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Review Article

Indonesian Cinnamon (*Cinnamomum burmanni* (Nees & T. Nees) Blume) as Promising Medicinal Resources: A Review

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ABSTRACT

Cinnamomum burmanni (Lauraceae) is one of the *Cinnamomum* species native to Indonesia. Given the worldwide use of cinnamon, the famous spice derived from its bark, cinnamon is also considered to possess medicinal properties. Consequently, a comprehensive review of *C. burmanni* was conducted to explore its medicinal benefits. This paper reviews several studies on the traditional use of *C. burmanni* in Indonesia, its phytochemistry, and its pharmacological properties. Traditionally, *C. burmanni* is utilized not only as spices but also for medicinal purposes, food ingredients, and ritual purposes. The bark is the most commonly used part, while few other parts of the plant are used. Several phytochemical compounds of *C. burmanni* have been identified. *C. burmanni* also has been reported to exhibit a wide range of biological activities. From those studies, it can be concluded that the medicinal use of *C. burmanni*'s bark has been scientifically validated due to its rich content of active compounds. Furthermore, other parts of *C. burmanni* should be analyzed to determine their content of active compounds.

1. Introduction

Indonesian cinnamon (*Cinnamomum burmanni*) earns its local name, "*kayu manis*" due to the sweet aroma emanating from its bark (Dao et al. 1999; Heyne 1987). The stripped bark of *C. burmanni* has long served as a staple in food, culinary enhancements, and spice blends. This bark, recognized as cinnamon from *Cinnamomum* species, ranks among the oldest spices, coveted by European explorers of the 15th and 16th Centuries (Dao et al. 1999). Most *Cinnamomum* bark contains essential oil ranging from 1–4%, presenting as a colorless to brownish-yellow liquid, contingent upon their chemical composition and concentration (Dao et al. 1999).

Over 350 species of *Cinnamomum* exist, predominantly native to tropical and subtropical regions of Asia but also dispersed across Australia, Oceania, and tropical America (POWO 2022a; Rohwer 1993). This genus encompasses 150–250 species, with a natural distribution spanning from tropical and subtropical Asia to the Western Pacific. Although *C. burmanni* is not exclusively native to Indonesia, its stripped bark is commonly recognized as Indonesian cinnamon because it is primarily found in Indonesia (Heyne 1987; POWO 2022b). Widely cultivated in Sumatra, Java, and extending to Timor, *C. burmanni* thrives at elevations up to approximately 2,000 meters above sea level (Hasanah et al. 2004; Heyne 1987). The primary hub of *C. burmanni* cultivation lies in Padang, West Sumatera, Indonesia (Dao et al. 1999; Hariyadi 2019; Hasanah et al. 2004). Notably, growth at higher altitudes results in slower growth rates, leading to thicker bark, thus enhancing its quality and economic value (Sujarwo and Keim 2021). This premium-grade bark contributes significantly to the substantial export volume of Indonesian cinnamon (Hasanah et al. 2004; Tanjung et al. 2024).

As one of Indonesia's native trees, *C. burmanni* plays a crucial role in Indonesia's tropical forests. This tree is relatively easy to find in various forest habitats in Indonesia, ranging from coastal forests and lowland tropical rainforests to lower montane forests (Sujarwo and Keim 2021). Well known for its bark as a source of spice, *C. burmanni* is widely cultivated by several communities. Since the 1920s, the cultivation of cinnamon has transformed the shifting cultivation practices of communities in Kerinci, Sumatra, into cinnamon agroforestry (Suyanto et al. 2007). Today, cinnamon is the major crop cultivated by smallholders in Kerinci, accounting for nearly 70% of Indonesian cinnamon production. In Jambi, Sumatra, cinnamon is planted alongside rubber and coffee and has become the communities' main income source. The development of cinnamon in agroforestry systems has been positively received by the communities, considering its economic, social, cultural, ecological, and environmental benefits (Lestari and Premono 2016). Furthermore, in Tanjung Kasri Village, one of the buffer zones of Kerinci Seblat National Park, traditional cinnamon agroforestry practices help preserve bird species diversity (Sartika et al. 2009).

Nowadays, Indonesian cinnamon has gained widespread recognition as a spice worldwide. However, its traditional use among communities in Indonesia is remarkably diverse, including its utilization as conventional medicine. According to Heyne (1987), its greyish bark with a strong, sweet aroma has been used by communities for traditional medicine. The cultural significance of cinnamon extends beyond its economic value, embedding itself deeply in the daily lives and practices of local communities. The use of cinnamon in the community is usually by processing the bark into a decoction with various health benefits, such as treating back pain and respiratory ailments, and is also used as an ingredient in "*jamu*", a traditional drink beneficial for healthcare (Dwi et al. 2021; Elsi et al. 2020; Islamia 2021; Mulu et al. 2020; Shanthi et al. 2014; Wulandara et al. 2018). Therefore, this study aims to provide a comprehensive analysis of research findings concerning the phytochemical and pharmacological properties of *C. burmanni*, highlighting its potential as a promising source of medicinal compounds.

2. Botanical and Ecological Description

Cinnamomum burmanni, a member of the Lauraceae family, is characterized by its small to fairly large evergreen tree reaching heights up to 30 meters, with a greyish bole. The tree features subopposite leaves with petioles measuring 0.5–1 cm in length. The leaf blade is oblong-elliptical to lanceolate, spanning 4–14 cm long and 1.5–6 cm wide. Young leaves exhibit a pale red and fine hairiness, while older leaves become glabrous and glossy green on the upper surface, with a glaucous pruinose texture underneath. The inflorescence takes the form of a short axillary raceme, with perianths measuring 4–5 mm long and pedicel spanning 4–12 mm. Following anthesis, the lobes tear off transversely approximately halfway, with stamens measuring about 4 mm in length and staminodes around 2 mm. The red-brownish berry fruit was ovoid, reaching approximately 1 cm long (POWO 2022b; Rohwer 1993), as depicted in **Fig. 1**. Flowering typically occurs during the rainy season, from October to February, while fruit ripening occurs around May to June (Dao et al. 1999).

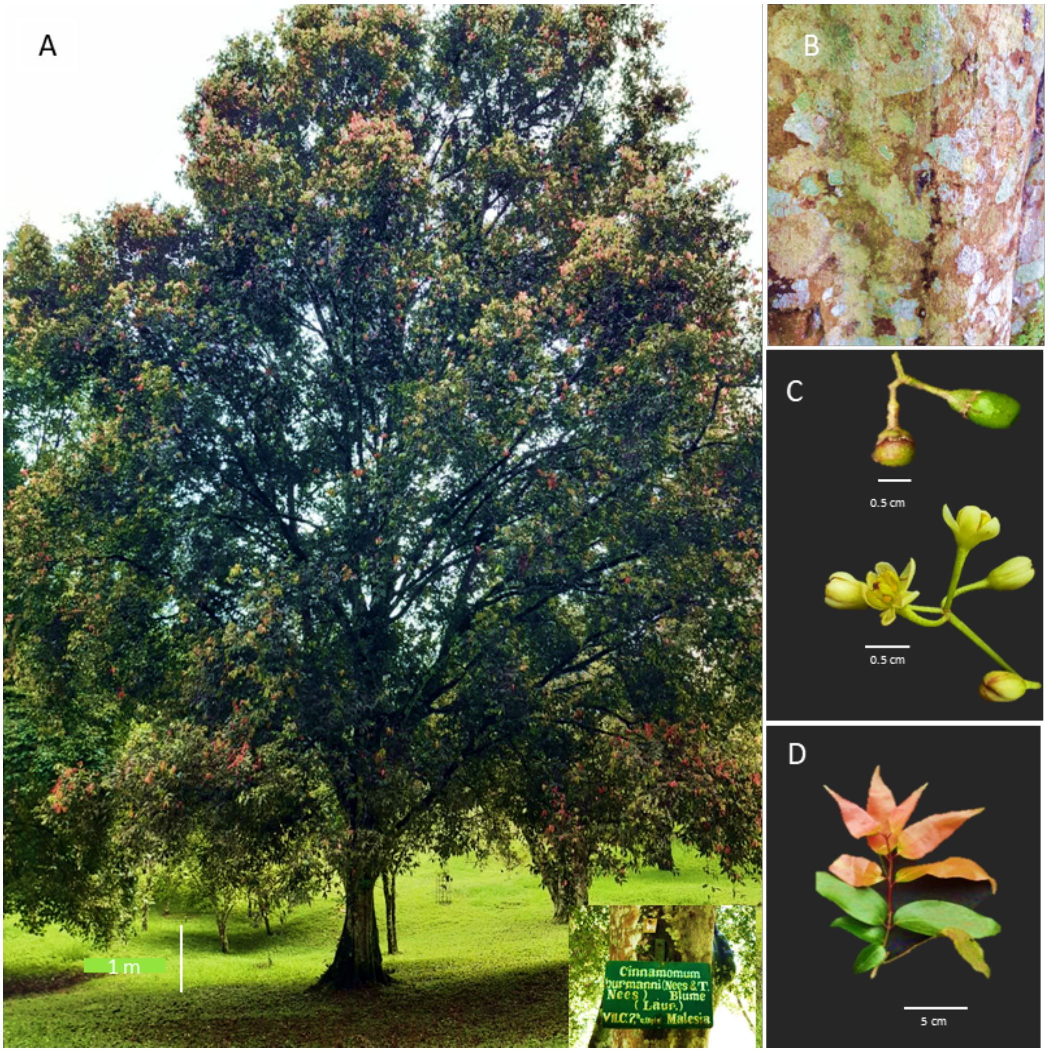

Fig. 1. *Cinnamomum burmanni* (Nees & T. Nees) Blume: (A) Living collection housed at Cibodas Botanic Gardens, (B) The bark of *C. burmanni* is distinctive in appearance, (C) The flower and fruit, (D) Its leaves are characterized by a pale red hue when young.

Cinnamomum burmanni grows primarily in the wet tropical biome (POWO 2022b). The native range of this species is from South China to Western and Central Malesia. It is distributed in Bangladesh, Borneo, South-Central China, Southeast China, Hainan, Java, the Lesser Sunda Islands, Myanmar, the Philippines, Sulawesi, Sumatra, Taiwan, and Vietnam. It has also been introduced to Cuba, the Gulf of Guinea Islands, Hawaii, and Mauritius. The tree grows naturally in secondary forests and on land surrounding human settlements, where it is often cultivated alongside primary forests (Menggala et al. 2019). In Indonesia, *C. burmanni* occurs from sea level to an altitude of 2,000 masl (Heyne 1987). However, since the origin of the species is strongly suggested in the vicinity of Kerinci, in the highlands of Central-West Sumatera, this species is considered a fairly mountainous plant (Sujarwo and Keim 2021). In Padang, West Sumatera, an important production area, *C. burmanni* grows best between 500 and 1,500 meters. The growth of this species is slower at higher altitudes, resulting in thicker bark, thus enhancing its quality and economic value (Sujarwo and Keim 2021). The best bark of *C. burmanni* comes from trees grown in light, rich sandy loams with an evenly distributed annual rainfall of 2,000–2,500 mm (Menggala et al. 2019). However, as a multi-purpose tree species (MPTS), *C. burmanni* in Indonesia is recognized as a source of spices and medicines, essential oils, and timber (Hariyadi 2019; Nair et al. 2021). Therefore, this species is a distinctive component of the agroforestry system in Indonesia (Nair et al. 2021).

3. History and Traditional Uses in Indonesia

Over the centuries, certain species of *Cinnamomum* stem bark have been harvested for international trade, such as cinnamon. Concerning trade, most of the cinnamon bark traded in Indonesia originates from *C. burmanni,* with smaller quantities coming from *C. cassia* and *C. zeylanicum*. A particular variant of *C. burmanni*, characterized by its young red leaves, flourishes at higher elevations on Mount Kerinci in Sumatra, earning it the moniker "Korintje cinnamon" (Hasanah et al. 2004). Renowned for its superior quality, most of the world's consumed cinnamon traces back to this Korintje cinnamon product. This cinnamon variety ranks among the four cinnamon species with high economic value, alongside *C. verum, C. cassia* (Chinese cinnamon), and *C. loureiroi* (Vietnamese or Saigon cinnamon) (Menggala and Damme 2018). It is believed that the first cinnamon plantations were established in the Kerinci area of West Sumatra, managed by the Kedatuan (Kingdom) Minanga (645–682 AD). This kingdom is reputed to have facilitated cinnamon trade on the island. Subsequently, the trading legacy was upheld by Kedatuan Dharmasraya (1183–1347 AD), the wealthiest kingdom in Bhumi Malayu (Sumatera), which continued to trade gold and spices, particularly gambier (*Uncaria gambir*) and cinnamon (*C. burmanni*), with China and India (Sujarwo 2021).

The primary product derived from *C. burmanni* is its dried spanning bark, renowned as a spice for aromatic seasoning in cuisine. Additionally, cinnamon bark yields various other products, including cinnamon powder, essential oil, and oleoresin, which find widespread applications across the food, beverage, pharmaceutical, and cosmetics industries today (Humaira and Rochdiani 2021). According to Sujarwo and Keim (2021), cinnamon bark has long been traded as one of the significant spices from Eastern Indonesia, likely alongside other esteemed such as nutmeg (*Myristica fragrans*), clove (*Syzygium aromaticum*), and candlenut (*Aleurites moluccana*), sharing similar historical significance and trade values. Cinnamon accounts for 12.4% of Indonesia's spice exports (Humaira and Rochdiani 2021).

With its extensive history in Southeast Asia, particularly in Indonesia, *C. burmanni* holds significant cultural importance for the local communities. Despite its recognition as a spice, numerous literature sources highlight the predominant traditional use of *C. burmanni* in Indonesia for medicinal purposes (**Table 1**). According to Sujarwo and Keim (2021), the cultivation and trade of *C. burmanni* in Sumatra date back to the 1800s. Additionally, the ancient use of *C. burmanni* as a traditional medicine in Indonesia dates back to 1934. Given its widespread distribution across Indonesia, this species bears various names in local languages, including Kayu manis (Indonesian); Holim, Holim manis, Modang siak-siak (Batak); Padang kulik manih (Minangkabau); Huru mentek, Ki amis (Sunda); Manis jangan (Java); Kesingar, Kecingar, Cingar (Bali); Kuninggu (Sumba); dan Puu ndinga (Flores).

Table 1. Traditional applications of *Cinnamomum burmanni* in Indonesia

Utilized parts	Purposes	Formulation	Community/ Location	References
Bark	Spice, aromatic seasoning	The bark mixed as a seasoning in cuisines	Banyumas, Central Java	(Apriliani et al. 2014)
Bark	Anticancer	Cinnamon bark (*C. burmanni*) mixed with duri kapok (*Ceiba pentandra*), benalu (*Scurrula otropurpurea*), and beras topemangu (*Oryza sativa*) with the skin removed	Kulawi tribe, residing in Lore Lindu National Park, Central Sulawesi	(Arham et al. 2016)
Bark	Weight loss	Dried cinnamon bark and roselle flower (*Hibiscus sabdarifa*) are boiled and consumed daily as a decoction	Kulawi tribe, residing in Lore Lindu National Park, Central Sulawesi	(Arham et al. 2016)
Bark	Alleviation of rheumatic pain	The bark is boiled to prepare a decoction	Community of Cibulakan, Buanamekar Village, Panumbangan Ciamis, West Java	(Bastaman et al. 2021)
Bark	Spice, aromatic seasoning, traditional drink "*jamu*" and traditional syrup "*pokak*"	The bark is mixed as a seasoning in cuisines; the bark is boiled with other species to prepare a decoction	Community of Clarak Village, Probolinggo District, East Java	(Dwi et al. 2021)
Bark	Relief from back pain	The dried bark is boiled and consumed as a decoction	Dayak Meratus tribe, South Kalimantan	(Elsi et al. 2020)
Bark	Medicine, food additive, spice, aromatic seasoning	NA	Tamao Village, near the Kapuas Hulu Forest Management Unit (KPH), West Kalimantan	(Haryanti and Diba 2015)
Bark	Traditional drinks, spice, aromatic seasoning	The dried bark is boiled and consumed as a decoction	Communities around Kerinci Seblat National Park, Jambi, Sumatra	(Helida et al. 2015, 2016)
Bark	Postpartum healthcare	The bark is used as an ingredient in the ointment "*lampok*" which is a mixture of 29 species of medicinal plants	Bangkalan, Madura, East Java	(Islamia 2021)

Utilized parts	Purposes	Formulation	Community/ Location	References
Bark	Postpartum healthcare	The bark is used as an ingredient in the ointment "*lampok*" which is a mixture of 29 species of medicinal plants	Bangkalan, Madura, East Java	(Islamia 2021)
Bark	Medicine and traditional drinking	NA	Manggarai tribe, Ruteng Mountain, Nusa Tenggara Timur	(Iswandono et al. 2015)
Bark	Reduce inflammation	The dried bark is boiled and consumed as a decoction	Manggarai tribe in Nusa Tenggara Timur	(Jamun et al. 2020)
Bark	Internal disorders (diseases that affect the internal organ system of the body)	The dried bark is boiled and consumed as a decoction	Dayak Banuaq tribe resides in Intu Village, located in West Kutai, East Kalimantan	(Lestari and Syafah 2019)
Bark	Spice and aromatic seasoning (satay, goat curry) and traditional drinks "*wedang uwuh*"	The crushed dried bark is boiled with other spices and consumed as a traditional drink; the bark is mixed as a seasoning in cuisines	Ponorogo, East Java	(Ningsih 2021)
Bark	*Betangas* (traditional spa and sauna practices among the Malays community in Sintang serve medicinal, relaxation, and beauty purposes)	The bark is boiled along with several other species, and the resulting steam is utilized for spa or sauna purposes	Malays community in Sintang, West Kalimantan	(Putri et al. 2017)
Bark	Spice, aromatic seasoning, preserves	The bark mixed as a seasoning in cuisines	Sanggau, West Kalimantan	(Robi et al. 2019)
Bark	Women's healthcare services include prenatal, postpartum, and breastfeeding support tailored to their needs.	The bark is utilized as an ingredient in numerous types of potions. There are 24 varieties of decoctions for consumption and 11 potions intended for body scrub. Two decoctions are consumed for nursing mothers, and two potions are applied as a body scrub	Keraton Surakarta Hadiningrat, Central Java	(Shanthi et al. 2014)

Utilized parts	Purposes	Formulation	Community/ Location	References
Bark	To manage diabetes	Bark pieces measuring 3 to 4 cm in size are boiled in 1 liter of water until it reduces by half, after which the decoction is consumed 1-2 times a day	Batak Karo, North Sumatera	(Situmorang et al. 2015)
Bark	Spice, aromatic seasoning	The bark mixed as a seasoning in cuisines	Bali	(Sujarwo et al. 2015)
Bark	Enhancing fertility, inducing pregnancy, alleviating pain	NA	Malays community, Bukit Rimbang Bukit Baling Wildlife Reserve in Kampar Kiri Hulu, Riau, Sumatra	(Susandarini et al. 2021)
Bark	Spice, aromatic seasoning	The bark mixed as a seasoning in cuisines	Communities around Candi Muaro Jambi, Jambi, Sumatra	(Susanti et al. 2020)
Bark	Relief for stomachache and back pain	The bark is pounded and then applied as a smear	Malays community, Kayong Utara District, West Kalimantan	(Wulandara et al. 2018)
Bark	Respiratory ailments	NA	Mbeliling tribe, Nusa Tenggara Timur	(Mulu et al. 2020)
Bark	Spice, aromatic seasoning	The bark mixed as a seasoning in cuisines	Samawa community, Sumbawa Island, Nusa Tenggara Barat	(Rahayu and Rustiami 2017)
Bark	Ceremonial purposes	The bark is raw material for Javanese incense, with *Styrax benzoin* being the main ingredient	Javanese	(Sangat-Roemantyo 1990)
Bark	Spice, aromatic seasoning	The bark mixed as a seasoning in cuisines	Batak Karo, Sumatera Utara	(Silalahi and Nisyawati 2018)
Bark	Spice, medicine	NA	Dayak Tribe, Kalimantan Tengah	(Tamai et al. 2015)
Bark	Spice, aromatic seasoning	The bark mixed as a seasoning in cuisines	Rokan Hulu District, Riau, Sumatra	(Tribudiarti et al. 2018)
Bark, leaves	Skincare, cardiovascular health, arthritis, diabetes management, hernia treatment, oral hygiene	NA	Bulungan Tribe, Kalimantan Utara	(Kartina et al. 2022)

Utilized parts	Purposes	Formulation	Community/ Location	References
Bark, leaves	*Oukup* (traditional steam-bathing)	*Oukup* is a traditional sauna of Batak Karo, initially employed to aid in the recovery of postpartum mothers. It also treats conditions such as high cholesterol, hypertension, rheumatism, headache, stroke, and promotes and preserves smooth skin. Approximately 30 species are boiled, and the resulting steam is utilized for spa/sauna purposes	Batak Karo, North Sumatra	(Silalahi et al. 2015; Silalahi and Nisyawati 2019)
Leaves	Relief from muscle soreness	The bark is crushed and applied to the skin	Tengger tribe in Ranu Pani village, East Java	(Bhagawan and Kusumawati 2021)
Leaves	To alleviate heartburn, fever, diarrhea, hypertension, aphthous stomatitis (canker sores), and various other minor health issues.	The bark is used as one of the ingredients in *Loloh,* a traditional herbal drink in Bali, which comprises 51 plant species	Bali	(Sujarwo and Keim 2021)
Leaves	Alleviate heartburn, sore throat, cough, fever, hypertension, and stimulate appetite	The leaves are boiled and consumed as a decoction	Bali	(Sujarwo et al. 2015)
Sap	Relief from toothache	NA	Communities around Kerinci Seblat National Park, Jambi, Sumatra	(Helida et al. 2016)
Seeds	Postnatal healthcare	NA	Samawa community, Sumbawa Island, Nusa Tenggara Barat	(Rahayu and Rustiami 2017)
Wood and branches	Firewood	The wood and branches are utilized as firewood	Communities around Kerinci Seblat National Park, Jambi, Sumatra	(Helida et al. 2016)

Cinnamomum burmanni holds considerable cultural significance in Indonesia, particularly among the Javanese, where it is deeply integrated into traditional cuisine, herbal remedies, and religious ritual (Apriliani et al. 2014; Bhagawan and Kusumawati 2021; Dwi et al. 2021; Islamia 2021; Ningsih 2021; Sangat-Roemantyo 1990; Shanthi et al. 2014). Sangat-Roemantyo (1990) documents that *C. burmanni* plays a crucial role in Javanese incense, providing its distinctive scent through the bark. This tradition of burning incense likely dates back to ancient times and continues to be practiced today (Sujarwo and Keim 2021). While the specifics of its utilization in custom are not extensively documented, this species remains integral to Javanese culture.

In terms of health-related applications, the majority of *C. burmanni* usage focuses on treating muscle soreness and digestive disorders (**Fig. 2**). Muscle soreness encompasses conditions such as arthritis, back pain, and rheumatic, while digestive disorders include ailments like diarrhea, stomachaches, heartburn, and appetite stimulation (Bastaman et al. 2021; Bhagawan and Kusumawati 2021; Elsi et al. 2020; Hariyadi and Ticktin 2012; Sujarwo and Keim 2021; Wulandara et al. 2018). An intriguing finding is the usage of *C. burmanni* to treat cancer, although this remains relatively underexploited (Arham et al. 2016). The bark, often combined with other plants and processed into a decoction, is used by the Kulawi tribe in Central Sulawesi for cancer treatment (Arham et al. 2016). However, the specific type of cancer targeted in these treatments is not explicitly described.

Despite the bark of *C. burmanni* being widely recognized as a valuable spice source, it is noteworthy that several communities also utilize other parts of the *C. burmanni* tree (**Fig. 2**). Despite the centuries-old spice spreading knowledge about the utilization of *C. burmanni* bark across many communities, the usage of other parts of the tree remains relatively less known. This presents an intriguing finding and underscores the potential for future study into the phytochemistry and pharmacology of different parts of *C. burmanni* tree, particularly if the parts are utilized for medicinal purposes.

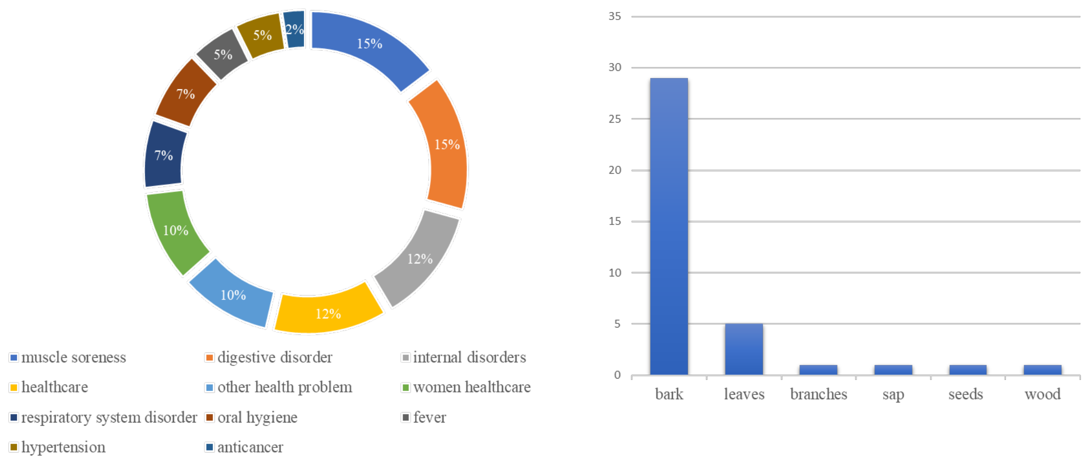

Fig. 2. On the left: Health problem categories treated with *C. burmanni* as medicinal treatment; On the right: Parts of *C. burmanni* utilized by communities.

4. Phytochemistry

Based on the previous report, the most utilized part of *C. burmanni* is its bark (**Fig. 2**). This part contains primary metabolites such as crude protein, crude fat, and carbohydrates. The bark *C. burmanni* is also rich in secondary metabolite compounds, including flavonoids, pectins, cellulose, alkaloids, terpenoids, and phenolics. The bark of *C. burmanni* also contains volatile compounds responsible for its aromatic flavor and odor characteristics. While 47 volatile compounds were identified in *Cinnamomum* essential oil, only 15 volatile compounds have been detected in *C. burmanni* oil, including alcohol, ketone, aldehyde, ester, carboxylic acid, and alkanes (Liang et al. 2019). However, Herdwiani et al. (2016) characterized 40 compounds in *C. burmanni* essential oil, and those volatile crude extracts showed acute toxicity at dose treatment of 5000 mg/Kg Body Weight. Furthermore, Lin et al. (2020) identified a new apocarotenoid and burmannic acid from the root extract of *C. burmanni.* A study by Liang et al. (2019) has identified several compounds in the ethanol extract of *C. burmanni*'s bark, with (E)-Cinnamaldehyde being the most active compound, as listed in **Table 2**.

Table 2. Bioactive compounds derived from *Cinnamomum burmanni*'s bark

Bioactive compounds	Medical properties	References
Procyanidin B1; Procyanidin B2; Procyanidin trimer; Procyanidin dimer	It is a natural antioxidant that stabilizes food pigmentation and prevents food oxidation. Procyanidins have been reported to exhibit anticancer, cardioprotective, antimutagenic, antimicrobial, antihyperglycemic, antiviral, and anti-inflammatory. Procyanidin B1 was used for intestinal dysfunction therapy by maintaining barrier function and ameliorating pathological inflammation	(González-Quilen et al. 2020; Rue et al. 2018)
Catechin; Epicatechin.	Catechin and epicatechin were polyphenol compounds that improved antioxidant capability, inhibited tyrosinase-inducing aging performance, protecting cells against UV radiation, promoted antibacterial, anti-allergenic, antiviral, anticancer, and anti-inflammatory activities	(Bae et al. 2020)
Coumarin	Coumarin, a benzopyrone group performed anticoagulant, antifungal, antiviral, anticonvulsant, neuroprotective effects, and antihypertensive	(Sharifi-Rad et al. 2021)
(E)-Cinnamic acid; (E)-Cinnamaldehyde; (Z)-Cinnamaldehyde; Cinnamyl alcohol	Cinnamic acid promotes antioxidant, anticancer, anti-inflammatory, and neuroprotective effects. Furthermore, in a recent study, cinnamic acid and cinnamaldehyde derivates from *Cinnamomum* bark performed anti-diabetes by improving blood glucose homeostasis	(Ruwizhi and Aderibigbe 2020; Rychlicka et al. 2021; Sarifah et al. 2024)

5. Pharmacological Activities

5.1. Antioxidants Properties

In a study by Muhammad et al. (2020), the antioxidant activity of cinnamon extracts was evaluated through the DPPH test. The study employed various solvents (water, acetone, methanol, and ethanol) and extraction methods (traditional and ultrasonic methods). The phenolic content extracted through conventional methods was found to be higher compared to the ultrasonic method. The IC_{50} values ranged from 31.5–92.9 µg/mL for traditional extraction and 33.0–60.9 µg/mL for ultrasonic extraction (Muhammad et al. 2021). Moreover, there was a positive correlation between the antioxidant activity of the crude and its phenolic content.

In another study, Muhammad et al. (2020) employed cinnamon essential oil to enhance the antioxidant activity of white chocolate during food processing. Incorporating 0.1 % (w/w) essential oil resulted in a more than 2-fold increase in the antioxidant activity of white chocolate without altering its properties. Furthermore, Muhammad et al. (2021) examined the antioxidant properties of the aqueous extract of *C. burmanni* through the DPPH and FRAP assay. The chemical analysis revealed a total polyphenol content of 1554.9 mg/L, corresponding antioxidant capacities of 5125.0 µmol Trolox/L3 and 3658.8 µmol Trolox/L2 for DPPH and FRAP, respectively. The antioxidant activity of the extract was significantly correlated with its polyphenol content (Rachid et al. 2022). These studies demonstrate that natural compounds from *C. burmanni* serve as a viable alternative source of antioxidants and can be integrated into various food and pharmaceutical formulations. The phytochemical compounds that performed antioxidant activity were procyanidins, coumarin, polyphenolic compounds such as catechin and epicatechin, and volatile compounds, such as sesquiterpenoid compounds (Bae et al. 2020; González-Quilen et al. 2020; Rue et al. 2018; Ruwizhi and Aderibigbe 2020; Rychlicka et al. 2021; Sharifi-Rad et al. 2021).

5.2. Anti-Inflammatory Properties

Cao et al. (2008) investigated the anti-inflammatory characteristics of *C. burmanni* bark crude ethanolic extract by examining Tristetraprolin (TTP) expression. The result revealed that the cinnamon extract increased Tumor Necrosis Factor (TNF) mRNA and TTP expression levels 2- and 6-fold, respectively. Additionally, the extract enhanced GLUT1 expression to levels 3-fold higher than the control (Cao et al. 2008). Furthermore, Budiastuti et al. (2021) explored the anti-inflammatory properties of cinnamon essential oil using a rat model injected with 1%/100 µL/paw of carrageenan. The administration of essential oil led to a significant increase in edema inhibition compared to the negative control. Moreover, there was a reduction in TNF-α expression and inflammatory cells (Budiastuti et al. 2021).

In a study by Khatib et al. (2005), the anti-inflammatory activity of 2-hydroxy cinnamaldehyde from *C. burmanni* bark was examined using soybean lipoxygenase (SLO). Results demonstrated that this compound inhibits SLO with an IC_{50} value of 60 µM. However, 2-hydroxy cinnamaldehyde showed no hyaluronase inhibitory activity (Khatib et al. 2005). Previous studies reported that cinnamaldehyde, E-cinnamyl acetate, cinnamic acid, eugenol, and caryophyllene performed anti-inflammatory effects (Singh et al. 2021). Cinmganoid D-F, a new compound found in *Cinnamomum migao*, also reported anti-inflammatory by decreasing nitric oxide levels and pro-inflammatory expression (Muhammad et al. 2024). These findings collectively suggest that *C. burmanni* can modulate immune responses by regulating the expression of both anti-inflammatory and pro-inflammatory genes, highlighting its potential as an anti-inflammatory agent.

5.3. Antimicrobial Properties

The antimicrobial activity of crude extract of *C. burmanni* has been evaluated against several pathogenic bacteria, demonstrating significant antibacterial effects against *Escherichia coli, Staphylococcus aureus, Salmonella anatum, Listeria monocytogenes, Streptomyces sanguinis,* and *Streptomyces mitis* (Liang et al. 2019; Waty et al. 2018). Additionally, cinnamaldehyde, a prominent compound found in cinnamon, exhibits antimicrobial activity against both gram-negative and gram-positive bacteria, including *S. aureus, E. coli, Salmonella, Yersinia enterolitica* and *Bacillus cereus* (Siddiqua et al. 2015; Yossa et al. 2012).

Moreover, the derivates of the trans-cinnamaldehyde have been synthesized and investigated by Wei et al. (2011), demonstrating dose-dependent antibacterial activity against *E. coli, S. aureus,* and *B. subtilis*. As highlighted by Shan et al. (2007), the antibacterial efficacy of cinnamon bark is attributed to trans-cinnamaldehyde and the polyphenol content, particularly proanthocyanins. In gram-negative bacteria, treatment with cinnamaldehyde induces structural cell damage and cellular content leakage, leading to cell death (Yossa et al. 2012). Sesquiterpenoids of *C. burmanni,* such as eugenol, caryophyllene, and cinnamic acid, reported promising antibacterial activity (Singh et al. 2021). Cinnaladehyde and eugenol have previously been shown to inhibit a bacterium's beta-lactamase (Lee et al. 2021). Overall, *C. burmanni* is a promising antimicrobial agent capable of being integrated with other materials for antibacterial applications.

5.4. Hepatoprotective

Non-alcoholic fatty liver disease represents a spectrum of liver conditions marked by increased triglyceride accumulation without the influence of alcohol consumption, drug-induced steatosis, or viral infection. In a study by Susilowati et al. (2022), treatment with ethanol extract from *C. burmanni* resulted in notably elevated Superoxide Dismutase (SOD) activity level compared to treatment involving quercetin and atorvastatin in rats subjected to a high-fat and cholesterol diet. Moreover, administration of *C. burmanni* extract maintained SOD activity in rats fed a normal diet, as well as in those treated with quercetin and atorvastatin. Phenolic and aldehyde compounds from *Cinnamomum* have been reported to show hepatoprotective effects by lowering lipid activity, protecting the liver, and potentially as therapeutic agents for non-alcoholic fatty liver disease and alcoholic fatty liver disease (Ju et al. 2023). Cinnamon oil from cinnamon bark also performed hepatoprotective by regulating oxidative stress and inducing angiogenesis (Abdel-Kawi et al. 2022). These findings suggest that *C. burmanni* extract possesses hepatoprotective properties by modulating oxidative stress levels.

5.5. Gastroprotective

Excessive secretion of gastric acid by parietal cells in the stomach lining can lead to gastrointestinal disorders, significantly impacting patients' quality of life. The enzyme hydrogen potassium adenosine triphosphatase (H+/K+ ATPase) plays a pivotal role in the acidification process within the stomach. Inhibiting H+/K+ ATPase activity is a potential strategy for reducing gastric acid production (Reyes-Chilpa et al. 2006). DLBS2411, a bioactive fraction derived from *C. burmanni,* has inhibited H^+/K^+ ATPase in both in vitro and in vivo models. Treating human embryonic kidney HEK 293 cell lines with 50 µg/mL of DLBS2411 decreased H^+/K^+ ATPase mRNA expression (Tjandrawinata et al. 2013).

Furthermore, DLBS2411 administration decreased the number of petechiae in animal models of gastric ulcers, indicating its gastroprotective activity (Tjandrawinata et al. 2013; Tjandrawinata and Nailufar 2020). In an ethanol-induces animal model, histopathological examination demonstrated the gastroprotective effect of DLBS2411 at a dose of 50 mg/kg body weight (Tjandrawinata and Nailufar 2020). These results indicate that DLBS2411 holds promise as a therapeutic intervention for treating gastric disorders by inhibiting H^+/K^+ ATPase and exhibiting gastroprotective effects. Moreover, cinnamaldehyde exhibited potential therapeutic for gastritis model induced by *H. pylori* infection by decreasing IL-8 and ROS (Lee et al. 2021).

The pharmacological properties of *Cinnamomum burmanni*'s bark, summarized from various literatures, are presented in **Table 3**.

Table 3. Pharmacological properties of *Cinnamomum burmanni*

Pharmacological properties	Utilized part	Extract/ compound	Dose	Method	Results	Reference
Antioxidants activity	Bark	Cinnamon oleoresin of the crude extract (water, acetone, methanol, and ethanol)	IC_{50}: 31.5 -92.9 µg/ml	In vitro	Water and methanolic extract showed the best antioxidant activities through DPPH assay from traditional and ultrasonic extraction, respectively	(Muhammad et al. 2021)
	Bark	Essential oil	328 µmol L^{-1} ascorbic acid equivalent 579 µg tannic acid equivalent	In vitro	The essential oil exhibits antioxidant activity and increases the antioxidant activity of white chocolate by more than 2-fold	(Muhammad et al. 2020)
	Bark	Crude extract	5152 µmol Trolox/L)	In vitro	Showed strong antioxidant activity according to the DPPH assay	(Rachid et al. 2022)
	Bark	Crude extract	3658/6 µmol Trolox/L	In vitro	Showed strong antioxidant activity according to the FRAP assay	(Rachid et al. 2022)
	Bark	Crude methanol extract	50-200 µg/mL	In vitro	Blocking the production of nitric oxide production in LPS stimulated RAW264.7 macrophage cell lines	(Choi and Hwang 2005)
Antidiabetic activity	Bark	*Trans-cinnamaldehyde*	IC_{50}: 67.6 µM	In vitro	Suppression of protein tyrosine phosphatase 1B activity by up to 98%	(Saifudin et al. 2013)
	Bark	5'-Hydroxy-5-hydroxymethyl-4'',5''-methylenedioxy	IC_{50}: 29.7µM	In vitro	Suppression of protein tyrosine phosphatase	(Saifudin et al. 2013)

Pharmacological properties	Utilized part	Extract/ compound	Dose	Method	Results	Reference
		-1,2,3,4-dibenzo-1,3,5-cycloheptatrien			1B by up to 88.7%	
	Bark	Crude extract	IC_{50}: 205.0 µg/ml	In vitro	Dipeptidyl peptidase IV inhibitory activity	(Ahmad et al. 2020)
	Bark	Aqueous extract	Ingestion of 6 g/100 ml	Clinical trial	The intervention did not notably impact the postprandial glucose response in diabetic patients during an oral glucose tolerance test	(Rachid et al. 2022)
	Bark	Cinnamon tea	-	Clinical trial	The decreased postprandial blood glucose level in non-diabetic adults	(Bernardo et al. 2015)
Anticancer	Bark	Trans-cinnamaldehyde	IC_{50}: 2.94-12.92 µg/mL	In vitro	Inhibition of nasopharyngeal (HK1, C666-1, and HaCaT cell lines) cell proliferation by downregulating Ki67 and proliferating cell nuclear antigen (PCNA), induction of apoptosis	(Daker et al. 2013)
	Bark	Essential oil	IC_{50}: 75 µg/ml	In vitro	Cytotoxic effect and induce apoptosis on breast cancer T47D cell line	(Anjarsari et al. 2013)
	Bark	Crude ethanolic extract	IC_{50}: 465.21 µg/ml	In vitro	Showed cytotoxic effect on breast cancer T47D cell line	(Indrayudha and Hapsari 2021)
	Bark	Crude extract	-	In vitro	Promote Nrf2 nuclear translocation, enhance the	(Shen et al. 2014)

Pharmacological properties	Utilized part	Extract/ compound	Dose	Method	Results	Reference
					expression of the Nrf2 protein and its target genes, and elevate intracellular glutathione levels	
	Bark	Crude ethanolic extract Trans-cinnamaldehyde	2-10 µM	In vitro	Nrf2 upregulated cellular glutathione levels and shielded the cells from hydrogen peroxide damage in colon cancer cell lines	(Wondrak et al. 2010)
Anti-inflammatory activity	Bark	2-hydroxy cinnamaldehyde	IC_{50}: 60 µM	In vitro	Soybean lipoxygenase (SLO) inhibition	(Khatib et al. 2005)
	Bark	Essential oil	60-90 mg/kg BW	In vivo	Edema inhibition and decreased cell inflammatory and TNF-a expression	(Budiastuti et al. 2021)
	Bark	Crude ethanolic extract	100 mg/L	In vitro	Increased Tristetraprolin (2-fold) and TNF-α mRNA (6-fold) levels and improved glucose transporter expression in mouse RAW264.7 macrophage cell	(Cao et al. 2008)
Hepatoprotective	Bark	Crude ethanol extract	200-300 mg/kg BW	In vivo	Lowing MDA level, higher SOD activity level, lowing steatohepatitis level in mice with a high-fat and cholesterol diet.	(Susilowati et al. 2022)

Pharmacological properties	Utilized part	Extract/ compound	Dose	Method	Results	Reference
Antimicrobial activity	Bark	Crude extract	MBC: 1.25-160 mg/mL	In vitro	Showed antimicrobial activity against *S. aureus, L. monocyte gene, S. anatum,* and *E. coli,* with inhibition zone range from 7.43-24.32 mm	(Liang et al. 2019)
	Bark	Crude ethanolic extract	6.25-25%	In vitro	Inhibition of *S. mitis* and *S. sanguinis* growth	(Waty et al. 2018)
	-	Cinnamaldehyde essential oil (commercial)	800-1000 ppm	In vitro	Inhibit *E. coli* and *Salmonella* growth	(Yossa et al. 2012)
	-	Cinnamaldehyde (commercial)	MIC: 0.1875-0.5000 mg/mL	In vitro	Showed an antibacterial activity against *S. aureus, E. coli, B. cereus,* and *Y. enterolitica*	(Siddiqua et al. 2015)
Gastroprotective	Bark	DLBS2411	50 µg/mL	In vitro	Decreased expression of H+/K+ ATPase mRNA in HEK 293 (90%) and rat gastric parietal (50%) cell lines	(Tjandrawinata et al. 2013)
	Bark	DLBS2411	20-40 mg/kg BW	In vivo	Reduce the number of petechiae in gastric ulcer animal model	(Tjandrawinata et al. 2013)
	Bark	DLBS2411	25-50 mg/kg BW	In vivo	Reduce ulcer area by inhibiting ulceration	(Tjandrawinata and Nailufar 2020)

Notes: BW: Body weight; IC_{50}: Inhibitory concentration 50; MDA: Malondialdehyde; SOD: Superoxide dismutase; DPPH: 2,2-diphenyl-1-picryl-hydrazil-hydrate; FRAP: Ferric reducing antioxidant power.

6. Conclusions

Cinnamomum burmanni is recognized as a promising source of biologically active compounds with specific health benefits for humans. Ethnobotanical studies conducted in Indonesia indicate that most communities utilize *C. burmanni* for traditional medicinal purposes, followed by its use as a food ingredient and for various customs. Consequently, there is potential to develop *C. burmanni* into future medicine products, particularly by incorporating its active compounds into functional food ingredients. Given the current global health priorities, these functional food ingredients could be tailored to provide diverse health benefits by leveraging the active ingredients present in *C. burmanni*. Moreover, due to its essential oil content, *C. burmanni* could be explored for its applications in body treatments, such as bathing materials and postpartum care. This entails revealing chemical compositions and discovering a spectrum of compounds that contribute to the efficacy of the medicine, validating the effectiveness and safety of herbal treatments, and providing a scientific basis for their traditional use while potentially discovering new sources of drugs from natural ingredients. However, while pharmacological activities have primarily been documented for the bark, information regarding activities from other parts of the plant remains limited. Hence, it is imperative to conduct screening for active compounds from different parts of the *C. burmanni* tree, especially the leaves, which are the second most utilized part.

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