

Review: Phytochemical composition, biological activity, and health-promoting effects of *Avicennia* spp. (Avicenniaceae)

ARDITA RAHMANIA¹, ALYA ADYSTI REVALITHA¹, ABIZAN RAMADHAN TORIMBANU¹,
AMITA BELLA MUSTIKA¹, GILANG DWI NUGROHO², DARLINA MD NAIM³, AHMAD DWI SETYAWAN^{1,4,*}

¹Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, *email: volatileoils@gmail.com

²Biodiversity Study Club, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

³School of Biological Sciences, Universiti Sains Malaysia. 11800 Pulau Pinang, Malaysia

⁴Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

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Abstract. *Rahmania A, Revalitha AA, Mustika AB, Torimbanu AR, Nugroho GD, Md Naim D, Setyawan AD. 2025. Review: Phytochemical composition, biological activity, and health-promoting effects of Avicennia spp. (Avicenniaceae). Asian J Trop Biotechnol 22: 96-110.* Mangroves unique and valuable ecosystems, are groups of trees and shrubs that grow in coastal ecosystems exposed to tides. They play an important role in maintaining biodiversity and reducing the impact of coastal erosion. Mangroves are unique and valuable ecosystems because they provide coastal protection and carbon sequestration services. The genus *Avicennia* (Avicenniaceae) is a plant of mangrove consisting of eight species, namely *A. bicolor*, *A. germinans*, *A. marina*, *A. officinalis*, *A. schaueriana*, *A. balanophora*, *A. integra*, and *A. alba*, which are widely distributed in tropical and subtropical coastal areas. What sets *Avicennia* spp. apart is their remarkable adaptability to extreme environmental conditions, making them a key player in coastal ecosystems. Mangroves, especially *Avicennia* spp., have been known to contain many potentials and benefits. These plants are important for coastal ecosystems and have significant pharmacological potential. This study aims to identify and compile the phytochemical composition, biological activity, and health-promoting effect of *Avicennia* spp. There are 9 main phytochemical components: Alkaloids, terpenoids, steroids, phenolics, saponins, flavonoids, tannins, steroids, and glycosides. In addition, there are also several biological activity properties of *Avicennia* species, namely as antioxidants, anticancer, antimicrobial, anti-inflammatory, and antihyperglycemic. *Avicennia* spp. also offers traditional and modern treatments using various ingredients. By providing a comprehensive review of *Avicennia* spp., this study will provide a solid foundation for further research development, clinical application, and sustainable utilization and open up new opportunities in the field of natural material-based health.

Keywords: *Avicennia*, mangrove, medicine, pharmacology, phytochemicals

INTRODUCTION

Mangroves are groups of trees and shrubs that thrive in tidal coastal ecosystems characterized by soft, anaerobic mud (Song et al. 2022). These ecosystems dominate tropical and subtropical coastal areas worldwide, making them essential components of coastal regions (Tomlinson 2016; Nugroho et al. 2020). Mangrove forests rank among the world's most productive ecosystems, providing habitat for diverse flora and fauna while playing a critical role in biodiversity, coastal protection, and carbon sequestration (Romañach et al. 2018; Law et al. 2020; Irwansyah et al. 2021; Wiraatmaja et al. 2022; Dewi et al. 2023; Rohman et al. 2023). These unique ecosystems are vital in reducing wave impacts, preventing beach erosion, and maintaining biodiversity. Mangroves are highly resilient plants that survive extreme environmental conditions, including high salinity, fluctuating tides, elevated temperatures, strong winds, and anaerobic soils (Thatoi et al. 2016).

Mangrove ecosystems, which consist of woody vegetation found in intertidal and brackish marine environments, are essential coastal wetlands (Hamilton and Friess 2018).

Their preservation and restoration are critical due to their ability to capture and store substantial amounts of carbon, effectively offsetting anthropogenic greenhouse gas emissions (Murdiyarso et al. 2015; Howard et al. 2017; Kauffman et al. 2020; Nur et al. 2022). Additionally, mangroves possess a remarkable diversity of bioactive compounds. For instance, *Avicennia*, a true mangrove genus from the Acanthaceae family, is distributed globally across tropical and temperate coastal regions (da Silva Pontes et al. 2020). This genus has shown significant potential in the health sector, with applications as antimicrobial, antidiabetic, anticancer, and antioxidant agents (Sumarlin et al. 2014; Ridlo et al. 2017). Overall, mangroves play an indispensable role in maintaining environmental balance by serving as habitats for diverse species, protecting coastlines, naturally filtering pollutants, and storing carbon reserves. Their multifunctional nature underscores the importance of sustainable utilization and conservation efforts (Mukherjee et al. 2014; Kurniawati et al. 2022; Sujiwo and Nurlaili 2022).

The genus *Avicennia* contains eight species, but some of those previously reported are varieties or have evolved differently with respect to their morphological adaptations

relating to leaves and roots in different geographical locations (Thatoi et al. 2016). *Avicennia* are generally 10-25 m in height, and some reach up to 30 m in height. Leaves are simple, opposite, oval to pointed, have salt-secreting glands (Chan et al. 2022), and have short, low-branched stems. Among the frontier mangrove species is *Avicennia marina* (Forssk.) Vierh. It is one of the most widespread in tropical estuaries, inhabiting the outer zones of mangrove forests (Feher and Hester 2018). The eight species are distributed in two main water areas in the tropics: the Old World (Afro-Asia and Australasia) and the New World (Eastern Pacific and Caribbean). However, only four species are common in Indonesia (Halidah 2014). In the southeastern United States, there are three common native mangrove species: *Avicennia germinans* (L.) Stearn, *Rhizophora mangle* Roxb, and *Laguncularia racemosa* (L.) C.F.Gaertn (Snyder et al. 2022). These species can be found on coastlines, lagoons, and estuaries across multiple continents, including Southeast Asia, South Asia, East Asia, East Africa, South Africa, Madagascar, Northern Australia, Eastern Australia, North America, South America, the Caribbean Islands, and the Oceania Islands (POWO 2023). Currently, *Avicennia africana* Beauverd and *Avicennia nitida* Jacq. are considered synonyms of *A. germinans*. Meanwhile, *Avicennia lanata* (from India) and *Avicennia tonduzii* (from the Americas) are no longer considered valid species (POWO 2023/). The wide distribution of *Avicennia* spp. reflects its ecological tolerance and important role in coastal ecosystems (Singh et al. 2024). Mangrove forests dominated by *Avicennia* spp. provide a habitat for a wide variety of marine and terrestrial organisms and protect coast-lines from erosion and storm surges (Wang et al. 2023).

However, limited reviews are specifically discussed in-depth on *Avicennia* spp.. Therefore, a comprehensive review of *Avicennia* spp. is needed to identify and compile various studies related to its potential, especially in the medical field. Hopefully, the information presented in this study provides a solid foundation for further research, clinical applications, sustainable utilization, and new opportunities in natural material-based healthcare.

BOTANICAL DESCRIPTION AND DISTRIBUTION

Botanical description

Avicennia belongs to the Acanthaceae family. The genus *Avicennia* consists of eight species of mangrove plants (Lalitha et al. 2021), and it is the only genus of mangroves found worldwide. However, some previously reported species are now classified as varieties or have undergone distinct evolutionary changes in their morphological adaptations of leaves and roots due to variations in geographical locations.

The species of the genus *Avicennia* are *A. bicolor* Standl., *A. germinans*, *A. marina*, *A. alba* Blume, *A. officinalis* L., and *A. schaueriana* Stapf & Leechm. ex Moldenke., *A. balanophora* Staph & Moldenke and *A. integra* N.C.Duke. *Avicennia* represents the largest polymorphic genus of mangroves and is ecologically, systematically, morphologically,

and genetically different from other taxa (Sabdanawaty et al. 2021). *Avicennia* are generally 10-25 m tall, and some reach 30 m. The leaves are simple, opposite, oval to pointed in shape, have glands to secrete salt (Chan et al. 2022), and have short, low-branched stems. As a member of the Acanthaceae family, *Avicennia* is known as a mangrove tree widely distributed in tropical and subtropical regions worldwide. They are mainly in coastal ecosystems, providing protection against coastal erosion, habitat for various marine organisms, and effectively storing carbon in nutrient-rich mangrove soils. Genetic variation and environmental adaptations have led to significant variation in taxonomy and morphology among different *Avicennia* species.

Avicennia bicolor can grow up to 8-20 m with a dense, dark green crown. The flowers are identical to those of *A. germinans*, with hairy petals inside, but they are smaller in diameter (5-6 mm). The leaves are oval with tapered tips, varying from dark green to grayish brown. This species is often found in downstream tidal areas, where rivers meet the sea. Habitats include terrestrial, freshwater, and marine. This species has a high tolerance to hypersaline conditions.

Avicennia germinans is a mangrove species that lives on extensive coastlines (Lonard et al. 2017), also known as black mangrove (Pickens et al. 2022). This mangrove species has the northernmost distribution of all mangrove species in North America. It can grow up to 30-50 meters, and the leaf length is 3-15 cm and elliptical. Dookie et al. (2023) explained that *A. germinans* exhibit mesophyll characteristics and variation in leaf circumference, area, length, width, dry mass, wet mass, turgid mass, leaf-specific area, and relative water content across ecosystems. This species can grow in permanently flooded soil.

Avicennia marina is a medium-sized *Avicennia* species with a height ranging from 3-14 meters (Kandasamy et al. 2021), and it is the most widespread mangrove species in the world. This species has lance-shaped leaves with flat edges and a glossy surface. It can grow on soils with varying sand and clay proportions (Budiadi et al. 2022) at 0-50 m above sea level. *Avicennia marina* is known as white *api-api*. This species has small clusters of 3-5 yellow flowers, approximately one centimeter in diameter, and bears fruit with a single large, fleshy seed (Baishya et al. 2020). It also has a breath root, which is a branching root that grows at a regular distance vertically from a horizontal root that is immersed in the soil. The fruit is grain-shaped, like a mango. It forms shrubs or trees with a height of 12 to 20 meters.

Avicennia alba is a mangrove tree widely distributed in tropical and subtropical regions (Kar et al. 2015). This species, known as the white flame, is found on the coasts and estuaries of India, Southeast Asia, Australia, and Oceania. This species has 4 light yellow petals, 4 light green sepals, 4 broken anthers, and a stigma (Jeffry et al. 2024). It grows less than 20 meters tall and often develops under the trunk. The leaves are dark green and 15 cm long. *Avicennia alba* has been a pioneer species in the successional mangrove and is very effective in colonizing new intertidal areas. It shows the importance of *Avicennia* spp. in strengthening mangrove ecosystems, especially after geomorphological changes that cause mangrove

degradation and the establishment of potential new areas for mangrove colonization (Farshid et al. 2023).

Avicennia officinalis or ludic fire, a member of the Avicenniaceae family, is a mangrove tree commonly found in tidal forests of river estuaries along the coast of South Asia, including India, where it is one of the three prominent *Avicennia* species (Krishnamurthy et al. 2023). Native to Tropical Asia and extending to northern and eastern Australia, this species grows to a height of 12-18 meters and is characterized by spoon-shaped leaves with shiny green upper surfaces (Thatoi et al. 2016). Its flowers, the largest among the genus, are orange-yellow, round, and 1 cm in diameter, while the fruits are 2-3 cm long, oval, slightly beaked, smooth, and velvety, each containing a single seed that fills the capsule (Thatoi et al. 2016).

Avicennia schaueriana grows as a tree reaching 10 to 20 meters in height. The trunk is gray to brown. The fruits are pale sap green, rarely with a purple tinge, and flatter and more pointed than *A. germinans*. The roots of this species develop well in mud soils and brackish water, which help stabilize the soil and protect the coast from erosion. It grows in coastal and estuarine locations (POWO 2023).

Avicennia balanophora is native to Queensland and Australia and usually grows in coastal and estuarine locations. It is generally of modest length. The main root of this species can reach about 1 meter in length. These mangroves have aerial pencil roots and are often found in the intertidal zone of estuarial areas (Thatoi et al. 2016). This species is known for its ability to survive in wet environments and is often a habitat for various marine animals (Aluri 2022).

Avicennia integra is a mangrove tree species that grows in coastal areas and estuaries. It can grow up to 30 meters tall (Thatoi et al. 2016). The leaves of this species have distinctive characteristics, such as salt glands on their lower surface that produce white visible salt crystals (Li et al. 2016). These leaves are usually stalked, opposite, flat-edged, and with poorly defined veins (Thatoi et al. 2016).

Distribution and habitat

Mangroves are intertidal ecosystems or groups of plants that are widely adapted and live in coastal environments

(Giri et al. 2014). Mangroves are important in natural disaster mitigation, protecting the coast from storms, waves, and soil erosion (Marlianingrum et al. 2021). Thriving mangrove forests shield coastal ecosystems from natural disasters and are better at carbon sequestration than other forest types (Sahana et al. 2022). Although mangrove forests hold significant social, ecological, and economic value in coastal ecosystems, a limited understanding of their sensitivity has contributed to their degradation (Sobhani and Danekkar 2023).

The distribution of *Avicennia* species extends from Africa to Asia, Australia, and the Americas, with certain species adapted to local environmental conditions. *Avicennia* species typically dominate the coastal edge of mangrove forests, forming dense forests characterized by their distinctive aerial roots, known as pneumatophores, which help facilitate gas exchange in waterlogged soil. In some locations, mangroves are found on oceanic (freshwater) islands (Crameri and Ellison 2022) and in arid areas where freshwater only originates from groundwater (Adame et al. 2021). Mangrove habitats are dynamic because they depend on the hydrological regime of tides, waves, and continental waters. Mangroves have good ecological resilience because they thrive under harsh conditions, including high salinity, extreme tides, strong winds, high temperatures, and muddy and anaerobic soils (Ribeiro et al. 2019; Ellison et al. 2020). Moteriy et al. (2015) reported that mangroves that grow in coastal wetlands have unique adaptations to changes in salinity, temperature, nutrients, and excessive radiation (Rozirwan et al. 2021).

Avicennia spp. has a varied distribution in tropical and subtropical regions of North and South America, including Colombia, Costa Rica, Mexico; Panama, Brazil, and Chile; the African coast; the Middle East; South and Southeast Asia, which includes the Coasts of India, Bangladesh, Malaysia, Vietnam, Thailand, Indonesia; and the coasts of TransAsian countries of Australia and New Zealand (Figure 1). *Avicennia marina* is the most widely distributed mangrove species in the Western Indo-Pacific Region (EIDohaji et al. 2020). This species may be the only species with highly evolved morphological, biological, ecological, and physiological adaptations to various environmental conditions (Das et al. 2016).



Figure 1. Distribution of *Avicennia* spp. Note: The higher intensity of the orange color indicates that, at that point, the presence of the species is higher and dense (source: gbif.org)

Table 1. Summary on *Avicennia* distribution, phytochemistry, bioactivity, and medical utilization

Species name	Distribution	Phytochemistry	Bioactivity	Medical utilization	
				Traditional	Modern
<i>Avicennia bicolor</i>	Pacific coast of Central and South America (endemic) Central America: Mexico (southern), Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama. South America: Colombia, Ecuador, Peru.	Flavonoids: Quercetin, kaempferol (antioxidant, antimicrobial). Triterpenoids/Steroids: Lupeol, β -sitosterol, taraxerol (anti-inflammatory). Saponins/Tannins: Defense against pathogens/herbivores. Naphthoquinones: Avicennin (roots/bark). Trace alkaloids: similar to other <i>Avicennia</i> spp.	Antimicrobial (leaf extracts against Gram-positive bacteria) Antioxidant (phenolic compounds in bark) Traditional wound healing (Central American folk medicine)	Used in Central America for wound healing (bark poultice) Leaf extracts applied to skin infections	Antimicrobial creams: leaf extracts for skin infections Wound dressings: bark tannins for healing acceleration
<i>A. germinans</i>	Americas: USA (Florida, Louisiana), Mexico, Belize, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Guyana, Suriname, French Guiana, Brazil, Ecuador, Peru. Africa: Senegal, Mauritania, Gambia, Guinea-Bissau, Sierra Leone, Liberia, Nigeria, Cameroon, Gabon, Angola. Caribbean: Cuba, Jamaica, Dominican Republic, Puerto Rico, Bahamas.	Iridoids: Aucubin (leaves) (unique) Triterpenes: Lupeol, betulinic acid (bark/roots) Flavonoids: Vitexin (leaves), luteolin-7-O-glucoside (bark) Tannins: Proanthocyanidins (bark) (highest concentration in genus)	Anticancer (betulinic acid from bark against tumor cells) Antileishmanial (unique among <i>Avicennia</i> species) Antimalarial (leaf extracts) Salt-tolerance (phenolic acids in leaves)	Antimalarial (leaf decoctions in West Africa) Treatment of leprosy (bark extracts in Caribbean) Snakebite remedy (root preparations in South America)	Anticancer drugs: betulinic acid in clinical trials for melanoma Antileishmanial: bark extracts against parasitic diseases Antimalarial research: iridoids as lead compounds
<i>A. marina</i>	Asia: India, Bangladesh, Myanmar, Thailand, Vietnam, Malaysia, Indonesia, Philippines, China (Hainan), Taiwan, Japan (Ryukyu Is.), Pakistan, Iran, Oman, UAE, Saudi Arabia, Yemen. Africa: Egypt (Red Sea), Sudan, Eritrea, Somalia, Kenya, Tanzania, Mozambique, South Africa, Madagascar. Australia & Pacific: Australia (all coastal states), New Zealand (northern), Papua New Guinea, Fiji. Middle East: Israel, Jordan, Qatar, Kuwait.	Naphthoquinones: Avicequinone-C (roots) (salt tolerance) Limonoids: Marinoids (leaves) (species-specific) Flavonoids: Quercetin-3-O-glucoside (leaves/bark)	Antimicrobial (avicequinone-C against marine pathogens) Antioxidant (highest in leaves among mangroves) UV-protection (leaf flavonoids) Diabetes management (bark extracts show α -glucosidase inhibition)	Diabetes management (bark tea in India/Middle East) Rheumatism treatment (leaf poultice in East Africa) Antidiarrheal (fruit preparations in Southeast Asia)	Diabetes supplements: bark extracts for α -glucosidase inhibition UV-protective cosmetics: leaf flavonoids in sunscreens Antioxidant nutraceuticals: standardized phenolic extracts

<i>A. alba</i>	Asia: India, Bangladesh, Myanmar, Thailand, Malaysia, Singapore, Indonesia, Vietnam, Cambodia, Philippines, China (Hainan), Sri Lanka. Australia: Northern Territory (rare).	Flavonoids: Kaempferol derivatives (fruits), albaflavonoid (leaves) (antiviral) Diterpenes: Alba-diterpene A (bark)	Antiviral (leaf flavonoids against HSV) Mosquito larvicidal (bark compounds) Cytotoxic (fruit extracts on cancer cells)	Not recorded	Antiviral research: leaf flavonoids against HSV-1/HSV-2 Larvicidal products: mosquito control formulations
<i>A. officinalis</i>	Asia: India, Sri Lanka, Bangladesh, Myanmar, Thailand, Malaysia, Indonesia, Vietnam, Philippines, China (Guangdong, Hainan), Taiwan. Australia: Northern coasts (rare).	Naphthoquinones: Lapachol (fruits) (antitumor) Phenolics: Gallic acid (bark) (highest antioxidant activity)	Hepatoprotective (fruit extracts) Antitumor (lapachol from fruits) Radioprotective (leaf phenolics) Anti-ulcer (bark extracts)	Hepatitis treatment (fruit extracts in India) Ulcer remedy (bark paste in Myanmar) Fever reduction (leaf infusions in Thailand)	Hepatoprotective drugs: fruit-derived lapachol in liver therapies Radioprotective agents: for chemotherapy support Antitumor research: naphthoquinones in preclinical studies
<i>A. schaueriana</i>	South America: Brazil, Venezuela, Guyana, Suriname, French Guiana, Colombia (Caribbean coast).	Flavonoids: Vitexin (leaves) (cardioprotective) Triterpenes: Taraxerol (bark) (wound healing)	Cardioprotective (vitexin from leaves) Wound healing (bark taraxerol) Anti-inflammatory (leaf extracts)	Not recorded	Cardioprotective research: vitexin for ischemic injury
<i>A. balanophora</i>	Northern Australia (endemic): Queensland, Northern Territory.	Triterpenes: Balanophorin (leaves) (Australia-endemic)	Antimicrobial (unique leaf triterpenes) Antioxidant (phenolic content)	Not recorded	Not recorded
<i>A. integra</i>	Northern Australia (endemic): Northern Territory, Western Australia	Triterpenes: Integrins (bark) (unique pentacyclic compounds)	UV-protection (high leaf phenolics) Antimicrobial (bark integrins) Nematocidal (root compounds)	Not recorded	Not recorded

Note: Distribution: Ellison et al. (1999), Giesen et al. (2007), Spalding et al. (2010), Giri et al. (2011), Tomlinson (2016), Duke (2017); Phytochemistry: Bandaranayake (2002), Wu et al. (2008), Sadeer and Mahomoodally (2022), Govindhan (2024); Bioactivity: Patra et al. (2011), Assaw et al. (2018), Fauzi et al. (2021), Ibrahim et al. (2022), Rajivgandhi et al. (2024), Ghosh et al. (2025); Traditional Medical Utilization: Bandaranayake (1998), Kathiresan and Bingham (2001), Abeyasinghe et al. (2009), Sura et al. (2011), Mazumder et al. (2016); Modern Medical Utilization: Esau et al. (2015), Das et al. (2016), Sivakumar et al. (2018), Ahmed et al. (2022, 2024), Rashno et al. (2022).

Avicennia germinans species are found along the coastlines of North and South America, including the coastlines of Angola, Jamaica, Liberia, Mauritania, Mexico, Antigua and Barbuda. In addition, this species is widespread on the coastline of Africa, including Congo, Ghana, and Nigeria (Thatoi et al. 2016). *Avicennia bicolor* is widespread along the coastlines of Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama (Mori et al. 2015). Meanwhile, *A. officinalis* species is rarely found on the coast of South and Southeast Asia and is limited to Bangladesh, Brunei, Cambodia, India, Indonesia, Malaysia, Myanmar, Papua New Guinea, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam. *Avicennia schaueriana* species can be found widely distributed in North and South American coastlines, including Anguilla, Antigua and Barbuda, Brazil, Dominica, Trinidad and Tobago, and Venezuela (Thatoi et al. 2016).

Avicennia marina grows along the coast of East Africa and Madagascar to India, Indo-China, South China, Taiwan, Thailand, all of Malesia, Solomon Islands, New Caledonia, Australia and northern New Zealand, in South and Southeast Asia, including Singapore, Vietnam, Middle East, African coastline including Egypt, Madagascar, Mozambique, South Africa, Tanzania (Thatoi et al. 2016). This species is the most dominant mangrove species and the primary coastal vegetation found along the shores of the Arabian Gulf in the UAE, Saudi Arabia, Bahrain, Qatar, and Iran (El-Tarabily et al. 2021). Although the plant is mainly distributed through the tropics, it is also distributed in temperate regions, including Southwest Asia, along the coast of the Arabian Gulf. The eastern and western coasts of the Red Sea. *Avicennia marina* is the most extensive in distribution due to its adaptability to a wide range of environmental conditions (Baba et al. 2016).

Avicennia balanophora and *A. integra* have a restricted distribution on the Australian coastline. In this region, *Avicennia* species grow on pristine flats and densely packed mudflats along the coast, in brackish coastal swamps, and on riverbanks (Thatoi et al. 2016). *Avicennia alba* is mainly found in the east coast region of India, the Pacific Ocean Islands, and Australia (Singh et al. 2024). It usually grows in tidal areas along rivers and dirt parts of the coast. *Avicennia balanophora* is widely distributed in Southeast Asia and Australia, often growing in wet and soggy coastal regions. Meanwhile, *A. integra* is also found throughout Southeast Asia and Australia, usually growing in damp and water-affected coastal areas (Singh et al. 2024).

PHYTOCHEMICAL COMPOSITION

Plants have primary and secondary metabolites that can be used for medicine and other purposes. Phytochemicals, also known as phytonutrients, are chemical compounds produced by plants through primary or secondary metabolism (Roy and Datta 2019). In the search for new and natural medicines, marine plants, particularly mangroves, are an alternative source of health-essential

chemicals (Yang et al. 2014). Many reports have documented that the genus *Avicennia* spp. possess several unique metabolites of varied chemical classes, which may be responsible for their various pharmacological activities (Khan and Mubarak 2015). There are 9 major phytochemical components: alkaloids, terpenoids, steroids, phenolics, saponins, flavonoids, tannins, steroids, and glycosides. Studies on phytochemicals have revealed that most *Avicennia* spp. are rich in terpenoids, glucosides, and naphthalene derivatives (Sotheeswaran and Phomphalee 2016).

Figure 2 shows the reaction of flavonol reduction using magnesium (Mg) and hydrochloric acid (HCl). The initial flavonols are reduced by Mg in an acidic medium, producing positively charged flavonol ions (carbocations) with Cl⁻ as the ion partner. These positively charged ions then undergo rearrangement to form a more stable structure. Finally, the reaction produces a reduced compound with a change in the carbonyl group (C=O) and stabilization by the Cl⁻ ion. Studies often use this reaction to modify flavonoids chemical or biological properties. These natural compounds are concentrated in plants leaves, stems/bark, and aerial roots.

In the research conducted by Das et al. (2018), qualitative and quantitative phytochemical analysis of Ethanol Leaf (EL) and Stem Bark (EB) extracts from *A. officinalis* identified various phytochemical compounds responsible for their bioactivity. It showed that EL and EB extracts of *A. officinalis* effectively inhibit α-amylase and α-glucosidase enzymes and have antioxidant, antimicrobial, and cytotoxic potential (Das et al. 2018).

The extract of *A. alba* demonstrates activity against one specific bacterium, *Erwinia herbicola*, but not against the other tested bacteria (Witoyo and Utoro 2023). This lack of effectiveness may be attributed to bacterial resistance mechanisms, such as enzymatic degradation, modification of the target site, or reduced intracellular accumulation of the drug. Additionally, the extract concentration may have been insufficient to provide an adequate amount of the active ingredient (Wulandari et al. 2022). *Avicennia alba* extract is only effective against *E. herbicola*, with a MIC value of 400 µg/mL. The difference in sensitivity may be due to qualitative differences in the existing phytochemicals and the concentration of active ingredients in different plant extracts (Das 2020; Das and Das 2020).

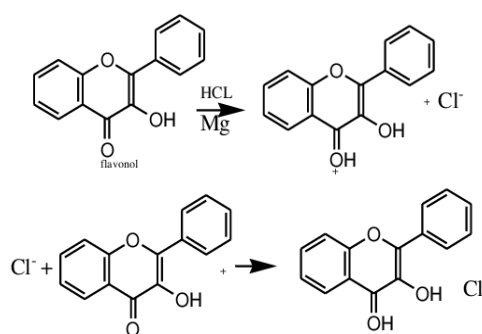


Figure 2. Flavonoid chemical compounds in *Avicennia* spp. species

Nguyen et al. (2022) reported that *A. officinalis* leaf extracts (methanol, ethanol, ethyl acetate, acetone, dichloromethane, and chloroform) revealed an increase in yield with increasing solvent polarity, and the extract with the highest Total Phenolic Content (TPC), Total Flavonoid Content (TFC), and antioxidant activity (measured using DPPH and ABTS assays) was acetone extract. Thus, acetone is an optimal solvent for extracting polyphenols from *A. officinalis* (Nguyen et al. 2022).

Avicennia marina is rich in flavonoids, carbohydrates, alkaloids, glycosides, phenols, proteins, reducing sugars, and cardiac glycosides (Moghal et al. 2016). Phytochemical analysis of different species of *Avicennia* showed the presence of similar bioactive compounds, although there were variations between different species. Species such as *A. marina*, *A. alba*, and *A. officinalis* contain major phytochemical compounds such as alkaloids, flavonoids, tannins, saponins, and glycase. The difference in the concentration of these compounds can be attributed to the ecological adaptations and the specific growth environment. For example, *A. marina* showcases higher tannins and flavonoids than *A. alba* and *A. officinalis*, potentially linked to its defensive role against pathogens and herbivores. *Avicennia alba*, on the other hand, boasts a more diverse range of flavonoids, suggesting its adaptation to a broader range of environmental conditions. Then, the presence of saponins in all three species underscores their potential in biomedical applications. Saponins are renowned for their diverse biological activities, including anti-inflammatory and antimicrobial properties. Despite their specific differences, the shared phytochemical composition among *Avicennia* species underscores the need for further research to isolate and characterize these compounds. This will enable us to evaluate their pharmacological potential and health applications, a crucial step in understanding their potential benefits to human health.

The first chemical investigation of the genus *Avicennia* dates back to 1913, when Bournot isolated lapachol, a compound with antitumor activity, from *A. officinalis* growing in West Africa and India (Thatoi et al. 2016). Further research has led to the chemical profile of *A. officinalis* showing the presence of a broad class of bioactive compounds such as terpenoids, steroids, alkaloids, flavonoids, polyphenols, phenolic acids, saponins, and tannins (Mehta et al. 2021).

BIOLOGICAL ACTIVITY

Medicinal plants, such as mangrove plants, are important in maintaining public health. Different parts of various *Avicennia* species are used in traditional medicine by indigenous communities in mangrove forests to treat several illnesses (Beniwal et al. 2024). Chemical substances in different compositions in medicinal plants provide curative properties (Kirom and Ramadhania 2017). Curative properties refer to the ability of an action, substance, or method to cure or treat a particular disease or health condition. In the medical context, curative properties are usually associated

with treatment or therapy that aims to eliminate the main cause of a disease so that it can provide a complete cure to the patient. Still, palliative care focuses more on reducing symptoms and improving the quality of life without necessarily curing the underlying disease. One of the mangrove species that has been widely studied is *Avicennia*.

Biological activities in *Avicennia* species have very complex roles and functions. *Avicennia officinalis* has many beneficial pharmacological properties, such as anticancer, antibacterial, analgesic, anti-inflammatory, antitumor, and antiviral (Islam et al. 2022). The fruit, leaves, and roots of *A. officinalis* were used to cure hepatitis, while the bark of the stem was used as an antitumor (Erwin et al. 2019).

The leaves of *A. marina* are widely used for traditional medicine due to their proven pharmacological activities, including antioxidant, antimicrobial, and anticancer properties (Huang et al. 2016; Ananthavalli and Karpagam 2017; Iranawati et al. 2018; Andriani et al. 2021; Sohaib et al. 2022; Yassien et al. 2021; Witoyo and Utoro 2023; Annas et al. 2023). Similarly, *A. officinalis* demonstrates significant pharmacological potential and is traditionally utilized for treating hepatitis through its fruits, leaves, and roots. Both *A. officinalis* and *A. marina* show immense promise in developing plant-based therapies for various health conditions, with *A. marina* being particularly notable for its potent leaf extracts. Meanwhile, *A. marina* and *A. officinalis* show the widest range of validated biological activities. *A. germinans* has unique antiparasitic properties (Bandaranayake 2002; Fauzi et al. (2021).

Antioxidants

Antioxidants are compounds that prevent and repair the damage of cells in the body. Antioxidants are chemical compounds that can provide one or more electrons to scavenge free radicals (Binuni et al. 2020). Antioxidants help neutralize free radicals and protect against diseases like cancer, diabetes, and stroke (Lalitha et al. 2021). *Avicennia officinalis* is significant in managing complications caused by oxidative stress. Its antioxidant potential has been demonstrated through in vitro and in vivo methods. Das et al. (2018) identified antioxidants in *A. officinalis* leaf extract at a 150 µg/mL concentration. Khushi et al. (2016) reported that phenolic components contribute to the plant's high antioxidant activity.

Avicennia marina, a well-known mangrove species, has high polyphenol content in ethanol extract and the potential to reduce oxidative stress in diabetic rats, which plays a significant role in antioxidant potential (Al-Jaghtmi et al. 2020), as indicated by decreased lipid peroxide levels in liver tissue (Al-Jaghtmi et al. 2020). Bioactive compounds like flavonoids and steroids also exhibit antioxidant potential (Alara et al. 2019). Like other mangrove plants, *A. germinans* contain many antioxidants, such as vitamins C and E, which protect the body's cells. The antioxidant content in *A. germinans* varies based on environmental conditions and serves as a natural raw material for health products. Additionally, *A. germinans* can absorb toxins, particularly heavy metals (Halidah 2014). *Avicennia alba*

also exhibits antioxidant activity due to its phenolic compounds, which play a crucial role in maintaining the health of biological systems (Wulandari et al. 2015).

Antimicrobial

Pathogenic bacteria and viruses are harmful microorganisms that cause infections and death (Janik et al. 2020). Antimicrobials are substances that can prevent or kill the growth of microbes and have little toxicity to humans (Cheng et al. 2016). Various studies have been conducted to explore the antimicrobial potential of mangrove plants. The leaf and bark extracts of *A. officinalis* possess a broad spectrum of antimicrobial activity (Das et al. 2018) due to diterpene excoecarin A (Sulaiman et al. 2022). In addition, other species of *Avicennia* have also shown promising antimicrobial potential.

Avicennia marina exhibits antimicrobial activity against seven marine pathogenic bacteria (Manilal et al. 2016). The ethanol extract of *A. marina* root had antibacterial activity against *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* and the chloroform root extract showed antibacterial activity against *E. coli*, *P. aeruginosa*, and *S. aureus*. In addition, *A. marina* leaf extract also showed antibacterial activity against *S. aureus* and *E. coli* (Okla et al. 2021; Yassien et al. 2021). *Avicennia marina* extract significantly affects *E. coli* bacteria due to antimicrobial compounds such as steroids and triterpenoids (Renaldi et al. 2018) in the bark of stems, leaves, flowers, and fruits. Triterpenoid compounds are secondary metabolite compounds that are effective as antimicrobials. Iswadi et al. (2015) found that *A. marina* leaves are effective as antibacterial agents due to their polar compounds, which can inhibit bacterial growth. These polar compounds typically include flavonoids, tannins, saponins, alkaloids, and phenols.

A study by Kar et al. (2015) suggested that methanol and chloroform extracts of *A. alba* were active against *Streptococcus mutans*, *Lactobacillus acidophilus*, *Rhizoctonia solani*, *Pseudomonas marginalis*, *Erwinia carotovora*, and *Acremonium strictum*. Research by Erwin et al. (2019) shows that *A. alba* extract can inhibit the growth of *Vibrio harveyi* and *Vibrio* sp. (MC3P5). Then, *A. germinans* inhibits the growth of pathogenic microorganisms and possess anticancer due to flavonoids, polyphenols, and triterpenoids content.

Antihyperglycemic

The antihyperglycemic compound lowers blood glucose (Mujianti and Sukmawati 2018). *Avicennia marina* contains flavonoids, tannins, and phenols, contributing to its antidiabetic properties or antihyperglycemic effects, and can stimulate cellular activity (Aljaghthmi et al. 2017; Cerri et al. 2022). The flavonoids, tannins, and phenols in *A. marina* possess antidiabetic and antihyperglycemic effects through several interrelated mechanisms. These compounds inhibit the enzyme alpha-glucosidase in the intestines, slowing glucose absorption and reducing post-meal blood sugar spikes. They also increase the sensitivity of cells to insulin, aiding in more efficient glucose

absorption from the bloodstream. The antioxidant properties protect the beta cells of the pancreas from oxidative damage, helping to maintain adequate insulin production. Tannins can form a protective layer in the intestines, further inhibiting glucose absorption.

Flavonoids, in addition to their insulin-stimulating properties, play a significant role in reducing inflammation and oxidative stress associated with insulin resistance. This dual action provides a reassuring prospect for the potential of flavonoids in diabetes management. By combining these effects - inhibiting glucose absorption, improving insulin sensitivity, protecting insulin-producing cells, and reducing insulin resistance - the flavonoids, tannins, and phenols in *A. marina* work synergistically to lower and control blood sugar levels, providing significant antihyperglycemic effects in diabetes management.

Avicennia alba possessed the antihyperglycemic activity (Biswas et al. 2018). Hyperglycemia worsens insulin resistance and interferes with secretion. The antihyperglycemic activity includes free radical antidote activity, increased insulin release, insulin-mimicking activity, and changes in glucose utilization (Biswas et al. 2018), which affect diabetic patients by reducing hepatic glucose output and increasing glucose absorption by skeletal muscles. Free radical antidotes can block reactive atoms or molecules in the human body so that they can trigger various diseases (Widiawati and Asih 2015).

Anticancer

Avicennia marina has the anticancer potential without any adverse effects (Behbahani et al. 2018; Tian et al. 2020). This species contains Hymecromone as an anticancer by inhibiting the synthesis of hyaluronic acid. Hymecromone is a dietary supplement that is not toxic, even in high doses. Bioactive substances with anticancer properties have been found in the ethanol and ethyl acetate extracts of *A. marina* leaves (Afshar et al. 2022). In addition to its anticancer effects, *A. marina* phytoconstituents exhibit antibacterial and antioxidant qualities. *Avicennia marina* also contains ursolic acid, oleanolic acid, and lupeol, which are pentacyclic triterpenoids. Then, *A. marina* leaf extract can lower serum urea to protect tissues such as the pancreas, liver, and kidneys. Research by Qurrohman et al. (2020) shows that *A. marina* leaf extract inhibits cancer cells due to the presence of anticancer compounds in the form of polyisoprenoids.

Eswaraiah et al. (2020) reported that the leaf extract of *A. alba* exhibits anticancer activity in the methanol extract. In the methanol extract, phenolic compounds can inhibit the growth of lung cancer cells. Cytochrome c in methanol extracts can trigger programmed cell death (apoptosis) in cancer cells by activating cell death signaling pathways, such as cytochrome c release from mitochondria and caspase activation (Do et al. 2020). In addition, the extract may contain compounds that inhibit the cancer cell cycle, preventing uncontrolled cell division by inhibiting key enzymes in the cell cycle or growth factors. The compounds in the extract may also have powerful antioxidant properties that protect normal cells from DNA damage while

interfering with the growth of cancer cells that depend on certain levels of oxidative stress. In addition, some compounds may be able to inhibit the formation of new blood vessels that tumors need to grow and metastasize, as well as alter cell signaling pathways that are important for cancer cell growth and survival, such as the PI3K/AKT or MAPK pathways. The anticancer effects of *A. alba* include reducing chronic inflammation that is often associated with cancer progression and inhibiting cancer cell migration as well as invasion into different tissues. Some types of bioactive compounds that are commonly found include alkaloids, which are nitrogen-containing compounds with strong pharmacological activity, namely terpenoids, a large group of natural compounds consisting of isoprene units, some of which show anticancer activity, namely flavonoids. These polyphenol compounds that are known to have antioxidant and anticancer properties are steroids, organic compounds with a distinctive ring structure, some of which show antitumor activity, namely peptides, short chains of amino acids with a wide range of biological activities including anticancer, i.e., quinone, a compound that often exhibits cytotoxic activity against cancer cells, as well as phenols and polyphenols, compounds with one or more hydroxyl groups bound to an aromatic ring that frequently have antioxidant and anticancer properties *A. germinans* contained naphthoquinone which has anticancer potential (Angio et al. 2022).

Anti-inflammatory

Avicennia has anti-inflammatory activity, in which inflammation could be caused by various stimuli such as pathogens or physical trauma through immunological responses (Rossi et al. 2021). Extracts from *A. officinalis* inhibit inflammatory mediators such as prostaglandins and cytokines and reduce inflammation (Borges et al. 2019). The sap of the stem in *A. marina* contains flavonoids that inhibit the activity of cyclooxygenase enzymes and lipoxygenase (Priamsarfi and Bima 2021). The flavonoid content in the leaf extract of *A. alba* plays a role in the anti-inflammatory process in two ways: by inhibiting capillary permeability and the anti-inflammatory mechanism of saponins (Wulandari et al. 2015). The anti-inflammatory activity of flavonoids limits the number of inflammatory cells that transform in the affected area so that they do not cause excessive tissue damage. *Avicennia lanata* Ridl. contains some polyisoprenoid compounds that can also be used as an anti-inflammatory (Pronin et al. 2014).

HEALTH-PROMOTING EFFECT

Traditional medicine

Medicinal plants have been used in traditional medicine (Dey et al. 2021) for thousands of years (Rakotoarivelo et al. 2015). The knowledge of using plants to treat diseases has been passed down from generation to generation. Mangrove plants, for instance, have long been utilized in traditional medicine for various ailments. These include asthma, arthritis, rheumatism, inflammation, and diabetes. It suggests mangrove plants have significant potential and

functions in everyday medicine (Habib et al. 2018; Alimbon and Manseguiao 2021).

The genus *Avicennia* is one type of mangrove plant that is known to have extensive and effective ethnomedical applications for various health conditions, such as use as an astringent, aphrodisiac, diuretic, and contraceptive, as well as in the treatment of asthma, cancer, antiulcer, rheumatism, malaria, bronchial ulcers, diarrhea, HIV, hepatitis, gastric ulcers, antitumor, anti-inflammatory, diabetes, smallpox, skin diseases, oxidative stress diseases, snakebite treatment, leprosy, toothache, and ulcers (Lalitha et al. 2021). *A. marina* and *A. officinalis* have the most extensive traditional applications (Bandaranayake 2002; Kathiresan and Bingham 2001; Fauzi et al. (2021).

According to Ahmed et al. (2022), *Avicennia germinans* (identified as *A. africana*) is an important ethnomedical plant that has long been used to treat various diseases, i.e., rheumatism, smallpox, asthma, ulcers, malaria, ringworm, gangrene wounds, and mouth ulcers. Many traditional societies use it as a remedy for several reasons, such as ease of access and hereditary beliefs. The wood in *A. germinans* has also been used as a supplement to the traditional oil (Genilar et al. 2021), with diverse benefits from different parts of this plant.

Avicennia germinans is traditionally used to treat rheumatic diseases, sore throats, and anti-inflammation (Glasesnapp et al. 2019). Leaf and twig extracts have cytotoxic effects against human cancer cell lines (Lonard et al. 2017). Its therapeutic potential of *A. germinans* could be used in both traditional and modern medicine. *A. germinans* (identified as *A. nitida*) has been traditionally used to treat various diseases, including cancer (Singh and Kathiresan 2015). Its bark or stem treats canker sores or oral infections (Thatoi et al. 2016) and accelerates wound healing in the oral cavity. This species remains a valuable resource in traditional healthcare practices.

Avicennia marina is known for its strong antibacterial properties, particularly in treating skin diseases caused by bacteria, such as ulcers and abscesses (EIDohaji et al. 2020). It also protects against fungal skin infections and other systems (EIDohaji et al. 2020) and antifertility drugs for family planning and reproductive health (Erwin et al. 2019). It highlights the versatility of *A. marina* as a medicinal source.

Avicennia alba is often traditionally used by coastal communities and has demonstrated strong antibacterial potential and antifungal activity (Purba et al. 2022). Its resin is used to treat ulcers and is a contraceptive in traditional medicine (Thatoi et al. 2016).

Avicennia officinalis is widely recognized in traditional medicine (Prakashamani et al. 2019) and is effective as an antibacterial and is utilized for the treatment of ulcers and abscesses, where raw seeds are applied to wounds to accelerate healing (Khushi et al. 2016; Prakashamani et al. 2019). The resin from the bark is used as a contraceptive in traditional practices (Das et al. 2018), and the decoction with added sugar and cumin is used to treat indigestion (Prakashamani et al. 2019). This species is also used to treat rheumatism, bronchial asthma, hepatitis, leprosy, gastric protection, aphrodisiac properties, antiulcer,

diuretic, and astringent (Prakashmani et al. 2019). These multifaceted benefits make *A. officinalis* a critical species in traditional medicine.

Modern medicine

Until now, medicinal plants continue to offer great benefits, both in terms of therapeutics in traditional medicine and in developing safer and more effective modern medicines (Aljaghtmi et al. 2017). The use of medicinal plants in modern medicine has been implemented through various widely disseminated programs. This enables the modern era to better experience the benefits of traditional medicinal plants (Dwisatyadini 2017). According to Sumayyah and Salsabila (2017), various factors contribute to the growing use of herbal medicines globally, particularly in developed countries, including a longer life expectancy. Additionally, increasing access to information on herbal medicine strengthens public trust in the effectiveness and benefits of medicinal plants. Besides, modern drugs, such as cancer treatments, often face challenges like side effects and failures (Sumayyah and Salsabila 2017). Mangrove plants have become one of the traditional medicinal plants increasingly utilized in modern medicine (Saranraj and Sujitha 2015; Sasidhar 2020). The diversity of mangrove plant species offers significant opportunities to search for medicinal uses. Different types of mangroves provide the potential to develop treatments for numerous diseases, including anticancer, antibacterial, antifungal, antiviral, antidiabetic, and immune system boosters (Erwin et al. 2019). The two most widely developed species are: *A. marina* (diabetic/cosmetic) and *A. germinans* (anticancer/antiparasitic) (Bibi et al. 2019; Oliveira et al. 2020).

Recent research conducted by Ahmed et al. (2024) showed that *A. germinans* (identified as *A. africana*) leaf extract has been proven to have potential as a malaria drug. Research conducted by Dossou-Yovo et al. (2017) states that the leaves and roots of *A. germinans* are used to treat malaria. This species leaves and roots are used as an antimalaria due to the active compounds that effectively fight malaria parasites (Dossou-Yovo et al. 2017).

Previous research by Ahmed et al. (2022) showed that *A. germinans* contains various compounds, such as glycosides, terpenoids, alkaloids, phytosterols, flavonoids, tannins, and saponins. Therefore, *A. germinans* has an antimalarial activity that is effective in laboratory tests (in vitro) and living organisms (in vivo), thus supporting its utilization in the traditional treatment of malaria. The disease is spread through the bite of the *Anopheles* mosquito. In addition to mosquitoes, malaria can also be transmitted through blood transfusions and using syringes alternately (Yohannes et al. 2020). Malaria today remains a crucial disease for global health, with 3.3 billion people in 97 countries at risk, causing about 200 million cases and about 600,000 deaths each year (Cowman et al. 2016). So, malaria treatment has become a concern, and further research needs to be conducted.

Avicennia marina can cure skin diseases (Vinoth et al. 2019). The leaves are used for ulcers, abscesses, rheumatism, burns (Bibi et al. 2019), and digestive problems such as

constipation. The fruit has aphrodisiacs, diuretics, and hepatitis activity. The stem bark is used to treat leprosy (Erwin et al. 2019). This species leaves have strong antioxidant activity, prevent and interfere with the formation of biofilms, which can exacerbate microbial infections and cause serious problems on various surfaces (Ibrahim et al. 2022). Mitra et al. (2023) research shows that *A. marina* has significant anticancer activity. A study conducted by Huang et al. (2016) showed that *A. marina* can inhibit liver and breast cancer cell lines. Breast cancer itself is the most common type of cancer in women worldwide, accounting for 25.4% of the total new cases diagnosed in 2018 (Prahartiwi and Dari 2021). This shows that the *A. marina* is significantly needed in modern medicine.

In the recent Indian medical system, *A. alba* is used extensively for a variety of health conditions, including as an aphrodisiac, treatment of skin diseases, asthma, rheumatism, scabies, antifertility agents, paralysis, snake bites, and ulcers, demonstrating the diversity of its therapeutic applications (Das 2020; Das and Das 2020). Its crude extract is effective against polymicrobial diseases, showing the potential to fight infections caused by various pathogenic microorganisms (Kar et al. 2015). Extracts from the leaves and bark of *A. alba* stems can inhibit the growth of pathogenic bacteria such as *P. aeruginosa*, *Aeromonas salmonicida*, and *S. aureus* (Purba et al. 2022).

Furthermore, research shows that *A. alba* leaves can protect the gastric mucosa from ethanol damage, which makes it potentially an effective gastric protective agent (Amrati et al. 2021). Further research by Mitra et al. (2022) shows that *A. alba* can also treat diabetes mellitus safely. Diabetes is a chronic disease that occurs frequently and is characterized by recurrent hyperglycemia and metabolic disorders. Diabetes Mellitus (DM) is the eighth leading cause of death, affecting 4% of the world's population. Its impact on various physiological systems, especially nerves and blood flow, makes it a serious medical condition in developing and developed countries (Mitra et al. 2022). It indicates the need for modern treatment of medicinal plants such as those offered from *A. alba* extract.

The fruit, leaves, and roots of *A. officinalis* are a hepatitis remedy (Erwin et al. 2019), relieve joint pain, and accelerate wound healing (Chowdhury et al. 2021). According to Das et al. (2018), its bark is known to be effective in treating skin diseases, especially scabies, and possesses a diuretic activity. The root can be used as an aphrodisiac. The fruit of *A. officinalis* is used as a plaster for tumors, demonstrating its potential in antitumor therapy (Das et al. 2018). Globally, tumors are the second leading cause of death after heart disease. Tumors are becoming a deadly disease, especially in developing countries. Slow-growing tumors usually do not have much effect on humans. In contrast, rapidly growing tumors (malignant tumors) can cause various abnormal effects (Digdoyo et al. 2022). Overall, the different parts of *A. officinalis* do offer diverse therapeutic benefits. It supports its use and shows its potential to be developed in modern medicine.

According to Inggi et al. (2023), the negative impact of consuming herbs is relatively small compared to the

continuous use of chemical drugs (Adamczak et al. 2019). Traditional medicine is considered safer than modern medicine because it is not too harmful (Yuan et al. 2016). However, using traditional medicine must be done with caution to minimize side effects (Sumayyah and Salsabila 2017). It is crucial to ensure accuracy in choosing the proper medication for a particular condition (Lheureux et al. 2019) and pay attention to the accuracy of the dosage used. The timing of use should also be carefully observed, ensuring the drug is used at the right time for maximum effectiveness. In addition, the drug's use must follow the recommendations (Sen and Chakraborty 2017), avoiding inappropriate methods that can reduce the benefits or cause side effects (Jamshidi-Kia et al. 2017). It is also important to prevent the misuse of traditional medicine (Schrot and Hubbard 2016), ensuring that the use follows the provided instructions (Luethi and Liechti 2020). Finally, accuracy in drug selection is very important to ensure that the drugs used are appropriate and effective for treating the disease or condition. By paying attention to all these factors, traditional medicine can be safer and more effective (Sumayyah and Salsabila 2017). It shows that using medicinal plants in modern medicine is important for further study.

In conclusion, *Avicennia* is a genus in the Acanthaceae family consisting of eight species of mangroves distributed worldwide. The *Avicennia* tree grows 10-25 meters tall with simple leaves with salt secretion glands and short, low-branched stems. They play an important role in coastal ecosystems by protecting beaches from erosion, providing habitat for marine organisms, and storing carbon. Species such as *A. bicolor*, *A. germinans*, *A. marina*, *A. officinalis*, and *A. schaueriana* are widespread in tropical and subtropical regions, highlighting the importance of *Avicennia* in maintaining the biodiversity and stability of coastal ecosystems. *Avicennia* spp. is one of the types of mangroves that are used as medicinal plants. The phytochemical components in stems, leaves, and bark are terpenoids, glucosides, and naphthalene derivatives. *Avicennia* spp. has several biological activity properties: antioxidant, anticancer, antimicrobial, anti-inflammatory, and antihyperglycemic. These biological activities can be found in parts of the species, such as leaves, stems, and flowers. *Avicennia* can be used in traditional and modern medicine. In traditional medicine, *Avicennia* is used for diseases like diabetes, smallpox, malaria, ulcers, asthma, canker sores, skin diseases, and cancer. *Avicennia* provides increasing benefits and holds the potential for development into safer and more effective modern medicines. There are nine main phytochemical components that helps health, i.e.: alkaloids, terpenoids, steroids, phenolics, saponins, flavonoids, tannins, steroids, and glycosides.

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