

Original Article

e-ISSN: 2581-0545 - <https://journal.itera.ac.id/index.php/jsat/>

Received 16th March 2025
Accepted 04th August 2025
Published 26th January 2026

Open Access

DOI: [10.35472/jsat.v9i2.2172](https://doi.org/10.35472/jsat.v9i2.2172)

Antibacterial Potency of Methanol Extracts from Leaves, Bark, and Fruit of Jambu Bol (*Syzygium malaccense* L.): A Comparative Study

M. Rifqi Efendi^{a*}, Diah Riski Gusti^b, Rizky Ananda^a, Mesa Sukmadani Rusdi^c^a Program Studi Farmasi, Fakultas Kedokteran dan Ilmu Kesehatan, Universitas Jambi, Jambi, Indonesia^b Program Studi Kimia, Fakultas Sains dan Teknologi, Universitas Jambi, Jambi, Indonesia^c Program Studi Farmasi, Politeknik Kesehatan Kementerian Kesehatan, Jambi, Indonesia* Corresponding E-mail: mrifqi@unja.ac.id

Abstract: *Syzygium malaccense* L., commonly known as Malay apple, is a medicinal plant traditionally used to treat various infectious diseases. However, scientific evidence supporting the antibacterial efficacy of different parts of this plant remains limited. This study aimed to compare the antibacterial activity of methanol extracts from the leaves, bark, and fruit of *S. malaccense* against *Escherichia coli* and *Staphylococcus aureus*. Each extract was characterized through organoleptic observations, moisture content determination, total ash content analysis, and phytochemical screening. Antibacterial activity was evaluated using the agar diffusion method, with dimethyl sulfoxide (DMSO) as the negative control and chloramphenicol (30 µg/disc) as the positive control. Phytochemical screening confirmed the presence of phenolic compounds, alkaloids, flavonoids, and saponins in all extracts. The antibacterial assay revealed that all tested extracts inhibited both bacterial strains, with inhibition zones ranging from 8.15 to 13.12 mm. The methanol extract of *S. malaccense* bark demonstrated the highest antibacterial activity at 20%, producing an inhibition zone of 13.12 mm against *S. aureus*.

Keywords: *Jambu Bol*, *Syzygium malaccense* (L.), antibacterial, disk diffusion.

Introduction

Infectious diseases are a major health concern in developing countries, ranking as the third leading cause of death after cardiovascular disorders and cancer. These infections can be caused by bacteria, viruses, fungi, or parasites. Antibiotics are effective in eliminating bacterial infections; however, their efficacy gradually declines due to the emergence of antibiotic resistance [1]. Consequently, the search for bioactive compounds with antibacterial properties has attracted considerable research interest.

One potential medicinal plant is *Syzygium malaccense* L. (Jambu Bol), which has been traditionally used in several countries to treat various ailments, including inflammation, hyperglycemia, ulcers, and infections of the mouth and throat [2–4]. Phytochemical studies of its bark, leaves, and fruit have revealed the presence of polyphenolic compounds such as gallic acid, isorhamnetin, rutin, isoquercitrin, myricetin, myricitrin, quercitrin, kaempferol, and naringin [4,5]. These compounds have been scientifically proven to exhibit biological activities, including antioxidant, antibacterial, anti-inflammatory, hypoglycemic, cytotoxic, and cholesterol-lowering effects [6–9]. Polyphenolic

compounds play a direct role in antimicrobial activity, and some studies have also linked their high antioxidant capacity to antibacterial efficacy [10]. Several reports have highlighted the antibacterial properties of various *Syzygium* species [11–13]. A study by Quenon et al. [14] demonstrated that methanol extracts of *S. malaccense* L. leaves and aliphatic derivatives of salicylic acid exhibit antibacterial activity against several Gram-positive and Gram-negative bacteria.

Although these findings highlight the medicinal potential of *S. malaccense*, most studies have focused primarily on leaf extracts, with the bioactivity of other plant parts, such as the bark and fruit, largely unexplored. A thorough comparative analysis of antibacterial activity across different plant parts could offer valuable insights into their therapeutic potential, aiding in identifying the most effective source for antimicrobial applications.

Method

Instruments

The instruments used in this study included an autoclave (Hiramaya®), oven (Memmert®), incubator



(Memmert®), laminar airflow (LAF) (Innotech-Biobase®), rotary evaporator (IKA®), hot plate (Velp Scientifica®), analytical balance (Kern®), Erlenmeyer flasks (Iwaki®), test tubes (Iwaki®), and petri dishes (Normax®).

Materials

The materials used in this study included powdered simplicia from the bark, leaves, and fruit of *S. malaccense* L. (Identification No. 21/HB/03/2023), nutrient agar (NA) (Merck®), 70% ethanol (Bratacem®), sterile paper discs, distilled water (Bratacem®), methanol (Bratacem®), 0.9% NaCl solution, *E. coli* (ATCC 25922), *S. aureus* (ATCC 25923), dimethyl sulfoxide (DMSO) (Merck®), and chloramphenicol (Sigma®).

Extraction Procedure

The extraction process was conducted using the maceration method with methanol as the solvent. The powdered simplicia (bark, leaves, and fruit of *S. malaccense* L. was macerated in brown bottles at a sample-to-solvent ratio of 1:10. The maceration was repeated three times, followed by filtration and concentration using a rotary evaporator at 60°C to obtain a thick methanol extract [15,16]

Extract Standardization

The extract was standardized by determining organoleptic characteristics, moisture content, total ash content, and phytochemical screening (alkaloids, phenols, flavonoids, terpenoids, steroids, and saponins) [1,15].

Antibacterial Activity Assay

The antibacterial activity was evaluated using the agar diffusion method against Gram-positive (*S. aureus* ATCC 25923) and Gram-negative (*E. coli* ATCC 25922) bacteria. The bacterial cultures were inoculated and collected using a sterile inoculating loop, then suspended in a test tube containing 5 mL of 0.9% NaCl solution to achieve a bacterial concentration of 1×10^8 CFU/mL (0.5 McFarland standard). The test extracts (bark, leaves, and fruit) were prepared at concentrations of 5%, 10%, and 20% in DMSO. A 10 µL aliquot of each extract was pipetted onto sterile paper discs, which were then placed on the surface of nutrient agar previously swabbed with the bacterial suspension (1×10^8 CFU/mL). The plates were incubated at 37°C for 18 hours. Antibacterial activity was determined by measuring the inhibition zone diameter using a caliper. Chloramphenicol (30 µg/disc) was used as the positive control, while DMSO served as the negative control [17].

Results and Discussion

This study aimed to compare the antibacterial activity of the bark, leaves, and fruit of *S. malaccense* L. Methanol extracts were obtained from each plant part using maceration. The extraction yields for the methanol extracts were 26% for leaves, 21.8% for bark, and 25.4% for fruit.

Each extract was characterized by assessing organoleptic properties, moisture content, total ash content, and phytochemical screening, as presented in **Table 1**. These characterizations ensure consistency in chemical composition and maintain the quality of the extracts produced within a single batch. Phytochemical screening was conducted to qualitatively detect secondary metabolites, providing an initial overview of the chemical constituents in each extract. The phytochemical profile of the methanol extracts from the leaves, bark, and fruit of *S. malaccense* is summarized in **Table 2**.

Qualitative phytochemical analysis revealed that, in general, all extracts exhibited similar chemical compositions. However, the presence of terpenoids was detected exclusively in the bark extract. This finding aligns with a previous study [18], which characterized the chemical constituents and quantified the total phenolic and flavonoid content in 80% methanol extracts of *S. malaccense* leaves and fruit. The study concluded that although both extracts contained similar polyphenolic compounds, the leaf extract had higher total phenolic and flavonoid content than the fruit extract, at 5.3% and 0.028%, respectively.

Table 1. Specific and Non-Specific Parameters of Methanol Extracts from *S. malaccense* L.

Parameter	Leaves	Bark	Fruit
Specific			
Color	Brownish Green	Dark Brown	Blackish Brown
Odor	Unique	Unique	Unique
Taste	Bitter	Bitter	Sweet
Form	Liquid	Thick	Thick
Non-specific			
Moisture content	12.3% ± 0.5647	10% ± 0.7823	7.4% ± 0.5206
Total Ash Content	8.21% ± 0.3233	7.8% ± 0.6161	5.86% ± 0.4291

Table 2. Phytochemical screening of *S. malaccense* L. methanol extract

Phytochemical screening	leaves	Bark	Fruit
Alkaloids	+	+	+
Flavonoids	+	+	+
Tanins	+	+	+
Saponins	+	+	+
Phenols	+	+	+
Terpenoids	-	+	-
Steroids	-	-	-

The antibacterial activity of the methanol extracts from the bark, leaves, and fruit of *S. malaccense* was evaluated using the agar diffusion method. This method is widely used in antibiotic susceptibility testing due to its advantages, including ease of use, cost-effectiveness, broad applicability to various bacterial strains, and its ability to measure antimicrobial potency with straightforward result interpretation [19]. The antibacterial activity assay was conducted against two pathogenic bacterial strains: *E. coli* (Gram-negative) and *S. aureus* (Gram-positive). These bacteria were selected to assess the potential broad-spectrum activity of the extracts against both bacterial types. Chloramphenicol was used as the positive control because it is a broad-spectrum antibiotic that inhibits the growth of both Gram-positive and Gram-negative bacteria [20].

The antibacterial activity of the extracts was classified based on the inhibition zone diameter: inactive (<8 mm), weak (8–12 mm), moderate (13–15 mm), and strong (>15 mm) [1]. The results in **Table 3** indicated that all extract concentrations exhibited antibacterial activity against the tested bacterial strains, with inhibition zone diameters ranging from 8.15 to 13.12 mm. The variation in extract concentration influenced the inhibition zone size, with the 20% (w/v) bark extract demonstrating the strongest antibacterial activity, classified as moderate against both *E. coli* (12.92 ± 0.18 mm) and *S. aureus* (13.12 ± 0.35 mm). This was followed by the fruit extract, which exhibited inhibition zones of 12.48 ± 0.27 mm for *E. coli* and 10.42 ± 0.24 mm for *S. aureus*, and the leaf extract, which showed inhibition zones of 10.88 ± 0.30 mm for *E. coli* and 11.22 ± 0.50 mm for *S. aureus*.

Comparable findings were reported in a previous study, where an 11% ethanolic leaf extract of *Syzygium malaccense* exhibited an inhibition zone of 8.6 mm against *S. aureus* [21]. Similarly, another study demonstrated that a 12.5% ethanolic bark extract produced an inhibition zone of 8.98 mm against *Shigella dysenteriae* [22]. In a related formulation study, Pamungkas et al. [23] developed a liquid soap containing an ethanolic extract of *S. malaccense* leaves, which showed antibacterial activity against *S. epidermidis*, with a 7.5% concentration producing an inhibition zone of 17.3 mm.

The antibacterial activity of the *S. malaccense* leaf, bark, and fruit extracts is strongly influenced by their chemical composition. Polyphenolic compounds are known to exhibit antibacterial properties through various mechanisms. Studies have shown that flavonoids can inhibit nucleic acid synthesis, disrupt cytoplasmic membrane function, and interfere with energy metabolism [24]. Additionally, flavonoids have been observed to reduce bacterial adhesion and biofilm formation, alter porin expression in the cell membrane, modify membrane permeability, and decrease pathogenicity, all of which are essential factors for bacterial growth [25].

Table 3. Antibacterial activity of *S. malaccense* L. methanol extract

Plant part	Concentration (%)	Diameter of the inhibitory zone (mm) $\pm$ SD	
		Bacteria	
		<i>E. coli</i>	<i>S. aureus</i>
Leaves	5	$8.32 \pm 0.24^{d**}$	$8.45 \pm 0.23^{c**}$
	10	$9.85 \pm 0.26^{c**}$	$9.15 \pm 0.21^{c**}$
	20	$10.88 \pm 0.30^{b**}$	$11.22 \pm 0.50^{b**}$
Bark	5	$10.51 \pm 0.23^{d**}$	$9.12 \pm 0.37^{d**}$
	10	$11.61 \pm 0.15^{c**}$	$10.65 \pm 0.26^{c**}$
	20	$12.92 \pm 0.18^{b***}$	$13.12 \pm 0.35^{b***}$
Fruit	5	$8.35 \pm 0.31^{d**}$	$8.15 \pm 0.2^{d**}$
	10	$11.45 \pm 0.25^{c**}$	$9.51 \pm 0.33^{c**}$
	20	$12.48 \pm 0.27^{b***}$	$10.42 \pm 0.24^{b**}$
Positive control	30 μ g/disk	$35.88 \pm 0.07^{a****}$	$28.28 \pm 0.07^{a****}$
Negative control	DMSO	-	-

The data are expressed as mean $\pm$ SD from three replicates; statistical significance was determined using one-way ANOVA. Data from different subsets of the same bacteria show significant differences ($p < 0.05$). *inactive (<8 mm), **weak (8–12 mm), ***moderate (13–15 mm), and ****strong (>15 mm)

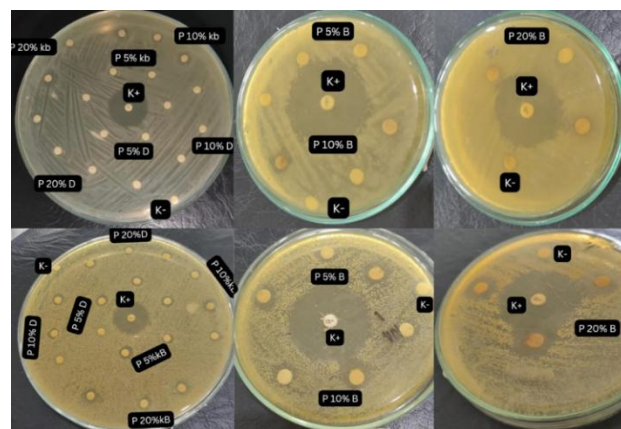


Figure 1. Inhibitory Zone of *S. malaccense* against *S. aureus* (up) and *E. Coli* (down). P: treatment concentration; K+: Positive control; K-: negative control; B: fruit; D: leaves; KB: bark

The presence of terpenoid compounds was detected in the bark extract of *S. Malaccense*. The antibacterial mechanism of terpenoids involves interactions with transmembrane proteins within the bacterial cell wall. Damage to these transmembrane proteins reduces the permeability of the bacterial cell wall, leading to the loss of essential nutrients and ultimately inhibiting bacterial growth or causing cell death [26]. The findings of this study serve as a preliminary basis for the discovery of new, highly effective antibacterial agents derived from natural sources. Furthermore, these results provide scientific justification for the traditional use of *S. malaccense* in the treatment of various infectious diseases.

Conclusion

This study evaluated the antibacterial activity of methanol extracts from the leaves, bark, and fruit of *S. malaccense* against *E. coli* and *S. aureus*. The bark extract at 20% (b/v) exhibited the strongest antibacterial effect, likely due to the presence of terpenoids and flavonoids, which disrupt bacterial cell membrane integrity. Phytochemical screening confirmed the presence of phenolic compounds, alkaloids, flavonoids, and saponins in all extracts, with terpenoids detected specifically in the bark. These findings suggest that *S. malaccense* has potential as a natural antibacterial agent, warranting further research to identify active compounds and explore its therapeutic applications.

Conflicts of interest

There are no conflicts to declare.

Acknowledgements

The authors would like to express their gratitude to the Faculty of Medicine and Health Sciences for its support of this research.

References

- [1] Efendi MR, Bakhtiar A, Rusdi MS, Putra DP. Comparative Study of Antibacterial Activity of *Elephantopus scaber* Linn. and *Elephantopus mollis* Kunth. Extract. Curr Appl Sci Technol 2024;24:e0258350–e0258350. <https://doi.org/10.55003/CAST.2023.258350>.
- [2] Noreen Y, Serrano G, Perera P, Bohlin L. Flavan-3-ols isolated from some medicinal plants inhibiting COX-1 and COX-2 catalysed prostaglandin biosynthesis. Planta Med 1998;64:520–4. <https://doi.org/10.1055/S-2006-957506/BIB>.
- [3] Dunstan CA, Noreen Y, Serrano G, Cox PA, Perera P, Bohlin L. Evaluation of some Samoan and Peruvian medicinal plants by prostaglandin biosynthesis and rat ear oedema assays. J Ethnopharmacol 1997;57:35–56. [https://doi.org/10.1016/S0378-8741\(97\)00043-3](https://doi.org/10.1016/S0378-8741(97)00043-3).
- [4] Giovana Batista A, Kelly Da Silva J, Betim Cazarin CB, Camar A, Biasoto T, Christine A, et al. Red-jambo (*S. malaccense*): Bioactive compounds in fruits and leaves 2016. <https://doi.org/10.1016/j.lwt.2016.05.013>.
- [5] Prasniewski A, da Silva C, Ayres BRB, Silva EA da, Pilau EJ, Nani BD, et al. Characterization of phenolic compounds by UHPLC-QTOF-MS/MS and functional properties of *S. malaccense* leaves. South African Journal of Botany 2021;139:418–26. <https://doi.org/10.1016/J.SAJB.2021.01.036>.
- [6] Savitha RC, Padmavathy S, Sundhararajan A. Invitro Antioxidant Activities on Leaf Extracts of *S. malaccense* (L.) Merr and Perry. Anc Sci Life 2011;30:110.
- [7] Arumugam B, Manaharan T, Heng CK, Kuppusamy UR, Palanisamy UD. Antioxidant and antiglycemic potentials of a standardized extract of *S. malaccense*. LWT - Food Science and Technology 2014;59:707–12. <https://doi.org/10.1016/J.LWT.2014.06.041>.
- [8] Bairy LK. Evaluation of the hypoglycemic, hypolipidemic and hepatic glycogen raising effects of *S. malaccense* upon streptozotocin induced diabetic rats. Article in Journal of Natural Remedies 2005.
- [9] Lako J, Trenerry VC, Wahlqvist M, Wattanapenpaiboon N, Sotheeswaran S, Premier R. Phytochemical flavonols, carotenoids and the antioxidant properties of a wide selection of Fijian fruit, vegetables and other readily available foods. Food Chem 2007;101:1727–41. <https://doi.org/10.1016/J.FOODCHEM.2006.01.031>.
- [10] Coppo E, Marchese A. Antibacterial Activity of Polyphenols. Curr Pharm Biotechnol 2014;15:380–90. <https://doi.org/10.2174/138920101504140825121142>.
- [11] Djoukeng JD, Abou-Mansour E, Tabacchi R, Tapondjou AL, Bouda H, Lontsi D. Antibacterial triterpenes from *Syzygium guineense* (Myrtaceae). J Ethnopharmacol 2005;101:283–6. <https://doi.org/10.1016/J.JEP.2005.05.008>.
- [12] Salem SS, Elsayed HE, Shabana S, Khazaal MT, Moharram FA. Phytochemical profile and antimicrobial activity of essential oils from two

- Syzygium species against selected oral pathogens. BMC Complement Med Ther 2023;23. <https://doi.org/10.1186/S12906-023-04277-1>.
- [13] Xu W, Tan J, Mu Y, Zheng D, Huang X, Li L. New antimicrobial terpenoids and phloroglucinol glucosides from *Syzygium szemaense*. Bioorg Chem 2020;103. <https://doi.org/10.1016/J.BIOORG.2020.104242>.
- [14] Quenon C, Hennebelle T, Butaud JF, Ho R, Samaillie J, Neut C, et al. Antimicrobial Properties of Compounds Isolated from *S. malaccense* (L.) Merr. and L.M. Perry and Medicinal Plants Used in French Polynesia. Life 2022;12:733. <https://doi.org/10.3390/LIFE12050733/S1>.
- [15] Kementerian Kesehatan RI. Farmakope Herbal Indonesia. 2nd ed. Jakarta: Direktorat Jenderal Kefarmasian dan Alat Kesehatan, Kemenkes RI; 2017.
- [16] Efendi MR, Gusti DR, Syahrial AD, Rusdi MS. Evaluation of Coffee Mistletoe Leaf Ethanol Extract on Burn Healing Activity on White Male Rat. Journal of Pharmaceutical and Sciences 2023;6:1059–67. <https://doi.org/10.36490/JOURNAL-JPS.COM.V6I3.72>.
- [17] Efendi MR, Rusdi MS, Dinda A. Antibacterial activity of ethyl acetate extracts of fungal endophytes isolated from leaf gambir leaves (*Uncaria gambir* (Hunter) Roxb). Journal of Pharmaceutical Science 2022;19:17–23. <https://doi.org/10.12928/mf.v19i1.20483>.
- [18] Batista ÂG, da Silva JK, Betim Cazarin CB, Biasoto ACT, Sawaya ACHF, Prado MA, et al. Red-jambo (*S. malaccense*): Bioactive compounds in fruits and leaves. LWT - Food Science and Technology 2017;76:284–91. <https://doi.org/10.1016/J.LWT.2016.05.013>.
- [19] Balouiri M, Sadiki M, Koraichi I, Bnsouda S. Methods for in vitro evaluating antimicrobial activity: A review 2015. <https://doi.org/10.1016/j.jpha.2015.11.005>.
- [20] Ritter J, Lewis L, Mant T, Ferro A. A Textbook of Clinical Pharmacology and Therapeutics, 5Ed 2008. <https://doi.org/10.1201/B13234>.
- [21] Erlisa R, Marcellia S, Retnaningsih A. Uji Aktivitas Antibakteri Ekstrak Etanol Daun Jambu Bol (*S. malaccense* L.) Terhadap Bakteri *Escherichia coli*. Analit: Analytical and Environmental Chemistry 2023;12–23. <https://doi.org/10.23960/AEC.V8I2.2023.P12-23>.
- [22] Irfayanti NA, Jasmiadi J, Musdalifah M. Uji Aktivitas Antibakteri Ekstrak Etanol Klika Jambu Bol (*S. malaccense* (L.) Merr. & Perry) terhadap Bakteri *Shigella dysenteriae*. Jurnal Farmasi Pelamonia/ Journal Pharmacy Of Pelamonia 2023;3:7–11.
- [23] Pamungkas PE, Yuniarti R. Formulasi Sediaan Sabun Cair Ekstrak Etanol Daun Jambu Bol (*Syzygium Malaccense* (L.) Merr) Dan Uji Aktivitas Antibakteri Terhadap *Staphylococcus Epidermidis*. Journal of Health and Medical Science 2022;1:76–86.
- [24] Shamsudin NF, Ahmed QU, Mahmood S, Shah SAA, Khatib A, Mukhtar S, et al. Antibacterial Effects of Flavonoids and Their Structure-Activity Relationship Study: A Comparative Interpretation. Molecules 2022, Vol 27, Page 1149 2022;27:1149. <https://doi.org/10.3390/MOLECULES27041149>.
- [25] Górniak I, Bartoszewski R, Króliczewski J. Comprehensive review of antimicrobial activities of plant flavonoids. Phytochemistry Reviews 2018 18:1 2018;18:241–72. <https://doi.org/10.1007/S11101-018-9591-Z>.
- [26] Yang W, Chen X, Li Y, Guo S, Wang Z, Yu X. Advances in Pharmacological Activities of Terpenoids. Nat Prod Commun 2020;15. https://doi.org/10.1177/1934578X20903555/ASSET/IMAGES/LARGE/10.1177_1934578X20903555-FIG11.JPEG.