

Potential of Secondary Metabolite Compounds of Dayak Onion as Antibacterial Agents: A Comprehensive Literature Review

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Abstract. Bacterial infections and increasing antibiotic resistance are major challenges in the treatment of infectious diseases, necessitating the development of new antibacterial agents derived from natural sources. Dayak onion is an Indonesian medicinal plant that has been empirically used to treat various infectious diseases and is known to contain a variety of secondary metabolites with antibacterial potential. This article aims to examine the potential of secondary metabolites of Dayak onion as antibacterial agents based on published research results. The method used is a literature review by searching scientific articles through Google Scholar, PubMed, and Google using keywords related to the antibacterial activity of Dayak onion. The results of the study indicate that Dayak onion extract has antibacterial activity against various Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Methicillin-resistant Staphylococcus aureus* (MRSA), *Staphylococcus epidermidis*, *Propionibacterium acnes*, *Escherichia coli*, *Salmonella typhi*, *Klebsiella pneumoniae*, *Porphyromonas gingivalis*, and *Enterococcus faecalis*. This activity is influenced by the content of secondary metabolites such as flavonoids, alkaloids, saponins, tannins, phenolics, terpenoids, essential oils, glycosides, and naphthoquinone compounds that work through various mechanisms, including damage to bacterial cell walls and membranes, inhibition of protein and nucleic acid synthesis, inhibition of important enzymes, and induction of *reactive oxygen species* (ROS) formation. This diversity of mechanisms of action suggests that Dayak onions have potential as a source of natural antibacterial candidates to address the increasing cases of antibiotic resistance.

Keywords: Antibacterials, Antibiotic Resistance, Dayak Onions, Secondary Metabolites.

INTRODUCTION

Bacterial infections remain a leading cause of morbidity and mortality in many countries. Irrational and prolonged use of antibiotics has led to the emergence of bacteria resistant to various antimicrobial classes, thus decreasing the effectiveness of conventional therapies. This situation poses a major challenge to the global health system and encourages the search for new sources of antibacterial agents that are more effective, safe, and have diverse mechanisms of action (Lucero-Prisno *et al.*, 2025). Medicinal plants are a highly potential source of candidate antimicrobial compounds because they contain various secondary metabolites with broad biological activities.

Indonesia is one of the countries with the greatest biodiversity in the world, possessing enormous potential as a source of bioactive compounds. Various medicinal plants have been empirically utilized by communities for hundreds of years and are now increasingly being scientifically researched as candidates for natural-based medicines (Febriyanti *et al.*, 2026). One such plant that has attracted attention is the Dayak onion, a plant endemic to Kalimantan that has long been used by the Dayak people as a traditional medicine for various ailments, including infections. Empirically, Dayak onion bulbs are used to treat wounds, ulcers, gastrointestinal disorders, diabetes, hypertension, and diseases related to microbial infections. Various pharmacological studies also show that this plant has antioxidant, anti-inflammatory, antifungal, anticancer, and antibacterial activities, thus its potential as a source of phytopharmaceuticals is gaining increasing attention (Aprianti, 2025).

Various phytochemical studies have shown that Dayak onions contain a variety of secondary metabolites, including flavonoids, alkaloids, saponins, tannins, phenolics, terpenoids, essential oils, and glycosides (Kusriadi, 2025). The main compounds in Dayak onions are *Naphthoquinones* and their derivatives, *elecanacine*, *eleutherine*, *eleutherol*, and *eleuthernone*. *Naphthoquinones* are bioactive compounds known to have antibacterial, antifungal, antiparasitic, and antiviral activity. Furthermore, *Naphthoquinones* also have anticancer and antioxidant effects (Naibaho *et al.*, 2023).

These compounds are known to inhibit bacterial growth through various mechanisms, such as disrupting cell membrane integrity, inhibiting cell wall and protein synthesis, disrupting metabolic enzyme activity, and inducing oxidative stress in bacterial cells (Nafi'ah, 2022). This diversity of mechanisms of action makes Dayak onion secondary metabolites potentially effective in treating

bacteria that have developed resistance to certain antibiotics.

The antibacterial activity of Dayak onion extract has been reported against various Gram-positive and Gram-negative bacteria (Naibaho *et al.*, 2023). While various studies have reported the antibacterial activity of Dayak onion, most have focused on general extract testing without thoroughly examining the relationship between secondary metabolite types and their antibacterial mechanisms. Furthermore, information on the contribution of each compound class to antibacterial activity is scattered across publications, thus lacking a comprehensive picture. Understanding the mechanisms of action of secondary metabolites is crucial to support the development of natural products as more effective, evidence-based antibacterial drug candidates.

Based on this background, this literature review aims to comprehensively examine the potential of secondary metabolites from Dayak onions as antibacterial agents. The discussion covers the main secondary metabolite content, antibacterial mechanism of action, activity against various pathogenic bacteria, and the prospects for developing Dayak onions as a source of natural antibacterial agents to address the growing problem of antibiotic resistance.

METHODS

This research method employed a literature review related to the title. The literature review was conducted online by searching publications in indexed journal databases using relevant keywords. Reference searches were conducted using *Google Search*, *Google Scholar*, and *PubMed* on the topic of Dayak onion plants as antibacterial agents.

RESULTS AND DISCUSSION

Several studies have shown that ethanol extract of Dayak onion bulbs can inhibit the growth of *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhi*, *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, *Porphyromonas gingivalis*, *Enterococcus faecalis* and *Propionibacterium acnes* bacteria.

Table 1. Antibacterial Activity of Dayak Onions

Author	Extract	Method	Bacteria	Results
Novaryatiin & Ardhan, (2019)	96% ethanol extract of Dayak onion	Disc diffusion method	<i>Propionibacterium acnes</i> , <i>Staphylococcus epidermidis</i> , and <i>Staphylococcus aureus</i>	- Zone of inhibition for <i>P. acnes</i>: 7.0±1.3 mm (1.25%), 8.5±0.6 mm (2.5%), 9.9±0.3 mm (5%), 11.2±0.1 mm (10%), 11.9±0.3 mm (20%) - Zone of inhibition for <i>S. epidermidis</i>: 18.8±3.3 mm (1.25%), 21.9±3.3 mm (2.5%), 20.8±0.6 mm (5%), 22.0±0.2 mm (10%), 23.1±0.6 mm (20%) - Zone of inhibition for <i>S. aureus</i>: 14.3±3.1 mm (1.25%), 13.5±0.9 mm (2.5%), 14.7±1.5 mm (5%), 16.1±1.0 mm (10%), 20.1±0.6 mm (20%) - Highest antibacterial activity: 20% concentration against <i>S. epidermidis</i> with inhibition zone diameter of 23.1±0.6 mm
Naibaho <i>et al.</i> , (2023)	96% ethanol extract of Dayak onion	Disc diffusion method (Kirby-Bauer Test)	<i>Escherichia coli</i> and <i>Staphylococcus aureus</i>	- The 96% ethanol extract inhibited <i>S. aureus</i> with an inhibition zone of 15.02 mm but could not inhibit <i>E. coli</i>. - The n-hexane extract inhibited <i>S. aureus</i> and <i>E. coli</i> with inhibition zones of 18.48 and 14.94 mm, respectively. - The MIC value obtained from 96% ethanol extract against <i>S. aureus</i> was 50 mg/mL. - The MIC value of n-hexane extract against <i>E. coli</i> and <i>S. aureus</i> is 10 mg/mL

Paramita <i>et al.</i> , (2018)	Ethanol extract of Dayak onion	TLC bioautography method	<i>Methicillin-resistant Staphylococcus aureus</i>	- TLC bioautography results showed that the ethanol extract of <i>E. bulbosa</i> could inhibit the growth of MRSA. - The MIC results showed that the ethanol extract of <i>E. bulbosa</i> had good antibacterial activity potential against MRSA with an MIC of 1 mg/mL.
Putri <i>et al.</i> , (2020)	Ethanol 96% Dayak onion extract	Kirby-Bauer method (diffusion with paper discs)	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i> and <i>Salmonella typhi</i>	Inhibition zone diameter: <i>S. aureus</i>: 16.23 mm (20%), 19.18 mm (40%), 21.25 mm (60%) <i>E. coli</i>: 10.7 mm (20%), 13.98 mm (40%), 15.87 mm (60%) <i>S. typhi</i>: 14.43 mm (20%), 14.6 mm (40%), 17.2 mm (60%)
Julianti <i>et al.</i> , (2020)	96% ethanol extract of Dayak onion	Minimum inhibitory concentration dilution method	<i>Klebsiella pneumoniae</i>	Dayak onion has antibacterial activity against <i>Klebsiella pneumoniae</i> bacteria at concentrations of 6.25%, 12.5%, 25%, 50%, 75%, and 100% with inhibition zone values of 10.3; 11.5; 11.5; 12.6; 13.6 and 15.6 mm, respectively.
Ramadhani <i>et al.</i> , (2020)	Dayak onion infusion	Diffusion method using disc paper	<i>Escherichia coli</i>	Dayak onion infusion has activity to inhibit <i>E. coli</i> bacteria with inhibition zone diameters of 100% = 0.94 mm; 50% = 0.9 mm; 25% = 0.82 mm; 12.5% = 0.8 mm and 6.25% = 0.3 mm at each concentration.
Indriani <i>et al.</i> , (2019)	Multilevel maceration of n-hexane, ethyl acetate and 70% ethanol	Minimum Inhibitory Concentration (MIC) and Wide Inhibitory Region (WIR) dilution methods	<i>Porphyromonas gingivalis</i> and <i>Staphylococcus aureus</i>	- Ethyl acetate extract provided the best inhibitory power against <i>P. gingivalis</i> bacteria with an MIC of 1.25%. - The 70% ethanol extract and n-hexane extract had MICs of 2.5% and 20% respectively against <i>P. gingivalis</i>. - Ethyl acetate and 70% ethanol extracts provided the same inhibitory power against <i>S. aureus</i> bacteria with an MIC of 5%. - Ethyl acetate and 70% ethanol extracts have WIR values against <i>S. aureus</i> bacteria of 9.21 mm and 6.48 mm, respectively.
Sari <i>et al.</i> , (2017)	96% ethanol extract of Dayak onion	Paper disk diffusion method	<i>Enterococcus faecalis</i>	Dayak onion bulb extract with concentrations of 40%, 50%, 60%, 70%, 80%, against <i>Enterococcus faecalis</i> sequentially amounted to 14.08mm, 16.35mm, 18.26mm, 19.30mm, and 21.28mm.
Kumalasari <i>et al.</i> , (2020)	70% ethanol extract of Dayak onion leaves	Paper disc diffusion method	<i>Escherichia coli</i>	Dayak onion leaf extract has antibacterial activity against the growth of <i>Escherichia coli</i> bacteria at concentrations of 100%, 80%, 60%, 40%, and 20% with an average inhibition zone diameter of 21.88 mm; 19.88 mm; 17.68 mm; 9.81 mm; 3.32 mm.
Harlita & Astiara, (2025)	Combination of ethanol extract of Dayak onion bulbs with red ginger rhizomes	Kirby Bauer diffusion method	<i>Escherichia coli</i>	- The inhibitory power of each Dayak onion bulb extract and red ginger rhizome with a concentration of 75 mg/mL was 13 mm and 7 mm, respectively. - The inhibitory power of the combination of Dayak onion extract and red ginger rhizome with a ratio

Dayak onions are a plant that has been traditionally used by the people of Kalimantan, particularly the Dayak tribe, as a natural remedy to treat various health problems. Secondary metabolites contained in Dayak onions include flavonoids, alkaloids, saponins, tannins, phenolics, terpenoids, essential oils, and glycosides (Kusriadi, 2025). The main compounds in Dayak onions are *naphthoquinones* and their derivatives, *elecanacine*, *eleutherine*, *eleutherol*, and *eleuthernone* (Naibaho *et al.*, 2023).

Flavonoid secondary metabolites work by damaging the bacterial cell wall, which consists of lipids and amino acids, then reacting with the alcohol group of the flavonoid compound, thus damaging the cell wall and allowing the compound to enter the bacterial cell nucleus. Furthermore, this compound reacts with the DNA in the bacterial cell nucleus through the difference in polarity between the lipids that make up the DNA and the alcohol group in the flavonoid compound, resulting in a reaction that causes the bacterial cell nucleus to lyse (Seja *et al.*, 2018).

Alkaloids inhibit bacterial growth through various mechanisms, including inhibition of bacterial nucleic acid and protein synthesis, modification of bacterial cell membrane permeability, damage to cell membranes and cell walls, inhibition of bacterial metabolism, and inhibition of efflux pumps (Yan *et al.*, 2021). Saponins are a group of antibacterials that disrupt the permeability of microbial cell membranes, resulting in damage to cell membranes and causing the release of various important components from within microbial cells, namely proteins, nucleic acids, nucleotides, and others (Ramadhani *et al.*, 2020).

The antibacterial activity of tannins works through several mechanisms, including inhibiting the activity of the enzymes DNA topoisomerase and reverse transcriptase, which play a crucial role in bacterial DNA replication and transcription, thereby disrupting bacterial growth and development. Furthermore, tannins can also disrupt bacterial cell wall synthesis, causing bacterial lysis (cell rupture) (Firdaus *et al.*, 2025).

Phenolic compounds can damage cell membranes, inactivate enzymes, and denature proteins, causing cell wall damage due to decreased permeability. This decreased permeability of bacterial cell membranes causes nutrient leakage from the cells, leading to bacterial cell death or stunted growth (Sari *et al.*, 2017).

The inhibitory mechanism of terpenoid compounds as antibacterials is by reacting with porins in the outer membrane of bacterial cell walls, forming strong polymer bonds, resulting in porin damage. Porin damage allows compounds to enter, reducing the permeability of the bacterial cell wall, leading to nutrient deprivation and stunted growth or even death (Nurulita *et al.*, 2022).

Dayak onion bulbs contain essential oils, which are phenol derivatives, and have antibacterial effects. The antibacterial action of essential oils begins with the degradation of bacterial cell walls and continues by damaging the cytoplasmic membrane and protein membranes, allowing the cytoplasmic contents to escape from the bacterial cell wall and result in bacterial cell death (Sari *et al.*, 2017).

The mechanism of action of glycosides as antibacterial agents involves their ability to penetrate bacterial cell walls. Glycosides that successfully penetrate the cell wall can disrupt structural stability and cause damage to the cell wall. This damage to the cell wall disrupts vital cell functions, ultimately leading to bacterial cell death (Firdaus *et al.*, 2025).

The *naphthoquinone* group has an antibacterial mechanism of action by damaging bacterial plasmids by disrupting plasmid replication and integrating into DNA. Furthermore, *naphthoquinone* can form reactive oxygen species (ROS) in bacteria, where ROS have the ability to target various biomolecules such as proteins, DNA, and lipids (building blocks required for cell survival) and show severe impacts on cell viability, leading to cell death. *Naphthoquinone* can also inhibit topoisomerase enzymes, known to regulate and alter DNA topology in cells. Damage to these enzymes can result in bacterial cell death (Mone *et al.*, 2021).

CONCLUSION

Based on the results of a literature review, Dayak onion is a medicinal plant with significant potential as a source of natural antibacterial agents. Various studies have shown that Dayak onion extract can inhibit the growth of various Gram-positive and Gram-negative pathogenic bacteria, including antibiotic-resistant bacteria such as *Methicillin-resistant Staphylococcus aureus* (MRSA). This

antibacterial activity is related to the content of secondary metabolites, namely flavonoids, alkaloids, saponins, tannins, phenolics, terpenoids, essential oils, glycosides, and *naphthoquinones*, which work through various mechanisms, such as damaging bacterial membranes and cell walls, inhibiting DNA, RNA, and protein synthesis, inactivating enzymes, and inducing ROS formation, which causes bacterial cell death.

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