibakteri terhadap *Salmonella*, *Staphylococcus aureus*, dan *Escherichia coli*. Biopendix. 7 (2): 71-79. https://ojs3.unpatti.ac.id/index.php/biopendix/article/view/3254.

Maulana, D.M & B.B. Sasmito. 2021. The dose effect of mangrove leaf extract (*Rhizophora apiculata*) on anticancer activity in HeLa cells. Journal of SCRTE. 5 (1): 1-15. https://doi.org/10.20473/jscrte.v5i1.29380.

Mile, L., H. Nusyam, D. Setijawati & P.D. Sulistiyati. 2021. Flavonoid content of mangrove *Rhizhopora mucronata* in Langge Village, District Anggrek, North Gorontalo. GOSPODARKA I INNOWACJE. 17: 1-4. https://doi.org/10.37905/jfpj.v3i1.8585.

Moito, R.A.A., R. Husain & A.S. Naiu. 2023. Analisis kadar saponin dan aktivitas antioksidan ekstrak daun mangrove *Sonneratia alba* dari Perairan Desa Monano Kabupaten Gorontalo Utara. Jurnal Ilmiah Perikanan dan Kelautan. 11 (2): 92-96. https://ejurnal.ung.ac.id/index.php/nike/article/view/1304.

Nasution, A.D.M., U. Amna & H. Halimatussakdiah. 2019. Skrining fitokimia daun jarak pagar (*Jatropha curcas* L.) dari Kota Langsa. Jurnal Kimia Sains dan Terapan. 1 (1): 11-15. https://ejurnalunsam.id/index.php/JQ/article/view/1688.

Permana, A.H.C., A. Husni & S.A. Budhiyanti. 2016. Antioxidant activity and toxicity of seagrass *Cymodocea* sp. extracts. Jurnal Teknologi Pertanian. 17 (1): 37-46. https://jtp.ub.ac.id/index.php/jtp/article/view/557.

Plaza, C.M., L.E.D. De. Torres, R.K., Lücking, M. Vizcaya & G.E. Medina. 2014. Antioxidant activity, total phenols and flavonoids of lichens from Venezuelan Andes. Journal of Pharmacy & Pharmacognosy Research. 2 (5): 138-147. https://doi.org/10.56499/jppres14.042_2.5.138.

Prasedya, E.S., N.W.R. Martyasari, R. Apriani, S. Mayshara,R.A. Fanani & H. Sunarpi. 2019. Antioxidant activity of Ulva *lactuca* L. from different Coastal Locations of Lombok Island, Indonesia. AIP Conference Proceedings. 2199: 1-6. https://doi.org/10.1063/1.5141281.

Prayitno, S.A., J. Kusnadi & E.S. Murtini. 2016. Antioxidant activity of red betel leaves extract (*Piper crocatum* Ruiz & Pav.) By difference concentration of solvents. Research Journal of Pharmaceutical Biological and Chemical Sciences. 7 (5): 1836-1843. https://www.researchgate.net/publication/320755645.

Purwaningsih, S., E. Salamah, A.Y.P. Sukarno & E. Deskawati. 2013. Aktivitas antioksidan dari buah mangrove (*Rhizophora mucronata* Lamk.) pada suhu yang berbeda. JPHPI, 16 (3): 199-206. https://doi.org/10.17844/jphpi.v16i3.8057.

Rahadian, A., B. Prasetyo, Y. Setiawan & K. Wikantika. 2019. A historical review of data and information of indonesian mangroves area. Media Konservasi. 24 (2): 163-178. https://doi.org/10.29244/medkon.24.2.163-178.

Ridlo, A., R. Pramesti, E. Supriyantini & N. Soenardjo. 2017. Aktivitas antioksidan ekstrak daun mangrove *Rhizopora mucronata*. Buletin Oseanografi Marina. 6 (2): 110-116. https://doi.org/10.14710/buloma.v6i2.16555.

Rumengan, A.P., E.S. Mandiangan, W.A. Tanod, D.S.J. Paransa, C.P. Paruntu & D.M.H. Mantiri. 2021. Identification of pigment profiles and antioxidant activity of *Rhizophora mucronata* mangrove leaves Origin Lembeh, North Sulawesi, Indonesia. Biodiversitas, 22 (7): 2805-2816. https://doi.org/10.13057/biodiv/d220730.

Sachithanandam, V., P. Lalitha, A. Parthiban, T. Mageswaran, K. Manmadhan & R. Sridhar. 2019. A review on antidiabetic properties of indian mangrove plants with reference to island ecosystem. Evidence-Based Complementary and Alternative Medicine. 2019. https://doi.org/10.1155/2019/4305148.

Sadeer, N.B., G. Rocchetti, B. Senizza, D. Montesano, G. Zengin, A. Uysal, R. Jeewon, L. Lucini & M.F. Mahomoodally. 2019. Untargeted metabolomic profiling, multivariate analysis and biological evaluation of the true mangrove (*Rhizophora mucronata* lam.). Antioxidants. 8 (10): 1-20. https://doi.org/10.3390/antiox8100489.

Sari, P., D.E. Embong & E. Marliana. 2019. Phytochemical screening and identification mangrove on Panrita Lopi Beach Muara Badak. Jurnal Aquarine. 6 (1): 58-66. https://e-journals.unmul.ac.id/index.php/aquarine/article/view/2948/0.

Saxena, M., J. Saxena, R. Nema, D. Singh & A. Gupta. 2013. Phytochemistry of medicinal plants. Journal of Pharmacognosy and Phytochemistry. 1(6): 168-182. https://www.phytojournal.com/archives/2013.v1.i6.83/phytochemistry-of-medicinal-plants.

Setyawan, A.D., P. Ragavan, M. Basyuni & S. Sarno. 2022. Review: *Rhizophora mucronata* as source of foods and medicines. International Journal of Bonorowo Wetlands. 9(1): 42-55. https://doi.org/10.13057/bonorowo/w090105.

Sopalun, K., W. Laosripaiboon, A. Wachirachaikarn & S. Iamtham. 2021. Biological potential and chemical composition of bioactive compounds from endophytic fungi associated with thai mangrove plants. South African Journal of Botany. 141: 66-76. https://doi.org/10.1016/j.sajb.2021.04.031.

Suhendra, C.P., I.W.R. Widarta & A.A.I.S. Wiadnyani. 2019. The effect of ethanol concentration on antioxidant activity of cogon grass rhizome (*Imperata cylindrica* (Linn.) Beuv.) extract using ultrasonic wave. Jurnal Ilmu dan Teknologi Pangan. 8 (1): 27-35. https://doi.org/10.24843/itepa.2019.v08.i01.p04.

Syamsudin, S., A.H. Alimuddin & B. Sitorus. 2022. Isolation and characterization of phenolic compound from putat leaves (*Planchonia valida* Blume). Indonesian Journal of Pure and Applied Chemistry. 5 (2): 85-98. https://doi.org/10.26418/indonesian.v5i2.56554.

Triyatno, T., F. Febriandi, A. Putra & E. Kamal. 2019. Identification of physical characteristics and the change of mangrove region in Coastal Southern Part of Padang City West Sumatra-Indonesia. Geography and Geography Education. 3 (1): 87-93. http://sjdgge.ppj.unp.ac.id/index.php/Sjdgge/article/view/196.

Usman, U., D. Fildzania & I. Fauzi. 2022. Uji aktivitas antioksidan dan antidiabetes ekstrak daun mangrove *Rhizopora mucronata*. Jurnal Sains Dan Kesehatan. 4 (1): 28-35. https://jsk.ff.unmul.ac.id/index.php/JSK/article/view/291.

Yang, L., K.S. Wen, X. Ruan, Y.X. Zhao, F. Wei & Q. Wang. 2018. Response of plant secondary metabolites to environmental factors. Molecules. 23 (4): 1-26. https://doi.org/10.3390/molecules23040762.

How to cite this article Rahmawati, R., Y.A. Sanjaya, Y.S. Pratiwi, E.P.N. Hendrawan, Z.N. Salsabila & T. Amalia. 2025. Antioxidant activity and phytochemical screening of Rhizopora mucronata mangrove leaf extract from Mangrove Botanical Garden, Surabaya City, East Java. Jurnal Perikanan Universitas Gadjah Mada. 27 (1): 1-7. https://doi.org/10.22146/jfs.90770