PLANT SCIENCE TODAY
Vol x(x): xx–xx
https://doi.org/10.14719/pst.6829

eISSN 2348-1900

REVIEW ARTICLE

Comprehensive review of selected traditional medicinal plants used by Jambi local communities as potential antibacterial agents

Muhammad Hanif Addienda*, **Endah Retnaningrum, Yekti Asih Purwestri & Laurentius Hartanto Nugroho**

Department of Tropical Biology, Faculty of Biology, Universitas Gadjah Mada, Sleman 55281, Indonesia

*Correspondence email - mhanifaddienda@mail.ugm.ac.id

Received: 20 December 2024; Accepted: 13 March 2025; Available online: Version 1.0: 12 July 2025

Cite this article: Addienda MH, Retnaningrum E, Purwestri YA, Nugroho LH. Comprehensive review of selected traditional medicinal plants used by Jambi local communities as potential antibacterial agents. Plant Science Today (Early Access). https://doi.org/10.14719/pst.6829

Abstract

The increasing antibiotic resistance in bacteria leads to the urgent need for alternative antibacterial agents. The discovery of potential antibacterial agents in plants has been conducted according to the information about traditional medicines used by communities and the local wisdom passed down from generations. Jambi local communities in Indonesia used traditional concoctions from various medicinal plants to treat diseases caused by pathogenic bacteria, such as skin infections, abscesses, diarrhea and mouth ulcers. Prominent medicinal plants widely used by Jambi local communities include *Calamus manan, Helminthostachys zeylanica* and *Zingiber montanum*. This comprehensive review examines the traditional uses, phytochemistry and antibacterial activity of selected Jambi medicinal plants. Furthermore, this review highlights the significant contributions and current updates in this research area surrounding the ethnobotany, phytochemistry and pharmacology of medicinal plants in Jambi. However, this review also emphasizes the need for further research due to the preliminary results of current updates, such as compound isolation and purification and the antibacterial mechanism of actions of those compounds. In conclusion, the current phytochemical and pharmacological studies supported the traditional use of Jambi medicinal plants and confirmed its efficacy significantly. This review aims to support the future development of antibacterial agents from medicinal plants.

Keywords: folk medicines; herbal; natural products; secondary metabolites

Introduction

The emergence of resistant pathogenic bacteria against antibacterial agents is the problem global health faces today. Excessive and inappropriate use of antibiotics in humans has led to the development of resistance in several pathogenic bacteria. The rise of antibiotic resistance in pathogens, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *S. aureus* (VRSA) and vancomycin-resistant *Enterococci* (VRE) highlights the urgent need for alternative solutions (1–3). The slow development rate of synthetic novel antibiotics also contributed to this problem and consequently, the interest in discovering plant-based alternative antimicrobial agents has been increasing (4). Plants naturally produce secondary metabolites to protect themselves from bacterial infection. Its diverse chemical features and complex structures opened up the opportunity to develop novel antibacterial compounds (5).

As a biodiversity hotspot, Indonesia is blessed with great potential to develop novel antibacterial agents due to the abundance of medicinal plants. Indonesia possesses 80 % of world-known medicinal plants, especially wild plants from the forest (6). Medicinal plants in Indonesia are used as ingredients for Jamu Gendong, herbal medicines, supplements, cosmetics and spas (7, 8). Medicinal plants in Indonesia are also used as traditional medicines by various local communities to treat diseases (9). Jambi province in Indonesia, abundant with its tropical rain forests, is a habitat for endemic plants and other forest plants that local communities use for their daily needs, including traditional medicines.

Forest plants are used in traditional medicines in Jambi's local communities, which have lived around the forest area for generations. There are several ethnobotanical studies regarding traditional medicines of local communities in Jambi, including Suku Anak Dalam, Serampas, Kerinci and Penguluh. Suku Anak Dalam, who is residing within Bukit Dua Belas National Park (TNBD), had used the traditional concoction called *ubat ramuon,* which contains *tunjuk langit* (*Helminthostachys zeylanica*) and *rotan manau* (*Calamus manan*) to treat diarrhea and malaria (10, 11). Meanwhile, Orang Serampas in Kerinci Seblat National Park (TNKS) used their medicinal concoction *Uras* containing *kunyit melai* (*Zingiber montanum*) and *manau* (*C. manan*) to treat skin infections, abscesses, diarrhea and mouth ulcers (12). These ethnobotanical studies revealed the potential of traditional medicinal plants used by Jambi local communities to develop novel antibacterial compounds.

The production of secondary metabolites contributes the antibacterial activity of plants. Plants produce these secondary metabolites to protect themselves from various invasions, including from bacterial infection (13). These compounds possess complex and diverse chemical structures that elicit distinctive mechanisms of action to inhibit bacterial growth (14). Due to these possibilities, understanding the antibacterial mechanism of action is necessary for developing novel antibacterial compounds from plant-based secondary metabolites.

Despite the advantages, the development of plant-based antibacterial agents has its own limitations. Most traditional medicinal plants are only processed using simple techniques like boiling or crushing; hence, the specific antibacterial compounds must be identified and purified first. Furthermore, it requires specific environmental conditions for the plants to produce the secondary metabolites optimally. There is also the need to study the risk of prolonged consumption of these secondary metabolites for humans as it may cause side effects or allergic reactions due to its mechanism of action (15). Therefore, it is crucial to determine the metabolic profile and antibacterial mechanism of action of traditional medicinal plants for their development as novel antibacterial agents. This review provides an overview of the ethnobotanical research and current progress on the antibacterial activity of selected medicinal plants used by Jambi local communities.

Plant secondary metabolites with antibacterial properties

Secondary metabolites are a group of compounds produced by organisms that are unnecessary for growth and development but important for survival in the environment. These compounds are limitedly distributed between organisms and sometimes only occur during specific conditions (16). The roles of secondary metabolites for plants include species propagation, defense against herbivores and signaling. Secondary metabolites are often used to improve human health due to their benefits as antioxidants, anticancer and antibacterial compounds (17). Plant secondary metabolites with antibacterial activity consist of phenols, glycosides, saponin, flavonoids, steroids, tannins, alkaloids and terpenes (18). The most prominent groups of antibacterial compounds are phenols, terpenes and alkaloids. Some examples of plant secondary metabolites with antibacterial activity are shown in Fig. 1.

Phenols

Phenols are a group of compounds with aromatic ring structures containing hydroxyl group (OH^-). Some derivatives of phenols include phenolic acid, coumarin, flavonoid, stilbene, tannin and polyphenols (19). Phenols have been known to possess antibacterial activity against pathogenic bacteria. Previous researchers have reported the antibacterial activity of phenolic compounds against Gram-positive and Gram-negative bacteria, including myricetin, chlorogenic acid and caffeic acid (Fig. 1, Structure 1-3). Caffeic acid has demonstrated antibacterial properties against *Escherichia coli, S. aureus* and *Enterobacter aerogenes* (20). Other phenols such as baicalein and kaempferol (Fig. 1, Structure 2-5) increased antibiotics effective against the resistant strain of *S. aureus* (21).

Phenols' antibacterial mode of action includes disruption of membrane integrity and membrane attachment to the cell wall. These properties are attributed to the

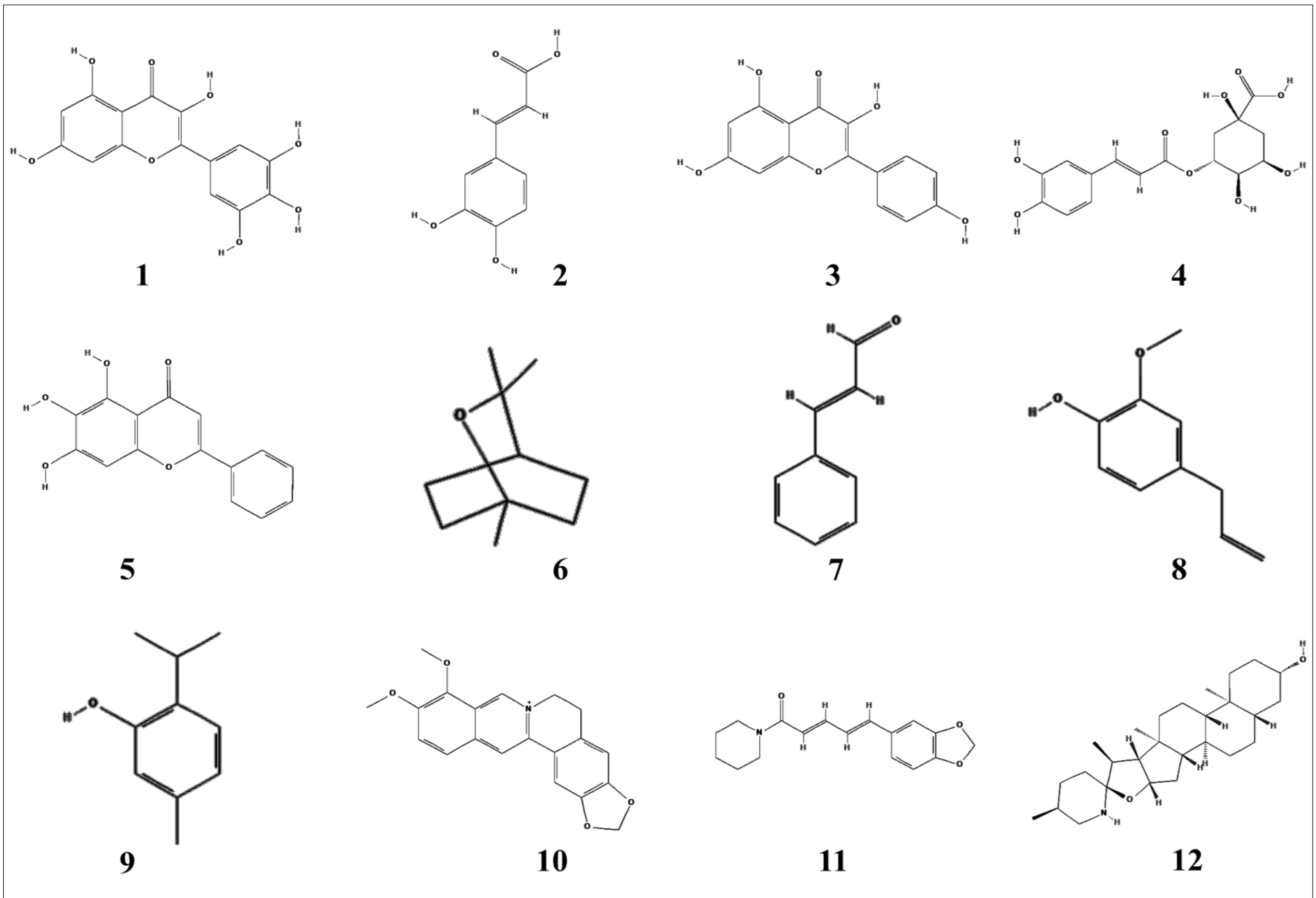


Fig. 1. Examples of plant secondary metabolites from the literature that have reported antibacterial activity.

amphipathic structure of phenols, which facilitates their penetration into lipid bilayers of the plasma membrane (22). Some phenols, including flavonoids, tannins and polyphenols, bind to adhesin in the cell wall and form an enzyme complex inhibiting cell wall synthesis (23). Phenols also counter the antibacterial resistance of pathogenic bacteria as efflux pump inhibitors (EPI) inhibit the efflux pump mechanism in resistant bacteria.

Terpenes

Terpenes contain isoprene group (C5) compounds in their carbon skeleton and are synthesized from the mevalonic acid pathway. Terpenes are categorized as both primary and secondary metabolites. The primary metabolites terpenes in plants, including sterol, carotenoid and polyprenol, while the secondary metabolites are further classified as monoterpenes, diterpenes, sesquiterpenes and triterpenes (24). The antibacterial activity of terpenes is especially shown by essential oils, mainly monoterpenes and diterpenes.

Essential oils, for example, eucalyptol, cinnamaldehyde and eugenol (Fig. 1, Structure 6-8), had shown antibacterial activity against *Pseudomonas aeruginosa, E. coli, Proteus vulgaris, Klebsiella pneumonia, Bacillus subtilis* and *S. aureus* (25). The derivative fatty acid groups of terpenoids also showed the ability to inhibit the growth of *S. aureus* (26). Terpenes inhibit bacterial growth by inducing structural changes in cellular membranes. The lipophilic properties of terpene molecules enable the compound to accumulate in the lipid bilayer of the plasma membrane. Eugenol and thymol (Fig. 1, Structure 8-9) have been reported to induce the formation of hydrogen bonds with enzymes that lead to enzyme inactivation, cell membrane disruption and induce changes in ion channels (27). Eugenol also showed anti-biofilm properties by down-regulating the expression of genes responsible for biofilm formation in *S. aureus* (28).

Alkaloids

Alkaloids are the most diverse secondary metabolites characterized by N-atom in the negative state. The diversity of alkaloids is due to their various biosynthetic pathways, combining various molecules from different pathways (29). These compounds act as toxic substances for defense and as an intermediary for defense mechanisms against plant pathogens. Alkaloids possess antibacterial activity against pathogenic bacteria. Several alkaloid compounds have been reported to inhibit bacterial growth, such as berberine, piperine and tomatidine (30) (Fig. 1, Structure 10-12).

The antibacterial mode of action of alkaloids is based on their ability to interact with enzymes in DNA synthesis. This binding leads to the disruption of replication and inhibition of bacterial cell division (31). Berberine and quinolone showed the ability to disrupt DNA replication and cell division in bacterial cells. These compounds bind to replication enzymes, such as DNA gyrase, DNA polymerase and topoisomerase, which cause replication errors that lead to cell death (32). Several alkaloids can also lower antibiotic resistance on resistant bacteria strains by the efflux pump inhibitor (EPI) mechanism. EPI mechanism disabled the efflux pump's ability to pump antibacterial compounds outside the cell and accumulate inside cells (33). Alkaloids also showed synergistic activity when combined with antibiotics. Simultaneous piperine and gentamicin application increased growth inhibition effectiveness against MRSA (34). Tomatidine also showed a synergistic effect when combined with antibiotic compounds and decreased MIC value compared to antibiotics alone (35).

Medicinal plants of Jambi local communities

Jambi is a province in the middle of Sumatra Island in Indonesia. It is known for its various ecosystems, ranging from lowland marshes to mountainous regions. As a region located near the equator, Jambi has tropical rainforests spread out over 4 national parks: Berbak, Bukit Dua Belas, Bukit Tiga Puluh and Kerinci Seblat National Parks (36). These tropical rainforests are habitats for endemic plants and other forest plants that local communities use for their daily needs.

Local communities in Jambi have used their ancestor's knowledge to use forest plants as traditional medicines. Several ethnobotanical studies have documented plant species used by Jambi's local communities in conventional medicinal practices. The lists of ethnobotanical studies in Jambi are shown in Table 1. These medicinal plants are mostly used as a traditional concoction for drinking by boiling them in water, but sometimes they can also be ground and used as a lotion for external use (37). Aside from medicinal properties, these plants are also used in spiritual ceremonies to exercise evil spirits (12).

Among those medicinal plants, *C. manan*, *H. zeylanica* and *Z. montanum* are selected to be discussed further. This article will review their morphological features, traditional uses, secondary metabolites content and antibacterial activity.

Morphological features and traditional usage

Calamus manan

Calamus manan (Miq.) is a member of the Arecaceae family that lives 50-1000 m altitude above sea level. This plant grows between trees in Sumatra and Kalimantan islands in Indonesia, especially Jambi, Riau and Bengkulu (38). This plant is called rotan manau or manau by the locals. The habitus consists of a single climbing stem that can grow up to 100 m in length with a diameter of 8 cm. Leaf sheaths are triangular and green-colored, densely organized. Compound leaves consist of lanceolate leaves growing up to 53 x 7.5 cm with a short petiole. Inflorescence up to 2.5 m in length produces ovoid fruit with yellowish scales up to 2.8 x 2.0 cm in size (39).

Several parts of *C. manan* are used in traditional medicine, ranging from the stem to its roots (Table 2). Suku Anak Dalam used stem water of *C. manan* to treat asthma, stomach ache, cough and fever (11, 37). Meanwhile, its stem sap is used by Orang Serampas to treat mouth ulcers (12). The Dayak tribe consumes its edible fruits to relieve oral candidiasis and abdominal pain (40). The *Harakit* tribe in Kalimantan also uses the roots as an aphrodisiac (41).

Helminthostacys zeylanica

Helminthostachys zeylanica ((L.) Hook.) is a fern from the Ophioglossaceae family that can live in various places, ranging from the forest floor in tropical forests to the swamp environment. The distribution of this plant occurs in Australia and Asia, including China, India and the Malayan Peninsula,

Table 1. Ethnobotanical studies of traditional medicinal plants in Jambi

Local communities	Location (Coordinates)	Findings	Reference(s)
Kerinci	Desa Pulau Sangkar, Kerinci (-2.1670, 101.5922)	39 species	(80)
	Lempur, Kerinci (-2.2613, 101.5330)	6 species of Zingiberaceae	(81)
Hiang	Hiang indigenous forest, Kerinci (-2.0739, 101.4905)	7 species	(82)
Pasir Mayang	VII Koto, Tebo (-1.1319, 102.1521)	57 species	(83)
Penghulu	Bukit Bulan, Sarolangun (-2.6583, 102.4391)	100 species	(84)
	Dwi Karya Bakti, Bungo (-1.7225, 102.1909)	19 species	(85)
	Tabun, Tebo (-1.1573, 102.0710)	39 species	(86)
Suku Anak Dalam	Bukit Dua Belas National Park, Sarolangun (-2.3051, 102.6821)	3 species of rattans	(11)
	Nyogan, Mestong (-1.8750, 103.4950)	17 species	(87)
	Air Hitam, Sarolangun (-1.9662, 102.6014)	48 species	(37)
Serampas	Jangkat, Merangin (-2.5121, 101.6995)	> 127 species	(12)
Teluk Rendah	Tebo Ilir, Tebo (-1.6036, 102.7664)	65 species	(88)

Table 2. Usage of the 3 Jambi medicinal plants in traditional medicines

Plant species	Used part	Medicinal usage	Reference(s)
Calamus manan	Stem	Medicine for asthma and stomach ache	(11)
	Stem sap	Medicine for mouth ulcer	(12)
	Fruit	Medicine for abdominal pain and oral candidiasis	(40)
	Root	Aphrodisiac	(41)
Helminthostachys zeylanica	Root	Medicine for whooping cough (pertussis), dysentery and respiratory tract infections	(44)
	Root, rhizome	Medicine for fever and cough	(45)
	Rhizome	Anti-inflammation, pulmonary disease treatment	(46)
	Whole plant, root	Aphrodisiac	(41)
Zingiber montanum	Rhizome, stem	Medicine for skin infections, fever and digestion disorders	(49,50)
	Rhizome	Medicine for fever, protection from evil spirits	(12)
	Rhizome	Relieves colic in infant	(51)

where it is often called tunjuk langit (42). The rhizome grows laterally underground, up to 7 mm in diameter. The frond consists of a pinna with green or purplish-brown petioles to 60 cm long. Lamina is organized in pinnate to sub-palmate, tripartite with rhomboid to the obdeltoid pinna, up to 25 x 5 cm. A cylindrical spike arises from the junction of the petiole and lamina, protruding beyond the lamina up to 13 x 7 cm. The spike bears numerous short branches containing sporangia (43).

As a traditional medicine, the roots and rhizome parts of *H. zeylanica* have long been used to treat various health ailments (Table 2). The roots are traditional medicines for whooping cough (pertussis), dysentery and respiratory tract infections (44). Suku Anak Dalam eats the leaves, while the rhizome is used as medicine (45). The communities in Lahat used this plant as an anti-inflammation agent and a pulmonary disease treatment (46). The root is also used as an aphrodisiac by the Dayak tribe in Kalimantan (41).

Zingiber montanum

Zingiber montanum [(J. Koenig) Link] is a member of the Zingiberaceae family that spreads across Asia, ranging from tropical to subtropical climates. This plant originally came from India and was then successfully cultivated in Asia, including Indonesia. The rhizome is yellowish to reddish-yellow with a distinctive camphoraceous odor. Aerial stems are herbaceous that can grow up to 1.8 m (47). Lamina is narrowly ovate or elliptic without a petiole and pubescent sheath. Each leaflet can grow up to 60 x 8 cm long. The inflorescence is cone-like, with dark red to purplish bracts and cream-white labellum (48).

The rhizome is the most extensively used part of *Z. montanum* for traditional medicines (Table 2). It is commonly used to treat fever, skin infections and digestive tract disease (49, 50). The rhizome of this plant is one of the most vital components in Orang Serampas's traditional concoction called Uras, which is used to treat various illnesses and ward off evil spirits (12). Rhizome is also commonly used in Indonesia as a colic reliever for infants, as it is rubbed on the abdomen (51).

Phytochemistry

Calamus manan

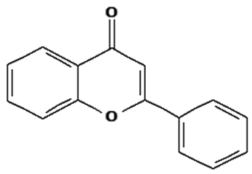
The information regarding the phytochemical constituents of *C. manan* is limited because it has been known for its economic value until recently. The fruits and seeds of *C. manan* have been extracted to investigate its secondary metabolite content (Table 3). In a study conducted flavonoid, saponin, tannin (Fig. 2, Structure 13-15), alkaloid and triterpenoids were detected from ethanolic extract of fruit flesh, pericarp and seeds of *C. manan* (40). Similar findings, identifying glycosides (Fig. 2, Structure 16), alkaloids, flavonoids, steroids and triterpenoids in the fruit extract of *C. manan* (52). Another part investigated was the young stem of *C. manan,* which contains flavonoid, glycoside, saponin and tannin (53).

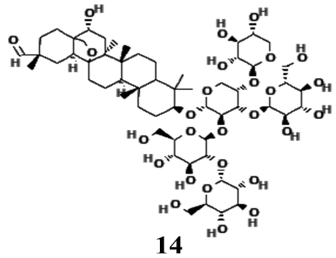
Helminthostachys zeylanica

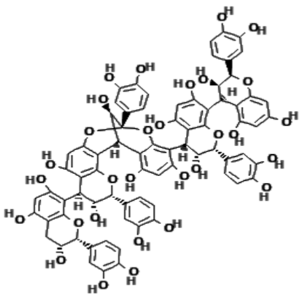
Secondary metabolite contents of *H. zeylanica* rhizome have been reported using various solvent extraction (Table 3). Ethanolic extract showed the presence of phenolic, flavonoid, triterpenes, saponin, tannin and glycosides (54). Some investigations have successfully isolated flavonoid compounds from the rhizome of *H. zeylanica* (Fig. 2). Extraction using ethyl acetate has reported flavonoid compounds ugonin J (Fig. 3, Structure 17), ugonin M, ugonin T and quercetin (Fig. 3, Structure 18-20) from *H. zeylanica* (46, 55). Flavonoid compounds, including ugonin J, ugonin M and quercetin, were isolated using a mixture of ethanol and methanol extracts from *H. zeylanica* (56).

Zingiber montanum

Various parts of *Z. montanum* have been investigated to identify the secondary metabolite contents using different solvents (Table 3). The stem, leaves and rhizome showed the presence of flavonoids, tannins, saponins, steroids and alkaloids when extracted using ethanol (57, 58). The rhizome of *Z. montanum* was extracted using methanol and reported to contain alkaloids, steroids and flavonoids (59). Ethanolic extract from the rhizome also showed the presence of terpenoids and phenylbutenoids (60).


13


14


15

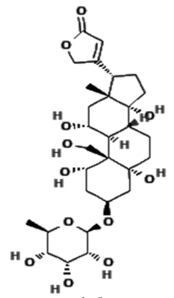

16

Fig. 2. The chemical structures of some secondary metabolite groups reported from *C. manan.*

Table 3. Secondary metabolites contents of the three Jambi medicinal plants

Plant species	Extract (solvent)	Result	Reference(s)
Calamus manan	Fruit pericarp (ethanol)	Flavonoid, alkaloid, tannin, saponin, triterpenoid	
	Fruit flesh (ethanol)	Flavonoid, tannin, saponin, triterpenoid	(40)
	Seeds (ethanol)	Flavonoid, alkaloid, tannin, triterpenoid	
	Fruit (ethanol)	Gyicoside, alkaloid, flavonoid, steroid, triterpe-noid	(52)
	Young stem (ethanol)	Flavonoid, glycoside, saponin,, tannin	(53)
Helminthostachys zeylanica	Rhizome (ethanol)	Phenolic, flavonoid, triterpenoid, tannin, saponin, glycosides	(54)
	Rhizome (ethyl acetate)	Flavonoid (ugonin J)	(46)
	Rhizome (ethyl acetate)	Flavonoid (ugonin M-T, ugonin J, quercetin)	(55)
	Root, rhizome (ethanol, methanol)	Flavonoid (ugonin J, ugonin M, quercetin)	(56)
Zingiber montanum	Stem, leaves, rhizome (ethanol)	Flavonoid	(57)
	Leaves (ethanol)	Flavonoid, tannin, saponin, steroid, alkaloid	(58)
	Rhizome (methanol)	Alkaloid, steroid, flavonoid	(59)
	Rhizome (ethanol)	Terpenoid, phenylbutenoid	(60)
	Rhizome essential oils	Terpenoid (monoterpenes, sesquiterpenes)	(61)
	Rhizome (ethanol)	Zerumbone (sesquiterpenoid) and five kaempferol derivatives (flavonoid)	(63)
	Rhizome (ethanol)	Terpinen-4-ol (monoterpenoid)	(64)
	Rhizome essential oils	Sabinene, γ-terpinene, terpinen-4-ol (monoterpenoid)	(65)

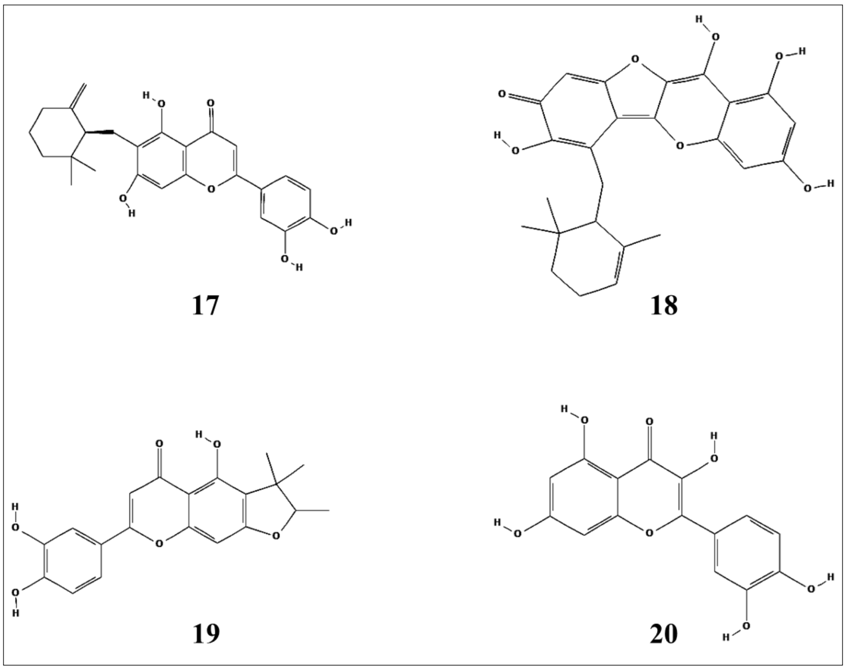


Fig. 3. The chemical structures of some major compounds isolated from *H. zeylanica.*

Distilled extracts of *Z. montanum* rhizome produce essential oils that contain various chemically active compounds. 15 compounds isolated successfully from *Z. montanum* rhizome, which consisted mainly of sesquiterpenes (98.78 %) and small amounts of monoterpenes (1.22 %) (61). One of the significant sesquiterpenoids of *Z. montanum* essential oil is zerumbone (Fig. 4, Structure 21) (62). Furthermore, previous study reported successful isolation of zerumbone as well 5 kaempferol derivatives from *Z. montanum*: kaempferol 3-O-methyl ether, kaempferol 3-O-rhamnopyranoside, kaempferol 3-O-(4”-O-acetyl)-rhamnopyranoside, kaempferol 3-O-(3”-O-acetyl)-rhamnopyranoside and kaempferol 3-O- -(3”,4”-di-O-acetyl)-rha mnopyranoside (63). Additionally, terpinen-4-ol is the major monoterpenoid in *Z. montanum* essential oils, along with sabinene and γ-terpinene (Fig. 4, structure 22-24) (64, 65).

Antibacterial activity

Calamus manan

Several parts of *C. manan* have been studied for their antibacterial activity (Table 4). Ethanolic extract of fruit pericarp and seeds of *C. manan* showed antibacterial activity against *E. coli* and Streptococcus mutans, with more substantial and more potent inhibition for *E. coli* (40). Similar findings have also reported growth inhibition on *Vibrio cholerae* and *Staphylococcus epidermidis* (52). Furthermore, *C. manan* seed extract also inhibited growth against *Salmonella typhi* (66). These antibacterial properties might be attributed to secondary metabolites inside *C. manan*, such as flavonoids, glycosides, tannins and saponins. Those groups of secondary metabolites can disrupt bacterial cell membrane integrity and induce intracellular leakage, which leads to bacterial cell death (67–69).

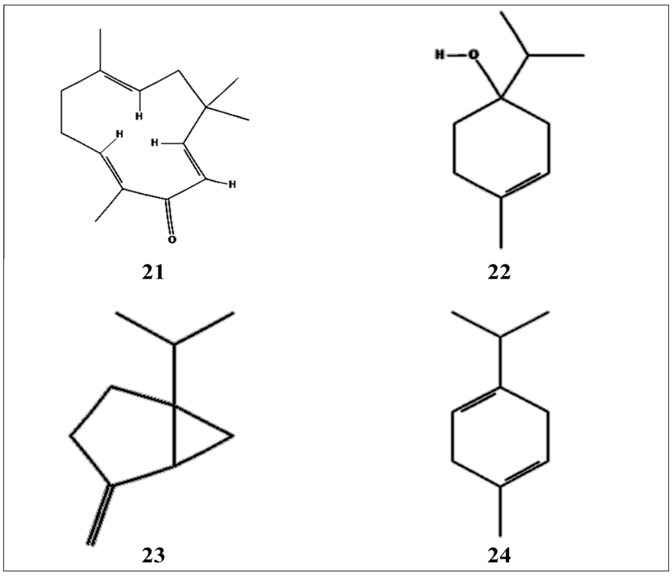


Fig. 4. The chemical structures of *Z. montanum* essential oil.

Helmintostachys zeylanica

The antibacterial activity of *H. zeylanica* has been investigated by several studies (Table 4). A study was conducted with ethanolic leaf extract from *H. zeylanica* and it showed growth inhibition against *Bacillus cereus* (70). Another study reported inhibitory activity against various strains of Gram-positive and Gram-negative bacteria from *H. zeylanica* root extract (71). In addition, *H. zeylanica* extracts could inhibit the activity of multiple enzymes linked to bacterial infection, such as glucosyltransferase (GTase) on *Streptococcus sobrinus* and lipase on *Propionibacterium acnes* (72, 73). These antibacterial activities are attributed to the abundance of ugonin and quercetin in *H. zeylanica*. Ugonin J has been reported as a noncompetitive inhibitor of bacterial neuraminidase (BNA), which plays a pivotal role in bacterial infection and biofilm formation (74). In addition to be a BNA inhibitor, quercetin is also able to inhibit bacterial DNA supercoiling by binding to DNA gyrase (75). Quercetin is also reported to induce bacteriostasis effect by damaging bacterial cell walls and membranes, which leads to increased permeability and intracellular leakage (76).

Zingiber montanum

Previous research has reported the antibiotic activity of *Z. montanum* extract and its essential oils (Table 4). Ethanolic extract from the leaves was reported to inhibit the growth of *P. aeruginosa* (58). The rhizome showed the ability to inhibit the growth of *B. cereus* and *K. pneumonia* when extracted using

Table 4. Antibacterial activity of the 3 Jambi medicinal plants.

Plant species	Extract (solvent)	Tested Bacteria	MIC (µg/mL)	Reference(s)
Calamus manan	Fruits pericarp and seeds (ethanol)	*Escherichia coli*	-	(40)
		Streptococcus mutans	-	
	Fruits (ethanol)	*Vibrio cholerae*	-	(52)
		Staphylococcus epidermidis	-	
	Seeds (ethanol)	*Salmonella typhii*	-	(66)
Helminthostachys zeylanica	Leaf (ethanol)	*Bacillus cereus*	6.25	(67)
	Root (dichloromethane)	*Bacillus subtilis*	250	(68)
		Bacillus cereus	> 500	
		Staphylococcus aureus	> 500	
		Listeria monocytogenes	> 500	
		Vibrio parahaemolyticus	125	
		Vibrio alginolyticus	> 500	
		Salmonella typhimurium	> 500	
	Flower, root (methanol)	*Streptococcus sobrinus*	-	(69)
	Whole plant (methanol, ethanol 50 %)	*Propionibacterium acnes*	-	(70)
Zingiber montanum	Leaves (ethanol)	*Pseudomonas aeruginosa*	400	(58)
	Rhizome (ethanol)	*Bacillus cereus*	15	(60)
		Klebsiella pneumonia	15	
	Rhizome essential oils	*Bacillus cereus*	-	(61)
		Escherichia coli	-	
	Rhizome essential oils	*Acinetobacter baumanni* MDR strain	7	(71)

ethanol (60). Additionally, essential oils of *Z. montanum* rhizome also showed antibacterial activity against *B. cereus* and *E. coli* and against multi-drug resistant strain of *Acinetobacter baumannii* (61, 77). Terpinen-4-ol, as one of the major constituents of essential oils from *H. zeylanica* might be the primary reason for these antibacterial properties. Terpinen-4-ol has been reported to produce structure alterations in bacterial cells, including decreased cell size, irregular cell shape, unequal cell division, vacuolization and plasmolysis (78). These alterations might be due to the bonding of terpinen-4-ol to carbohydrate parts of the cell wall through glycosidic bonds formation, as well as the hydrogen bonds formation of terpinen-4-ol to proteins, phospholipids and nucleic acids, which disturb conformations stability (79).

Conclusion

In this review, there is considerable evidence that traditional medicinal plants from Jambi local communities possess secondary metabolites for developing novel antibacterial compounds, specifically *C. manan, H. zeylanica* and *Z. montanum*. These compounds can be used for drug development to solve the emergence of drug-resistant bacteria problems. Further research on compound isolation, purification and antibacterial mechanisms is crucial to optimize the potential of these medicinal plants as novel antibacterial agents.

Acknowledgements

The authors' research on medicinal plants of Jambi's folks medicine was financially supported by Pendidikan Magister menuju Doktor Sarjana Unggul (PMDSU) Scholarship Grant year 2021 (111/E4.1/AK.04.PT/2021) from the Ministry of Education and Culture of Indonesia.

Authors' contributions

MHA, ER, YAP and LHN designed and conceptualized the study. MHA curated the data and wrote the original draft. ER and YAP provided critical revisions and edited the final version. LHN supervised the study and revised the final version of the document. All authors have read and agreed to the published version of the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

References

1. Fukuda K. Antimicrobial resistance: global report on surveillance. Geneva: World Health Organisation. 2014:256.
2. Basak S, Singh P, Rajurkar M. Multidrug-resistant and extensively drug-resistant bacteria: A study. J Pathog. 2016;2016(1):4065603. https://doi.org/10.1155/2016/4065603
3. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: An international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18(3):268–81. https://doi.org/10.1111/j.1469-0691.2011.03570.x
4. Ventola CL. The antibiotic resistance crisis: causes and threats. P T. 2015;40(4):277–83.
5. Okwu MU, Olley M, Akpoka AO, Izevbuwa OE. Methicillin-resistant *Staphylococcus aureus* (MRSA) and anti-MRSA activities of extracts of some medicinal plants: A brief review. AIMS Microbiol. 2019;5(2):117–37. https://doi.org/10.3934/microbiol.2019.2.117
6. Pramono E. The commercial use of traditional knowledge and medicinal plants in Indonesia. In: Multi-Stakeholder Dialogue on Trade, Intellectual Property and Biological Resources in Asia, 2002; BRAC Centre for Development Management, Rajendrapur, Bangladesh.

7. Mitra R, Mitchell, Gray C, Orbell J, Coulepis T, Muralitharan MS. Medicinal Plants of Indonesia. Asia Pac Biotech News. 2007;11 (11):726–43. https://doi.org/10.1017/CBO9780511753312.026

8. Pribadi ER. Pasokan dan permintaan tanaman obat Indonesia serta arah penelitian dan pengembangannya. [Supply and demand of Indonesian medicinal plants and the direction of their research and development]. Perspektif. 2009;8(1):52–64. https://doi.org/10.21082/p.v8n1.2009

9. Hariyadi B. Obat rajo obat ditawar: medicinal plants and traditional medicine of Serampas - Jambi. Biospecies. 2011;4 (2):29–35. https://doi.org/10.22437/biospecies.v4i2.524

10. Setyowati FM. Hubungan keterikatan masyarakat kubu dengan sumberdaya tumbuh- tumbuhan di Cagar Biosfer Bukit Duabelas, Jambi. Biodiversitas. 2003;4(1):47–54. https://doi.org/10.13057/biodiv/d040110

11. Mairida D, Muhadiono M, Hilwan I. Ethnobotanical study of rattans on Suku Anak Dalam Community in Bukit Duabelas National Park. Biosaintifika. 2016;8(1):64. https://doi.org/10.15294/biosaintifika.v8i1.5164

12. Hariyadi B, Ticktin T. Uras: medicinal and ritual plants of Serampas, Jambi Indonesia. Ethnobot Res Appl. 2012;10:133–49. https://doi.org/10.17348/era.10.0.133-149

13. Cowan MM. Plant products as antimicrobial agents. Clin Microbiol Rev. 1999;12(4):564–82. https://doi.org/10.1128/CMR.12.4.564

14. Silva LN, Zimmer KR, Macedo AJ, Trentin DS. Plant natural products targeting bacterial virulence factors. Chemical Rev. 2016;116(16):9162–236. https://doi.org/10.1021/acs.chemrev.6b00184

15. Shreaz S, Wani WA, Behbehani JM, Raja V, Irshad M, Karched M, et al. Cinnamaldehyde and its derivatives, a novel class of antifungal agents. Fitoterapia. 2016;112:116–31. https://doi.org/10.1016/j.fitote.2016.05.016

16. Dewick PM. Medicinal natural products: A biosynthetic approach: 3rd ed. Chichester: Wiley; 2009. https://doi.org/10.1002/9780470742761

17. Malini M, Abirami G, Hemalatha V, Annadurai G. Antimicrobial activity of ethanolic and aqueous extracts of medicinal plants against waste water pathogens. Int J Res Pure Appl Microbiol. 2013; 3(2):40–42.

18. Sen A, Batra A. Evaluation of antimicrobial activity of different solvent extracts of medicinal plant: *Melia Azedarach* L. Int J Curr Pharm Res. 2012;4(2):67–73.

19. Stalikas CD. Extraction, separation and detection methods for phenolic acids and flavonoids. J Sep Sci. 2007;30(18):3268–95. https://doi.org/10.1002/jssc.200700261

20. Puupponen-Pimia R, Nohynek L, Meier C. Antimicrobial properties of phenolic compounds from berries. J Appl Microbiol. 2001;90 (4):494–504. https://doi.org/10.1046/j.1365-2672.2001.01271.x

21. Holler JG, Christensen SB, Slotved HC, Rasmussen HB, Guzman A, Olsen CE, et al. Novel inhibitory activity of the *Staphylococcus aureus* NorA efflux pump by a *Kaempferol rhamnoside* isolated from *Persea lingue* Nees. J Antimicrob Chemother. 2012;67 (5):1138–44. https://doi.org/10.1093/jac/dks005

22. Tyagi P, Singh M, Kumari H, Kumari A, Mukhopadhyay K. Bactericidal activity of curcumin I is associated with damage to bacterial membrane. PLoS One. 2015;10(3):1–15. https://doi.org/10.1371/journal.pone.0121313

23. Bouarab-Chibane L, Forquet V, Lanteri P, Clement Y, Leonard-Akkari L, Oulahal N, et al. Antibacterial properties of polyphenols: characterization and QSAR (quantitative structure-activity relationship) models. Front Microbiol. 2019;10:829. https://doi.org/10.3389/fmicb.2019.00829

24. Schilmiller AL, Schauvinhold I, Larson M, Xu R, Charbonneau AL, Schmidt A, et al. Monoterpenes in the glandular trichomes of tomato are synthesized from a neryl diphosphate precursor rather than geranyl diphosphate. Proc Natl Acad Sci USA. 2009;106(26):10865–70. https://doi.org/10.1073/pnas.0904113106

25. Prabuseenivasan S, Jayakumar M, Ignacimuthu S. *In vitro* antibacterial activity of some plant essential oils. Complement Altern Med. 2006;6:1–8. https://doi.org/10.1186/1472-6882-6-39

26. Kelsey JA, Bayles KW, Shafii B, McGuire MA. Fatty acids and monoacylglycerols inhibit the growth of *Staphylococcus aureus.* Lipids. 2006;41(10):951–61. https://doi.org/10.1007/s11745-006-5048-z

27. Guimaraes AC, Meireles LM, Lemos MF, Guimaraes MCC, Endringer DC, Fronza M, et al. Antibacterial activity of terpenes and terpenoids present in essential oils. Mol. 2019;24(13):1–12. https://doi.org/10.3390/molecules24132471

28. Yadav MK, Chae SW, Im GJ, Chung JW, Song JJ. Eugenol: A phyto-compound effective against methicillin-resistant and methicillin-sensitive *Staphylococcus aureus* clinical strain biofilms. PLoS One. 2015;10(3):1–21. https://doi.org/10.1371/journal.pone.0119564

29. Cushnie TPT, Cushnie B, Lamb AJ. Alkaloids: An overview of their antibacterial, antibiotic-enhancing and anti-virulence activities. Int J Antimicrob Agents. 2014;44(5):377–86. https://doi.org/10.1016/j.ijantimicag.2014.06.001

30. Scazzocchio F, Cometa MF, Tomassini L, Palmery M. Antibacterial activity of *Hydrastis canadensis* extract and its major isolated alkaloids. Planta Med. 2001;67(06):561–64. https://doi.org/10.1055/s-2001-16493

31. Boberek JM, Stach J, Good L. Genetic evidence for inhibition of bacterial division protein FtsZ by berberine. PLoS One. 2010;5 (10):1–9. https://doi.org/10.1371/journal.pone.0013745

32. Heeb S, Fletcher MP, Chhabra SR, Diggle SP, Williams P, Camara M. Quinolones: from antibiotics to autoinducers. FEMS Microbiol Rev. 2011;35(2):247–74. https://doi.org/10.1111/j.1574-6976.2010.00247.x

33. Khameneh B, Iranshahy M, Soheili V, Bazzaz BSF. Review on plant antimicrobials: A mechanistic viewpoint. Antimicrob Resist Infect Control. 2019;8(118):1–28. https://doi.org/10.1186/s13756-019-0559-6

34. Khameneh B, Iranshahy M, Ghandadi M, Ghoochi Atashbeyk D, Fazly Bazzaz BS, et al. Investigation of the antibacterial activity and efflux pump inhibitory effect of co-loaded piperine and gentamicin nanoliposomes in methicillin-resistant *Staphylococcus aureus.* Drug Dev Ind Pharm. 2015;41(6):989–94. https://doi.org/10.3109/03639045.2014.920025

35. Soltani R, Fazeli H, Najafi RB, Jelokhanian A. Evaluation of the synergistic effect of tomatidine with several antibiotics against standard and clinical isolates of *Staphylococcus aureus, Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Escherichia coli*. Iran J Pharm Res. 2017;16(1):290–96.

36. Badan Pusat Statistik (BPS). Provinsi Jambi dalam angka 2021. Jambi: BPS Provinsi Jambi; 2021. p. 593.

37. Susanti T, Suraida, Natalia D, Ningsih T. Local knowledge of Suku Anak Dalam tribe about the utilization of medical plants in Bukit Duabelas Sarolangun National Park area. Biospecies. 2023;16 (2):19–26. https://doi.org/10.22437/biospecies.v16i2.26629

38. Kusuma YWC, Dodo, Hendrian R. Propagation and transplanting of manau rattan (*Calamus manan)* in Bukit Duabelas National Park, Sumatra, Indonesia. Conserv Evid. 2011;8:19–25.

39. Kalima T, Sumarhani. Identifikasi jenis-jenis rotan pada hutan rakyat di Katingan, Kalimantan Tengah dan upaya pengembangan. [Identification of rattan species in community forests in Katingan, Central Kalimantan and development efforts]. Pros Sem Nas Masy Biodiv Indon. 2015;1(2):194–200. https://doi.org/10.13057/psnmbi/m010205

40. Salusu HD, Ariani F, Budiarso E, Kusuma IW, Arung ET. Increased benefits of *Calamus manan* Miq. Fruit by its potential bioactivity.

Proc Joint Symp Trop Stud (JSTS-19). 2021;11:180–85. https://doi.org/10.2991/absr.k.210408.030

41. Fauzi F, Widodo H, Haryanti S. Kajian tumbuhan obat yang banyak digunakan untuk aprodisiaka oleh beberapa etnis Indonesia. [Study of medicinal plants widely used as aphrodisiacs by several Indonesian ethnic groups]. Media Penelitian dan Pengembangan Kesehatan. 2019;29(1):51–64. https://doi.org/10.22435/mpk.v29i1.466
42. Manna S, Kamilya P, Ghara TK, Roy A. Swamp Forest: A phytoassociation analysis of *Helminthostachys zeylanica* in Barringtonia. Glob J Sci Front Res Bio Sci. 2013;13(5).
43. de Winter W. Cryptogams: Ferns and fern allies. Amoroso VB, editor. Backhuys Publishers; 2003. p. 263.
44. Hartini S. *Helminthostachys zeylanica* (L.) Hook: Potensinya sebagai obat masa depan. [Its potential as a future medicine]. Warta Kebun Raya. 2011;11(1):34–37.
45. Ulfa M, Mitaria Sirait dan. Jenis dan nilai ekonomi hasil hutan bukan kayu terhadap Suku Anak Dalam di Taman Nasional Bukit Duabelas. Jurnal Silva Tropika. 2019;3(1):2615–8353.
46. Fitrya F, Anwar L, Eliza E, Muharni M. Ugonin J Flavonoid from tunjuk langit (*Helminthostachys zeylanica* Linn.) root extract. Indones J Chem. 2010;10(2):226–31. https://doi.org/10.22146/ijc.21465
47. Acevedo-Rodriguez P, Strong MT. Monocotyledons and gymnosperms of Puerto Rico and the Virgin Islands. Contrib U S Natl Herb. 2005;52(1):128–33. https://doi.org/10.2307/25065559
48. Bai L, Maslin BR, Triboun P, Xia N, Leong-Skornickova J. Unravelling the identity and nomenclatural history of *Zingiber montanum* and establishing *Z. purpureum* as the correct name for Cassumunar ginger. Taxon. 2019;68(6):1334–49. https://doi.org/10.1002/tax.12160
49. Singh TT, Sharma HM. An ethnobotanical study of monocotyledonous medicinal plants used by the scheduled caste community of Andro in Imphal East District, Manipur (India). Res J Life Sci Bioinform Pharm Chem Sci. 2018;4(4):55–72. https://doi.org/10.26479/2018.0404.04
50. Silalahi M. Botani, metabolit sekunder dan bioaktivitas bangle (*Zigiber montanum*). Jurnal Ilmiah Ilmu Kesehatan. 2019;7(1):73–83.
51. Verma RS. Ethnobotany, phytochemistry and pharmacology of *Zingiber cassumunar* Roxb. (Zingiberaceae). J Sci Food Agric. 2018;98(1):1053–57. https://doi.org/10.1055/s-0031-1273656
52. Bariah S, Mayasari U. Uji aktivitas ekstrak buah rotan manau (*Calamus manan*) terhadap pertumbuhan bakteri *Vibrio cholerae* dan *Staphylococcus epidermidis*. BEST J. 2023;6(1):634–40. https://doi.org/10.30821/kfl:jibt.v6i1.11762
53. Maulina M, Rasyidah, Mayasari U. Uji Aktivitas antijamur ekstrak batang muda rotan manau (*Calamus manan*) terhadap jamur *Aspergillus flavus* dan *Candida albicans*. BEST J. 2023;6(2):43–49. https://doi.org/10.30821/kfl:jibt.v6i1.11762
54. Suja SR, Latha PG, Pushpangadan P, Shine VJ, Anuja GI, Bijukumar BS, et al. Evaluation of antihepatotoxic potential of *Helminthostachys zeylanica* (Linn.) Hook. f., a medicinal fern against ethanol-induced liver damage: *In vitro* and in vivo studies. AJEB. 2014 May 17;1:16–31.
55. Huang YL, Shen CC, Shen YC, Chiou WF, Chen CC. Anti-inflammatory flavonoids from the rhizomes of *Helminthostachys zeylanica* Yaun-Chao. J Nat Prod. 2009;72(2):1273–78. https://doi.org/10.1021/acs.jnatprod.5b01164
56. Wu KC, Huang SS, Kuo YH, Ho YL, Yang CS, Chang YS, et al. Ugonin M, a *Helminthostachys zeylanica* constituent, prevents LPS-induced acute lung injury through TLR4-mediated MAPK and NF-kB signalling pathways. Mol. 2017;22(4):1–15. https://doi.org/10.3390/molecules22040573
57. Herawati IE, Saptarini NM, Urip NR. Analisis kadar flavonoid total pada rimpang, batang, dan daun bangle (*Zingiber purpureum* Roscoe). In: Prosiding Seminar Nasional 'Perkembangan Terbaru Pemanfaatan Herbal Sebagai Agen Preventif Pada Terapi Kanker'. 2014. p. 158–62.
58. Noviyanto F, Hodijah S, Yusransyah Y. Aktivitas ekstrak daun bangle (*Zingiber purpureum* roxb.) terhadap pertumbuhan bakteri *Pseudomonas aeruginosa.* J Syifa Sci Clinical Res. 2020;2(1):31–38. https://doi.org/10.37311/jsscr.v2i1.2665
59. Hermansyah B, Utami WS. Bioactivity of a compound of standardized bangle (*Zingiber cassumunar* Roxb.) extract fraction as a complementary therapy to prevent malaria complications. J Agromed Med Sci. 2015;1(2):19–25. https://doi.org/10.19184/ams.v1i2.1955
60. Risnawati E, Ainurofiq A, Widyo Wartono M. Study of antibacterial activity and identification of the most active fraction from ethanol extraction of *Zingiber cassumunar* Roxb. rhizomes by vacuum liquid chromatography. J Chem Pharm Res. 2014;6(9):101–07.
61. Kamazeri TSAT, Samah OA, Taher M, Susanti D, Qaralleh H. Antimicrobial activity and essential oils of *Curcuma aeruginosa, Curcuma mangga* and *Zingiber cassumunar* from Malaysia. Asian Pac J Trop Med. 2012;5(3):202–09. https://doi.org/10.1016/S1995-7645(12)60025-X
62. Devkota HP, Paudel KR, Hassan MM, Dirar AI, Das N, Adhikari-Devkota A, et al. Bioactive compounds from *Zingiber montanum* and their pharmacological activities with focus on zerumbone. Appl Sci. 2021;11(21):10205. https://doi.org/10.3390/app112110205
63. Hassan MM, Adhikari-Devkota A, Imai T, Devkota HP. Zerumbone and kaempferol derivatives from the rhizomes of *Zingiber montanum* (J. Koenig) link ex a. dietr. from Bangladesh. Separations. 2019;6(31):1–8. https://doi.org/10.3390/separations6020031
64. Kantayos V, Paisooksantivatana Y. Antioxidant activity and selected chemical components of 10 *Zingiber* spp. in Thailand. J Dev Sustain Agric. 2012;(1):89–96.
65. Sukatta U, Rugthaworn P, Punjee P, Keeratinijakal V. Chemical composition and physical properties of oil from Plai (*Zingiber cassumunar* Roxb.) obtained by hydro distillation and hexane extraction. Kasetsart J Nat Sci. 2009;43(5):212–17.
66. Mahdiyah D, Maulina N, Hakim AR, Mukti BH. Aktivitas antimikroba ekstrak biji rotan manau (*Calamus manan* Miq.) Terhadap *Salmonella typhi* dan *Candida albicans*. Al-Kauniyah J Biol. 2024;17(2):247–56. https://doi.org/10.15408/kauniyah.v17i2.23122
67. Tagousop CN, Tamokou JDD, Ekom SE, Ngnokam D, Voutquenne-Nazabadioko L. Antimicrobial activities of flavonoid glycosides from *Graptophyllum grandulosum* and their mechanism of antibacterial action. BMC Complement Altern Med. 2018;18(1):1–10. https://doi.org/10.1186/s12906-018-2321-7
68. Maisetta G, Batoni G, Caboni P, Esin S, Rinaldi AC, Zucca P. Tannin profile, antioxidant properties and antimicrobial activity of extracts from two Mediterranean species of parasitic plant Cytinus. BMC Complement Altern Med. 2019;19(1):1–11. https://doi.org/10.1186/s12906-019-2487-7
69. Dong S, Yang X, Zhao L, Zhang F, Hou Z, Xue P. Antibacterial activity and mechanism of action of saponins from *Chenopodium quinoa* Willd. husks against foodborne pathogenic bacteria. Ind Crops Prod. 2020;149:112350. https://doi.org/10.1016/j.indcrop.2020.112350
70. Yenn TW, Ring LC, Zahan KA, Rahman MSA, Tan WN, Alaudin BJS. Chemical composition and antimicrobial efficacy of *Helminthostachys zeylanica* against foodborne *Bacillus cereus*. Nat Prod Sci. 2018;24(1):66–70. https://doi.org/10.20307/nps.2018.24.1.66

71. Army MK, Khodijah R, Haryani Y, Teruna HY, Hendra R. Antibacterial *in vitro* screening of *Helminthostachys zeylanica* (L.) Hook. root extracts. J Pharm Pharmacogn Res. 2023;11(2):291–96. https://doi.org/10.56499/jppres22.1540_11.2.291

72. Kuspradini H, Batubara I, Mitsunaga T. Antimicrobial and gtase inhibitory activity of crude methanol extracts of plants from Java and Kalimantan. J Ilmu Teknol Kayu Trop. 2010;8(1):39–46.

73. Batubara I, Mitsunaga T, Ohashi H. Screening antiacne potency of Indonesian medicinal plants: antibacterial, lipase inhibition and antioxidant activities. J Wood Sci. 2009;55(3):230–35. https://doi.org/10.1007/s10086-008-1021-1

74. Shah AB, Baiseitova A, Kim JH, Lee YH, Park KH. Inhibition of bacterial neuraminidase and biofilm formation by ugonins isolated from *Helminthostachys zeylanica* (L.) Hook. Front Pharmacol. 2022;13:890649. https://doi.org/10.3389/fphar.2022.890649

75. Plaper A, Golob M, Hafner I, Oblak M, Solmajer T, Jerala R. Characterization of quercetin binding site on DNA gyrase. Biochem Biophys Res Commun. 2003;306(2):530–36. https://doi.org/10.1016/S0006-291X(03)01006-4

76. Wang S, Yao J, Zhou B, Yang J, Chaudry MT, Wang M, et al. Bacteriostatic effect of quercetin as an antibiotic alternative in vivo and its antibacterial mechanism *in vitro*. J Food Prot. 2018;81(1):68–78. https://doi.org/10.4315/0362-028X.JFP-17-214

77. Boonyanugomol W, Kraisriwattana K, Rukseree K, Boonsam K, Narachai P. In vitro synergistic antibacterial activity of the essential oil from *Zingiber cassumunar* Roxb against extensively drug-resistant *Acinetobacter baumannii* strains. J Infect Public Health. 2017;10(5):586–92. https://doi.org/10.1016/j.jiph.2017.01.008

78. Li L, Shi C, Yin Z, Jia R, Peng L, Kang S, et al. Antibacterial activity of a-terpineol may induce morphostructural alterations in *Escherichia coli*. Sociedade Bras de Microbiol. 2014;45(4):1409–13. https://doi.org/10.1590/S1517-83822014000400035

79. Yang X, Zhao S, Deng Y, Xu W, Wang Z, Wang W, et al. Antibacterial activity and mechanisms of α-terpineol against foodborne pathogenic bacteria. Appl Microbiol Biotechnol. 2023;107(21):6641–53. https://doi.org/10.1007/s00253-023-12737-4

80. Adriadi A, Nursanti N, Puspitasari R. Keanekaragaman tumbuhan obat masyarakat di hutan talang rencong desa pulau sangkar, kabupaten kerinci, Jambi. Media Konservasi. 2020;25(2):134–39. https://doi.org/10.29244/medkon.25.2.134-139

81. Wardana ST. Ethnomedicinal approach of Zingiberaceae in traditional medicine of the Kerinci tribe, Jambi, Indonesia. Int J Biol Res. 202313;8(2):5–7.

82. Andesmora E, Muhadiono M, Hilwan I. Ethnobotanical study of plants used by people in Hiang indigenous forest, Kerinci, Jambi. J Trop Life Sci. 2017;7(2):95–101. https://doi.org/10.11594/jtls.07.02.02

83. Affandi H, Nuryadin A, Prayogo SB. Medicinal herbs of Pasir Mayang, Jambi: ethnopharmacy and toxicity screening. Biotropia (Bogor). 2004;(22):40–58.

84. Has DH, Zuhud EAM, Hikmat A. Etnobotani obat pada masyarakat suku penguluh Di KPHP Limau Unit VII Hulu Sarolangun, Jambi. Media Konservasi. 2020;25(1):73–80. https://doi.org/10.29244/medkon.25.1.73-80

85. Noerjoedianto D, Kalsum U, Halim R, Ridwan M, Dhermawan Sitanggang H, Suryani Nasution H, et al. Identifikasi tanaman obat tradisional yang dipergunakan suku anak dalam desa dwi karya bakti, Kabupaten Bungo, Provinsi Jambi. J Ilm Ibnu Sina. 2024;9(1):198–208. https://doi.org/10.36387/jiis.v5i1.1818

86. Indriati G. Etnobotani tumbuhan obat yang digunakan suku anak dalam di desa tabun kecamatan VII Koto kabupaten tebo Jambi. J Sainstek. 2014;6(1):52–56.

87. Yelianti U, Mutiara Aswan D, Author C, Name A. Medicinal plant used by indigenous people, namely Suku Anak Dalam (SAD) in Nyogan village, Jambi Province. J Penelit Pendid IPA. 2023;9(2):277–80. https://doi.org/10.29303/jppipa.v9i2.1008

88. Adriadi A, Budilaksono T. Etnobotani tumbuhan obat pada masyarakat desa teluk rendah di kecamatan tebo Ilir kabupaten tebo. J Biotek. 2023;11(2):222–35. https://doi.org/10.24252/jb.v11i2.37242

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.