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Phytochemical Constituents of *Cinnamomum burmannii* (Ness & T.Nees) Blume: *A Systematic Review*

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Abstract

Background: *Cinnamomum burmannii is an Indonesian native cinnamon species with significant potential for developing pharmaceutical and functional food products.* **Methodology:** *This study aims to identify and analyze the phytochemical constituents of C. Burmannii through a systematic literature review using PRISMA databases such as PubMed, Scopus, and Science Direct,were searched from 2015-2025.* **Findings:** *The findings reveal that C. Burmannii contains diverse bioactive compounds, including aromatic aldehydes, phenolics, flavonoids, terpenoids, coumarins, aromatic alcohols, organic acids, and aromatic esters. Dominant compounds such as cinnamaldehyde, quercetin, catechin, and eugenol exhibit strong antimicrobial, antioxidant, antidiabetic, anti-inflammatory, and analgesic activities. Quantitative analysis shows total phenolic content ranging from 31–89 mg GAE/100 g, total flavonoid 15–80 mg QE/100 g, and total tannin 89–217 mg CE/g, with ethanol extraction yielding optimal results. Several novel pure compounds, including Burmanoside, Burmafuranic acid, Burmannic acid, and o-hydroxycinnamic acid, have been isolated and demonstrate antiproliferative and photoprotective activities.* **Contribution:** *This systematic review highlights the diversity of phytochemical constituents in C. Burmannii and emphasizes the influence of plants parts and extraction methods on phytochemicals profiles.*

Keywords: *Bioactivity; Cinnamomum burmannii; Natural Compounds; Literature Review; Phytochemical Constituents*

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INTRODUCTION

Indonesian Cinnamon (*Cinnamomum burmannii*) is a strategic spice from Indonesia that has a global reputation in the international market. This species, belonging to the Lauraceae family, is not only used as a flavor enhancer in cooking but has also long been an integral part of traditional medicinal practices in various Asian regions. Indonesia's position as a major producer of local varieties of cassiavera, or cinnamon, has been internationally recognized, with several regions becoming significant cultivation centers. This commodity provides substantial economic benefits to local farming communities, while also holding very promising prospects in the pharmacology and nutraceutical sectors, which have so far been underutilized for the innovation of phytopharmaceutical-based health products (Yuwanda et al., 2023).

Phytochemical studies conducted on *Cinnamomum burmannii* have successfully identified a spectrum of bioactive compounds with a high level of diversity and complexity. The phytochemical components found in cinnamon can be classified into several major categories, including phenolics (which include flavonoids and tannins), volatile oil components, alkaloids, saponins, terpenoids, and glycosides. The phenolic group of compounds dominates the phytochemical composition and is a major contributor to antioxidant activity, with key components such as cinnamic acid, cinnamaldehyde, and various derivatives. The flavonoid category contains compounds such as quercetin, catechin, and various other polyphenols that play a crucial role in biological activity. On the other hand, the presence of tannins provides distinctive astringent characteristics and antimicrobial properties to Indonesian cinnamon extracts (Anggraini et al., 2015).

Quantification of active compounds in *Cinnamomum burmannii* is an essential element in the comprehensive phytochemical characterization process. Previous studies have shown significant concentration fluctuations, significantly influenced by extraction techniques and the type of solvent used. The ethanol extraction process yields optimal results in the recovery of bioactive compounds. Total flavonoid concentrations in *C. burmannii* have been recorded to range from 15.15 to 80.52 mg quercetin equivalents per 100 grams of extract, indicating varying levels depending on the extraction method. Total phenolic content has been reported to range from 31.33 to 89.79 mg gallic acid equivalents per 100 grams of extract, with the highest value reaching 66.34 mg GAE/100 g in the ethanolic extract of the bark. This quantitative information indicates that Indonesian cinnamon varieties contain substantial amounts of bioactive compounds and offer promising prospects for use as a source of natural antioxidants in the pharmaceutical and functional food industries (Khasanah et al., 2017).

The total flavonoid concentration in *Cinnamomum burmanii* extract is a crucial indicator that describes the potential of its antioxidant activity and pharmacological effects. Spectrophotometry with aluminum chloride ($AlCl_3$) reagent and quercetin as a reference compound has been widely adopted as a standard procedure in total flavonoid quantification. The working principle of this method is based on the interaction of $AlCl_3$ with the hydroxyl group found in the flavonoid structure, forming a complex compound that produces measurable light absorption at a certain wavelength, thus enabling concentration calculations with reference to the quercetin

standard (Darmayuda et al., 2021; Utami et al., 2022). The diversity of total flavonoid concentrations recorded from various studies indicates the substantial influence of a number of variables, including the geographical location where the plants grow, the harvest period or season, the method and duration of storage, and most importantly, the extraction procedure and characteristics of the solvent used in the isolation process of these bioactive components (Li et al., 2021; Rana & Sheu, 2023).

Quantification of total phenolic content through the Folin-Ciocalteu technique using gallic acid as a reference compound has become a globally adopted and standardized analytical method. The Folin-Ciocalteu procedure utilizes gallic acid as a reference in quantifying total phenolic concentration, where this reagent interacts with phenolic groups and produces a blue complex compound whose intensity can be quantified through spectrophotometry. The total phenolic concentration in cinnamon extracts showed variations in the range of 6.313 to 9.534 g GAE/100 g dry weight in extracts obtained with ethanol solvent (Qarani et al., 2023). These fluctuations in measurement results emphasize the urgency of standardizing extraction procedures and analytical methods in order to produce data with high consistency and reproducibility (Utami et al., 2022). Quantification of total phenolic concentration is fundamental in evaluating potential antioxidant capacity and its correlation with various other pharmacological activities (Pagliari et al., 2023).

Tannin is a complex phenolic compound that plays a significant role in various biological activities in cinnamon extract. Quantification of total tannin concentration is generally carried out using spectrophotometry techniques with vanillin-HCl reagents, or through protein precipitation methods using tannic acid or catechin as reference standards (Lopes et al., 2022). The tannins contained in *Cinnamomum burmannii* contribute to antimicrobial activity, astringent properties, and antioxidant capacity, which work through protein binding and free radical neutralization mechanisms (Fraga-Corral et al., 2020). In the development of herbal products based on *Cinnamomum burmannii*, quantitative measurement of tannin content is very important because excessive tannin concentrations can cause astringency or bitterness due to tannin-protein interactions and bitter taste mechanisms (Pires et al., 2020). Meanwhile, at controlled levels, tannins actually provide biological benefits such as antioxidant and antimicrobial activity (Queiroz et al., 2023), and it has been proven that cinnamon bark contains tannins that are technically and biologically relevans (Rizki et al., 2024).

In addition to the quantification of bioactive compounds, the efficiency of obtaining phytochemical components from extracts is also greatly influenced by the type of solvent used during the extraction process. Polar solvents such as ethanol and methanol have been proven to be most effective in extracting phenolic and flavonoid compounds, while semi-polar solvents such as ethyl acetate are more suitable for isolating compounds with medium polarity (Afdal et al., 2023; Ervina et al., 2023). Water as a highly polar solvent effectively extracts tannins and glycosides, although it is less optimal for lipophilic compounds. Variations in solvents with different polarities, such as water, 50–95% ethanol, acetone, and dichloromethane, produce extract profiles with varying chemical compositions and biological activities. Optimization of extraction parameters has a significant effect on the yield and quality of the active compounds obtained (Afdal et al., 2023; Wang et al., 2023).

A comprehensive study of the phytochemical components of *C. burmannii* using a contemporary analytical approach is urgently needed to encourage the development of the herbal sector in Indonesia. Based on the background review that has been described, this study aims to carry out the identification, isolation, and characterization of phytochemical components in a structured manner with a focus on grouping compounds according to their chemical classification, quantifying the concentration of active compounds using spectrophotometric and chromatographic techniques, and optimizing the solvent system to maximize the yield of bioactive components.

The output of this study is projected to provide a substantial contributions to the current body of knowledge. First, it compiles phytochemical information reported specifically for *Cinnamomum burmannii*, thereby minimizing species-related generalization observed in earlier reviews. Second, the identified compounds are systematically organized according to their chemical structures and biosynthetic origins, facilitating clearer interpretation of phytochemical diversity. Third, quantitative phytochemical parameters, including total phenolic, flavonoid, and tannin contents, are consolidated to enable comparative analysis across studies. Finally, the effects of extraction techniques and solvent selection on phytochemical composition are critically evaluated to support extract standardization efforts. Overall, this review provides a structured scientific foundation for future phytopharmaceutical, nutraceutical, and quality control studies involving *C. burmannii*., support the standardization process of cinnamon-based herbal products, as well as serve as a scientific foundation for the development of innovative pharmaceutical products and functional foods with high quality standards.

Numerous studies and review papers have discussed the phytochemical profile of cinnamon; however, most existing reviews examine multiple Cinnamomum species simultaneously and rely on narrative approaches without clearly defined screening procedures. Furthermore, prior reviews tend to emphasize specific groups of compounds, with limited integration of quantitative phytochemical data or evaluation of how extraction techniques and solvent selection affect compound composition. To the best of our knowledge, a comprehensive systematic review that synthesizes the phytochemical constituents of *Cinnamomum burmannii* by combining chemical and biosynthetic classification, quantitative phytochemical parameters, and methodological considerations within a PRISMA-guided framework has not yet been reported. Consequently, a systematic and focused review dedicated to *C. burmannii* is necessary to facilitate extract standardization and inform future phytopharmaceutical research.

METHOD

This study employed a systematic literature review with qualitative synthesis, conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This framework was adopted to ensure transparency, methodological rigor, and reproducibility in the processes of literature identification, screening, eligibility assessment, and reporting. The review aimed to

comprehensively synthesize available scientific evidence regarding the phytochemical constituents of *Cinnamomum burmannii* without performing statistical meta-analysis.

Data Sources, Literature Search and Software

Relevant scientific articles were retrieved from several electronic databases, namely PubMed, Scopus, ScienceDirect, Google Scholar, Web of Science, SpringerLink, and Wiley Online Library. The literature search covered publications from 2015 to 2025, ensuring the inclusion of recent and methodologically robust studies. Articles written in English and Indonesian were eligible for inclusion.The search strategy was developed using a combination of controlled vocabulary terms (MeSH terms for PubMed) and free-text keywords. The keywords used included *"Cinnamomum burmannii"*, *"Indonesian cinnamon"*, *"phytochemical"*, *"bioactive compounds"*, *"chemical composition"*, *"phenolic"*, *"flavonoid"*, *"tannin"*, and *"essential oil"*. Boolean operators (AND/OR) were applied to optimize search sensitivity and specificity across different databases. Reference manager Mendeley Desktop was used for automated reference and citation management, and ChemDraw for drawing chemical structures.General tools and materials do not need to be written down.

Eligibility Criteria

Inclusion Criteria

Studies were considered eligible for inclusion if they met the following conditions:

1. Original experimental or observational research focusing specifically on *Cinnamomum burmannii*.
2. Articles reporting qualitative or quantitative phytochemical findings, including compound identification, profiling, or concentration analysis.
3. Use of established analytical techniques such as GC–MS, HPLC, LC–MS, spectrophotometry, or NMR.
4. Peer-reviewed publications released between 2015 and 2025.
5. Full-text availability in either English or Indonesian.

Exclusion Criteria

Studies were excluded from the review if they:

1. Were review papers, meta-analyses, conference proceedings, theses, dissertations, or book chapters.
2. Investigated *Cinnamomum* species other than *C. burmannii* without clear species identification.
3. Did not provide sufficient methodological information or phytochemical data.
4. Represented duplicate publications identified across multiple databases.
5. Focused on topics outside phytochemical characterization, such as agronomy, economics, or taxonomy.

Study Screening and Selection

The selection of studies was conducted through a multi-stage screening process in line with the PRISMA framework. Initially, all retrieved records were screened based on titles and abstracts to eliminate irrelevant articles and duplicates. Subsequently, full-text articles deemed potentially relevant were evaluated against the

predefined eligibility criteria. Articles failing to meet these criteria were excluded, and the reasons for exclusion were documented.The complete process of study identification, screening, eligibility assessment, and final inclusion is summarized in a PRISMA flow diagram on figure 1.

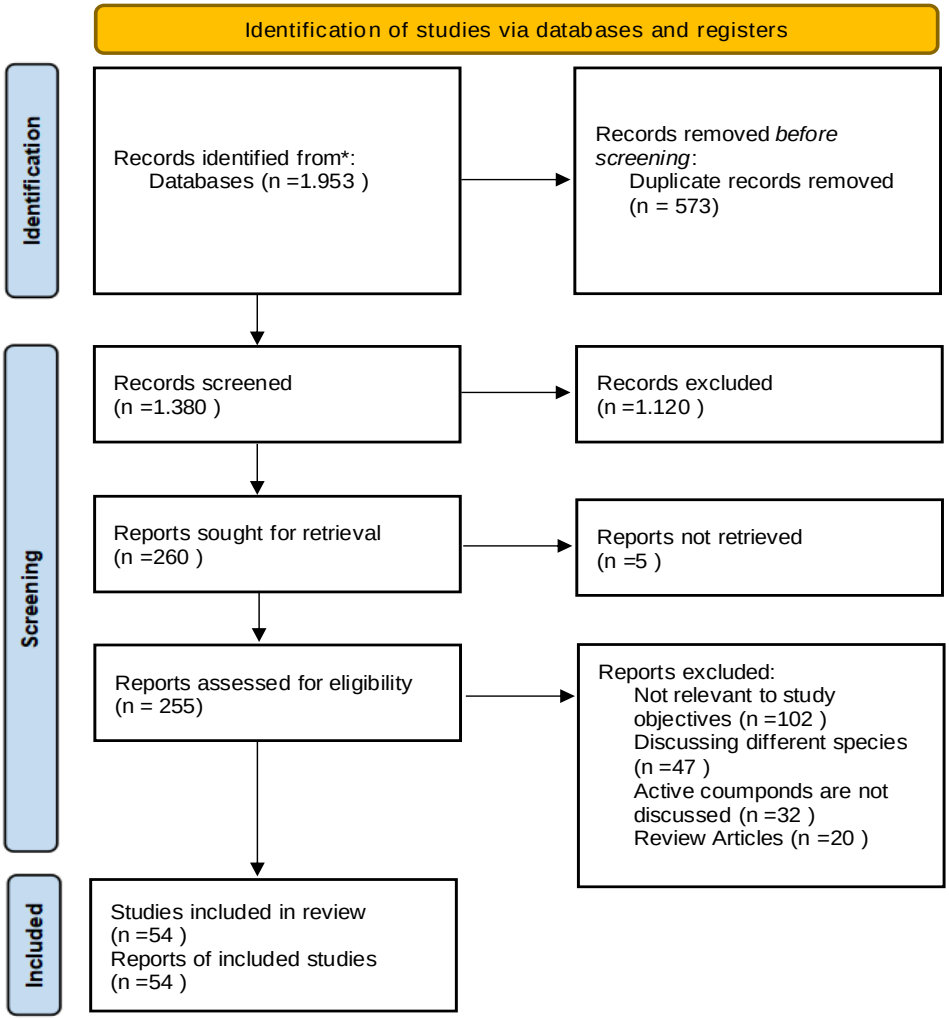


Figure 1. PRISMA Flowchart

Data Extraction

Information from the included studies was systematically extracted using a standardized approach. The extracted data encompassed plant parts analyzed, extraction techniques and solvents, analytical methods employed, classes and identities of phytochemical compounds, quantitative measurements of bioactive constituents, and reported biological activities. This structured extraction ensured consistency across the selected studies.

Data Synthesis and Analysis

Data analysis was performed using a qualitative synthesis approach. Identified phytochemical compounds were classified according to their chemical groups, such as phenolics, flavonoids, tannins, terpenoids, and aromatic aldehydes. Findings from

different studies were compared to identify recurring patterns, variations, and trends in phytochemical profiles. Additionally, factors influencing variability such as extraction methods, solvent polarity, plant parts, and geographical origin were critically examined. This synthesis provided a comprehensive understanding of the phytochemical characteristics and research gaps related to *C. burmannii*.

Data Analysis

The study selection process followed the PRISMA 2020 flowchart. An initial search across four databases identified 1,953 records. After removing duplicate records, 1,380 articles were screened based on title and abstract. Of these, 1,120 records were excluded due to irrelevance. A total of 260 full-text articles were retrieved, of which 255 were assessed for eligibility. Ultimately, 54 studies met the inclusion criteria and were included in this review. This structured screening approach ensured the relevance and methodological appropriateness of the included studies.

RESULT AND DISCUSSION

Phytochemical Constituents of *Cinnamomum burmannii*

The literature review conducted has yielded a comprehensive overview of the phytochemical constituents of *Cinnamomum burmannii*. The study data indicate that Indonesian cinnamon varieties contain a wide variety of bioactive compounds that can be grouped into several major categories. The primary chemical components identified include cinnamyl alcohol, coumarin, cinnamic acid, cinnamaldehyde, anthocyanins, and essential oils, along with additional components such as carbohydrates, proteins, lipids, and pectin. This diversity of phytochemical composition reflects the complex secondary metabolic pathways in *C. burmannii* and explains the diverse pharmacological activities documented in various scientific publications.

The phytochemical characterization obtained through this literature review provides a solid scientific foundation for extract standardization efforts and the development of herbal products based on native Indonesian cinnamon (Maslahah & Hera, 2023; Yuwanda et al., 2023). The complex phytochemical composition reflects the existence of equilibrium between primary and secondary metabolites produced through integrated biosynthetic pathways (Julianto, 2019). Primary metabolites including carbohydrates, proteins, and lipids perform fundamental physiological functions for plant survival, while secondary metabolites such as phenolic compounds, terpenoids, and alkaloids function as a natural defense system for plants in the face of biotic and abiotic stresses. The high concentration of essential oils in the bark of *C. burmannii* indicates the productivity of the highly active mevalonate and non-mevalonate biosynthesis pathways, producing a variety of volatile components with antimicrobial and antioxidant characteristics (Maslahah & Hera, 2023).

The presence of anthocyanins as flavonoid pigments indicates the activity of the flavonoid biosynthesis pathway which contributes to the characteristic color and antioxidant capacity (Julianto, 2019). The organoleptic properties of *Cinnamomum burmannii* extract, including its distinctive aroma, sweet-spicy flavor, and reddish-brown color, reflect the complexity of its phytochemical composition. The distinctive

aroma, which is the primary characteristic, originates from the volatile components present in the essential oil, with cinnamaldehyde being the primary contributor, providing an intense sweet-spicy aroma sensation (Djarot et al., 2023). The distinctive astringent taste of *Cinnamomum burmannii* extract, which is often accompanied by a slight bitterness, arises from the presence of tannins, particularly proanthocyanidins and other phenolic compounds that can bind to saliva proteins and stimulate bitter taste receptors on the tongue (Pires et al., 2020). The difference in the intensity of the extract color, ranging from yellowish to dark brown, is related to the amount of flavonoids and tannins as well as the oxidation process of phenolic compounds that occurs during the extraction and storage stages. The addition of antioxidants such as ascorbic acid is known to slow down color changes and maintain the chemical stability of Indonesian cinnamon extract (Utami et al., 2022). Therefore, understanding the correlation between chemical profiles is key to designing *C. burmannii*-based formulations that remain organoleptically acceptable while maintaining bioactive content at optimal levels (Ervina et al., 2023; Utami et al., 2022).

The distribution pattern of bioactive compounds in various organs of the *C. burmannii* plant exhibits unique characteristics, with the bark containing the highest concentrations of aromatic aldehydes and essential oils, while the leaves exhibit a higher proportion of flavonoids and phenolic compounds (Djarot et al., 2023).This variation in distribution is closely correlated with the physiological and ecological roles of each plant organ, as well as the level of tissue differentiation that impacts the expression of genes involved in secondary metabolite biosynthesis pathways. The diversity of phytochemical content is also strongly influenced by environmental conditions such as elevation, sunlight exposure intensity, soil nutrient availability, and the varying microclimate characteristics of each cultivation area. A thorough understanding of the various factors influencing the accumulation of bioactive compounds is crucial in medicinal plant cultivation practices to optimize the acquisition of desired target compounds (Yuwanda et al., 2023).

Separation Methods and Analysis Techniques for Determining Compounds in Cinnamon Samples

Various extraction and analysis techniques have been developed to identify and isolate bioactive compounds from *Cinnamomum burmannii*. The choice of this method greatly determines the profile of the detected compounds, as well as the effectiveness of pharmaceutical and food applications. Maceration is a simple extraction method commonly used to obtain non-volatile compounds from dried herbals. Various solvents such as methanol, ethanol (with various concentrations), ethyl acetate, and n-hexane are used according to the polarity of the target compound. Methanol is very effective for extracting phenolic compounds and flavonoids. Recent research shows that the highest total phenolic content is produced in extraction with methanol, reaching 111.43 mg GAE/g (Afdal et al., 2023). Ethanol 80 - 96% is the most popular solvent for pharmaceutical and food production due to its safety. Extraction with 80% and 96% ethanol yields high levels of cinnamaldehyde and flavonoids, as well as a rich polyphenol profile (Wang et al., 2023). Ethyl acetate is used as a semi-polar solvent, effective for the isolation of coumarin and some phenolic compounds (Ervina et al., 2023).

Table 1. Separation Methods and Analysis for Compound Determination

Parts of Plant	Separation Methods	Preparation of Samples	Analysis Methods	Main compounds detected	Reference
Bark	Hydrodistillation	Cinnamon bark is ground and distilled using a Clevenger-type apparatus.	GC-MS	Cinnamaldehyde (92.46%), cinnamyl alcohol, coumarin, cinnamic acid	(Tenouye et al., 2025)
	Maceration with methanol	Cinnamon bark powder (1 mm sieve), ratio 1:10 with methanol, room temperature, 3×24 hours with stirring	Spectrophotometric, DPPH Assay	Total phenolic (111.43 mg GAE/g), total flavonoid, coumarin, cinnamaldehyde	(Afdal et al., 2023)
	Maceration with ethanol 96%	Cinnamon bark is dried at 60°C, ground to 80 mesh, and macerated with 96% ethanol for 72 hours.	Colorimetric, GC-MS, Bioassay	Cinnamaldehyde (65-80%), quercetin, kaempferol, phenolic compounds, total polifenol (17.96%)	(Susilowati & Setiawan, 2020; Tisnadjaja et al., 2020)
	Maceration with 80%	Cinnamon bark powder was macerated with 80% ethanol at room temperature for 3×24 hours.	Spektrofotometri, GC-MS, LC-MS	Total phenolic (22.27 mg GAE/g), total flavonoid (25.81 mg/g), quercetin, kaempferol	(Utami et al., 2022; Wang et al., 2023)
	Maceration with ethanol 30%	The powdered crude drug is macerated with 30% ethanol at room temperature for 3-7 days.	Spectrophotometric	Yield 29.25%	(Ilmi et al., 2022)
	Maceration with ethyl acetate	The crude powder was macerated in stages with ethyl acetate after hexane extraction.	GC-MS, TLC	Coumarin, phenolic compounds, senyawa semi-polar	(Ervina et al., 2023)
	Maceration with n-hexane	1000 g of crude powder was macerated with n-	TLC, Spectrophotometr	Essential oils (non-polar), terpenoids, fatty acids,	(Prasetyorini et al., 2022)

Parts of Plant	Separation Methods	Preparation of Samples	Analysis Methods	Main compounds detected	Reference
		hexane at a ratio of 1:10 at room temperature.	ic	hidrokarbon	
	Soxhletation with ethanol	Dried cinnamon bark is placed in a Soxhlet thimble, ~25 circulations (~6-8 hours)	HPLC, Spectrophotometric, DPPH	Phenolic compounds, flavonoids, saponins (IC50: 24.98 ppm)	(Ervina et al., 2023)
	Microwave Assisted Extraction	Cinnamon bark samples were extracted with ethanol using microwave-assisted extraction.	GC-MS	Trans-cinnamaldehyde, eugenol, camphor, cinnamyl acetate	(Liu et al., 2021)
	Ultrasonic Assisted Extraction	Cinnamon powder was extracted with 95% ethanol at 40°C for 60 minutes.	Spectrophotometric	Total phenolic (466.8 mg/g)	(Ilmi et al., 2022)
	Steam Distillation	The bark is crushed and then distilled using steam for 4-5 hours.	GC-MS	Cinnamaldehyde, cinnamyl acetate, cinnamyl alcohol, cinnamic acid, copaene	(Chairunnisa et al., 2017)
	Decoction	Cinnamon bark is boiled in water at 90-100°C for 30-60 minutes.	HPLC, Rheological Analysis	Arabinoxylans, polysaccharides, phenolic compounds	(Nunes et al., 2022)
Leaves	Hydrodistillation	Fresh/dried cinnamon leaves are crushed and distilled for 3-4 hours.	GC-MS	Trans-cinnamaldehyde (68.30-84.12%), cinnamyl acetate (2.97-16.10%), cinnamyl alcohol	(Fajar et al., 2019)
	Maceration with ethanol 70%	Fresh/dried leaves are macerated with 70% ethanol at room temperature	Spectrophotometric, TLC	Total phenolic, flavonoid (quercetin, kaempferol), tanin	(Wang et al., 2023)

n-Hexane is an optimal non-polar solvent for extracting essential oils, terpenoids, and lipid compounds (Prasetyorini et al., 2022). The application of multistage maceration (sequential with solvents of increasing polarity) is also common to obtain a broader spectrum of compounds from a single biomass sample. Modern techniques such as Microwave-Assisted Extraction (MAE) and Ultrasonic-Assisted Extraction (UAE) have been widely applied to improve the efficiency of isolating active compounds from cinnamon. Both methods accelerate the extraction process, increase yield, and maintain the stability of heat-sensitive compounds. Research by Lee et al., (2018) mshows that MAE provides the highest efficiency in extracting major compounds such as cinnamic acid and cinnamaldehyde from cinnamon powder compared to UAE and conventional reflux. Meanwhile, Gilani & Najafpour (2022) reported that both MAE and UAE were equally effective in extracting bioactive compounds from cinnamon bark, but MAE produced the highest yield and polyphenol content under optimal conditions of 85% ethanol with a ratio of 1:40 g/mL. Extraction success is greatly influenced by the type of solvent, temperature, contact duration, and method used. Maceration with polar solvents is excellent for isolating flavonoids and phenolic compounds, while non-polar solvents produce optimal yields for essential oils and low-polarity metabolites. MAE and UAE offer efficiency and time savings.

Hydro-distillation and steam distillation are widely used to obtain essential oils, which contain volatile compounds such as cinnamaldehyde, eugenol, and linalool. This method utilizes hot steam to capture aromatic compounds from fresh or dried herbs, and is very important in researching the essential oil profile of cinnamon (Fajar et al., 2019). After the evaporation process, the vapor mixture is condensed and produces two liquid phases, namely oil and water, which are then separated. Research by Lewa & Gugule (2022) shows that steam distillation of cinnamon bark (*Cinnamomum burmannii*) produces essential oil with a distinctive sweet-spicy aroma and a cinnamaldehyde content of 60.72%, followed by eugenol (17.62%) and coumarin (13.39%), which contribute to the antibacterial and antioxidant activity of the oil. Fajar et al., (2019), the steam distillation process was carried out at a temperature of around 96.5 °C with a pressure of 0.92 atm, and condenser cooling at a temperature of 0–10 °C. The distillate produced is a mixture of water and essential oil, which is then separated through liquid-liquid extraction using dichloromethane, dried with anhydrous sodium sulfate, and evaporated at 50 °C using a rotary evaporator to obtain a golden yellow oil.

The highest yields were found in branch bark (3.2 ± 0.07%) and stem bark (2.95 ± 0.30%), with a moisture content of 36–47%. GC–MS analysis showed that the main components of the oil were cinnamaldehyde (68.3–82%), cinnamyl acetate (2.5–16%), cinnamyl alcohol (2.25–4.6%), and cinnamic acid (3–8%), which meet the quality standards of SNI 06-3734-2006 and ISO 3216:1997 with a cinnamaldehyde content of ≥ 70%. In addition to hydrodistillation and steam distillation, modern approaches such as microwave-assisted distillation and ultrasonic-assisted extraction are beginning to be applied to improve the efficiency of volatile component release with shorter times and lower energy consumption without reducing the stability of bioactive compounds. The development of these distillation techniques is important to ensure the standardization of the quality of Indonesian cinnamon essential oil as a competitive

raw material for pharmaceuticals, cosmetics, and aromatherapy in the global market (Liu et al., 2021; Wang et al., 2023).

GC-MS (Gas Chromatography - Mass Spectrometry) is very effective for volatile compounds from essential oils and hexane and ethyl acetate extraction results (Liu et al., 2021). Spectrophotometry and HPLC/LC-MS (High Performance Liquid Chromatography / Liquid Chromatography–Mass Spectrometry) are recommended for the analysis of polar compounds such as phenolics, flavonoids, and saponins. Both methods are capable of accurately detecting and quantifying bioactive compounds from polar and semi-polar solvent extracts (Wang et al., 2023).

Identification of Bioactives Compounds

Phytochemical compounds in *Cinnamomum burmannii* can be grouped into eight main categories based on their chemical structure and biosynthetic pathway. Table II shows the complete profile of bioactive compounds identified through GC-MS and HPLC analysis from various studies. Aromatic aldehydes are the most dominant group, with cinnamaldehyde as the main marker compound (34.44%) and benzaldehyde (0.12%). The aromatic aldehyde structure contains an aldehyde functional group (-CHO) bound to a benzene ring, conferring high reactivity and potent antimicrobial activity. The coumarin group is represented by coumarin (16.82%), which has a benzopyrone core structure. Coumarins belong to the group of phenolic compounds with lipophilic properties that facilitate penetration of biological membranes. Aromatic alcohols include cinnamyl alcohol (3.98%), with a benzene structure bound to an alcohol hydroxyl group. This compound is a reduction product of cinnamaldehyde in the biosynthetic pathway (Zhang et al., 2024).

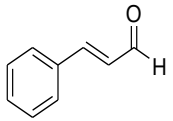
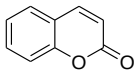
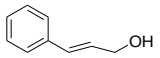
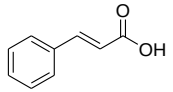
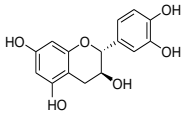
The organic acid group, especially cinnamic acid (1.64%), acts as a precursor for the biosynthesis of various phenolic compounds. Cinnamic acid has an unsaturated carboxylic acid structure bound to a benzene ring. The flavonoid group includes various subclasses such as catechin (1.65%), procyanidin B1 (0.04%), procyanidin B2 (4.06%), procyanidin trimer (11.98%), procyanidin dimer (0.24%), and epicatechin (0.01%). Flavonoids have a basic C6-C3-C6 carbon skeleton consisting of two benzene rings bound by a propane chain, with varying hydroxyl substitution patterns. Terpenoid groups such as eugenol (25.67%), camphene (0.13%), α-pinene (0.08%), β-pinene (0.14%), α-terpineol (0.85%), borneol (3.28%), α-thujene (0.59%), β-myrcene (0.52%), α-thujene (0.26%), o-cymene (1.56%), D-limonene (1.49%), terpinen-4-ol (1.69%), β-caryophyllene (1.84%), α-selinene (0.13%), bicyclogermacrene (0.29%), and guaiol (0.63%). Terpenoids are products of the isoprenoid biosynthesis pathway with the basic unit isoprene (C5), which can be monoterpenes (C10), sesquiterpenes (C15), or diterpenes (C20) (Liang et al., 2019; Zhang et al., 2024).

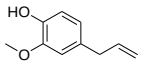
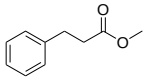
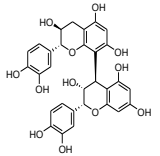
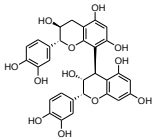
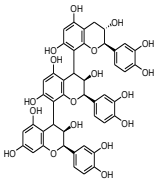
Aromatic esters include methyl cinnamate (3.16%), ethyl cinnamate (0.22%), linalyl propionate (11.91%), linalyl acetate (0.28%), and isobornyl acetate (10.48%). Aromatic esters are formed by the esterification reaction between a carboxylic acid or alcohol and an acyl group, imparting their characteristic aroma. Other aromatic compounds include styrene (0.30%), carvone (0.12%), methoxyacetophenone (0.22%), and 1,5,9,9-tetramethyl-1,4,7-cycloundecatriene (0.67%). Classification of compounds

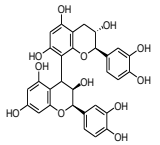
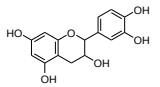
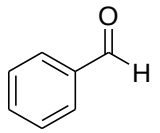
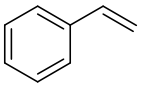
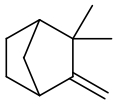
based on chemical structure provides a systematic framework for understanding molecular diversity and predicting biological activity. The aromatic aldehydes, dominated by cinnamaldehyde, have a basic structure consisting of a benzene ring with a propenal side chain containing a reactive aldehyde group. The reactivity of this aldehyde group explains the antimicrobial mechanism through the formation of covalent bonds with amino and sulfhydryl groups in the cell membrane proteins of microorganisms, causing denaturation and loss of vital functions (Zhang et al., 2024).

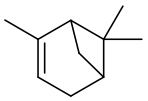
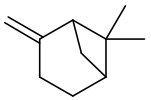
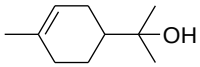
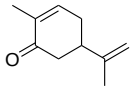
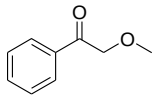
The flavonoid group in *C. burmannii* includes various subclasses with varying hydroxyl substitution and glycosidation patterns, including quercetin, catechin, and procyanidin (Qarani et al., 2023; Utami et al., 2022). The hydroxyl substitution pattern at positions 3', 4', and 5' in the B ring of flavonoids is strongly correlated with antioxidant capacity through hydrogen donation ability and free radical stabilization through electron resonance (Qarani et al., 2023; Tisnadjaja et al., 2020). Catechin as flavan-3-ol has metal-chelating activity which contributes to the antioxidant effect by preventing the Fenton reaction which produces hydroxyl radicals (Farag et al., 2022). The terpenoid group is the second largest group of compounds after aromatic aldehydes in *C. burmannii*. Eugenol with an allylbenzene structure containing phenol and allyl groups exhibits analgesic activity through modulation of sodium ion channels and antiseptic activity through disruption of cell membranes (Sharifi-Rad et al., 2021). Monoterpenes such as α-pinene and β-pinene contribute to the characteristic aroma and have significant antimicrobial activity (Singh et al., 2023). The identification and characterization of bioactive compounds from *Cinnamomum burmannii* has progressed rapidly thanks to the use of modern analytical techniques such as gas chromatography-mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC), nuclear magnetic resonance spectroscopy (NMR), and infrared spectroscopy (IR) (Qarani et al., 2023; Sirait et al., 2023). The use of high-resolution mass spectrometry (HRMS)-based metabolomics techniques such as UPLC-MS and chemometric analysis is able to identify hundreds of previously undetected minor metabolites, thereby enriching the phytochemical database and deepening the understanding of the structure and potential bioactivity of cinnamon metabolites (Farag et al., 2022; Serrano et al., 2024). Comprehensive knowledge of phytochemical profiles and compound grouping based on structure and biological activity now provides a very strong scientific basis for the development of standardized herbal products, innovation of pharmaceutical formulations, and exploration of new therapeutic candidates based on *C. burmannii* from Indonesia (Husna et al., 2024; Utami et al., 2022).

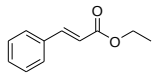
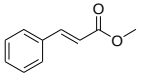
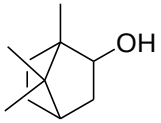
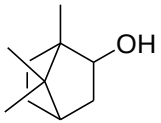
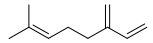
Tabel 2. Chemical Composition of *Cinnamomum burmannii*

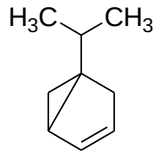
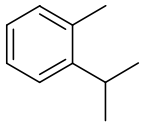
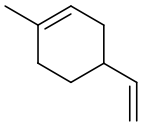
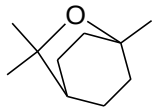
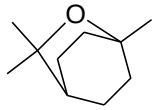
No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
1.	Aromatic aldehyde	Cinnamaldehyde (PubChem CID: 637511)	Ethanol	Bark	34.44%		(Liang et al., 2019)
2.	Coumarin	Coumarin (PubChem CID: 323)	Ethanol	Bark	16.82%		(Liang et al., 2019)
3.	Aromatic alcohol	Cinnamyl alcohol (PubChem CID: 5315892)	Ethanol	Bark	3.98%		(Liang et al., 2019)
4.	Phenolic acid	Cinnamic acid (PubChem CID: 444539)	Ethanol	Bark	1.64%		(Liang et al., 2019)
5.	Flavonoid	Catechin (PubChem CID: 9064)	Ethanol	Bark	1.65%		(Liang et al., 2019)

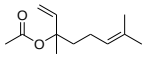
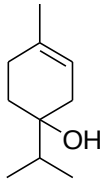
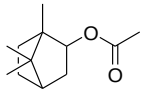
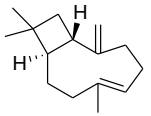
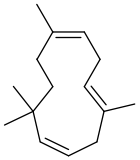
No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
6.	Terpenoid	Eugenol (PubChem CID: 3314)	Ethanol	Bark	25.67%		(Liang et al., 2019)
7.	Aromatic ester	Methyl Cinnamate (PubChem CID 637520)	Ethanol	Bark	3.16%		(Liang et al., 2019)
8.	Flavonoid	Procyanidin B1 (PubChem CID 11250133)	Ethanol	Bark	0.04%		(Liang et al., 2019)
9.	Flavonoid	Procyanidin B2 (PubChem CID 122738)	Ethanol	bark	4.06%		(Liang et al., 2019)
10.	Flavonoid	Procyanidin Trimer (PubChem CID 58571364)	Ethanol	bark	11.98%		(Liang et al., 2019)

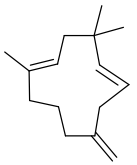
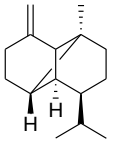
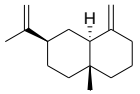
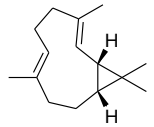
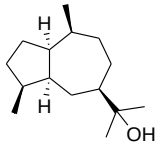
No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
11.	Flavonoid	Procyanidin Dimer	Ethanol	bark	0.24%		(Liang et al., 2019)
12.	Flavonoid	Epicatechin (PubChem CID 72276)	Ethanol	bark	0.01%		(Liang et al., 2019)
13	Aromatic aldehyde	Benzaldehyde (PubChem CID: 240)	n-butane	bark	0.12%		(Liang et al., 2019)
14.	Senyawa Aromatik	Styrene (PubChem CID 7501)	n-butane	bark	0.30%		(Liang et al., 2019)
15.	Terpenoid	Camphene (PubChem CID 6616)	n-butane	bark	0.13%		(Liang et al., 2019)

No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
16.	Terpenoid	α-Pinene (PubChem CID 6654)	n-butane	bark	0.08%		(Liang et al., 2019)
17.	Terpenoid	β-Pinene (PubChem CID 14896)	n-butane	bark	0.14%		(Liang et al., 2019)
18.	Terpenoid	α-Terpineol (PubChem CID 17100)	n-butane	bark	0.85%		(Liang et al., 2019)
19.	aromatic	Carvone (PubChem CID 7439)	n-butane	bark	0.12%		(Liang et al., 2019)
20.	aromatic	Methoxyacetophenone (PubChem CID 7476)	n-butane	bark	0.22%		(Liang et al., 2019)

No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
21.	Aromatic ester	Ethyl cinnamate (PubChem CID 637758)	n-butane	bark	0.22%		(Liang et al., 2019)
22.	Ester Aromatik	Methyl cinnamate (PubChem CID 637520)	n-butane	bark	3.16%		(Liang et al., 2019)
23.	Terpenoid	Borneol (PubChem CID 64685)	n-butane	bark	3.28%		(Liang et al., 2019)
24.	Terpenoid	β-Thujene (PubChem CID 520384)	GC-MS	Leaves & bark	0.59%		(Zhang et al., 2024)
25.	Terpenoid	β-Myrcene (PubChem CID 31253)	GC-MS	Leaves & bark	0.52%		(Zhang et al., 2024)

No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
26.	Terpenoid	α-Thujene (PubChem CID 17868)	GC-MS	Leaves & bark	0.26%		(Zhang et al., 2024)
27.	Terpenoid	o-Cymene (PubChem CID 10703)	GC-MS	Leaves & bark	1.56%		(Zhang et al., 2024)
28.	Terpenoid	D-Limonene (PubChem CID 440917)	GC-MS	Leaves & bark	1.49%		(Zhang et al., 2024)
29.	Terpenoid	Eucalyptol (PubChem CID 2758)	GC-MS	Leaves & bark	8.42%		(Zhang et al., 2024)
30.	Ester Aromatik	Linalylpropionate (PubChem CID 61098)	GC-MS	Leaves & bark	11.91%		(Zhang et al., 2024)

No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
31.	Ester Aromatik	Linalylacetate (PubChem CID 8294)	GC-MS	Leaves & bark	0.28%		(Zhang et al., 2024)
32.	Terpenoid	Terpinen-4-ol (PubChem CID 11230)	GC-MS	Leaves & bark	1.69%		(Zhang et al., 2024)
33.	Ester Aromatik	Isobornylacetate (PubChem CID 637531)	GC-MS	Leaves & bark	10.48%		(Zhang et al., 2024)
34.	Terpenoid	Caryophyllene (PubChem CID 5281515)	GC-MS	Leaves & bark	1.84%		(Zhang et al., 2024)
35.	Senyawa Aromatik	1,5,9,9-Tetramethyl-1,4,7-cycloundecatriene (PubChem CID 5368784)	GC-MS	Leaves & bark	0.67%		(Zhang et al., 2024)

No	Compound Groups	Name	Solvent	Part of Plants	Yield	Compound Structure	Reference
36.	Terpenoid	Humulene (PubChem CID 5281520)	GC-MS	Leaves & bark	0.01%		(Zhang et al., 2024)
37.	Terpenoid	β-copaene (PubChem CID 57339298)	GC-MS	Leaves & bark	0.13%		(Zhang et al., 2024)
38.	Terpenoid	β-Selinene (PubChem CID 442393)	GC-MS	Leaves & bark	0.13%		(Zhang et al., 2024)
39.	Terpenoid	Bicyclogermacrene (PubChem CID 13894537)	GC-MS	Leaves & bark	0.29%		(Zhang et al., 2024)
40.	Terpenoid	Guaiol (PubChem CID 227829)	GC-MS	Leaves & bark	0.63%		(Zhang et al., 2024)

Characterization of Chemical Structure and Physicochemical Properties

A thorough analysis of the molecular architecture of phytochemical compounds in *Cinnamomum burmannii* reveals distinctive structural characteristics in each major group. Cinnamaldehyde, the dominant aromatic aldehyde component, is composed of a benzene skeleton bound by an aldehyde group and an unsaturated carbon chain, allowing it to react strongly with nucleophilic molecules and effectively damage the integrity of microbial cell membrane proteins. Coumarin has a basic benzenoid lactone structure that produces lipophilic properties and increases permeability across cell membranes (Sharifi-Rad et al., 2021). Flavonoids such as quercetin in cinnamon exhibit antioxidant activity through aromatic and hydroxyl ring groups, which are very effective in electron transfer and neutralizing reactive oxygen species (Qarani et al., 2023; Utami et al., 2022). Identification and confirmation of the chemical structure of these compounds have been achieved through modern spectroscopic techniques including NMR, MS, GC-MS, and FTIR, thus providing a strong foundation in studying the correlation between chemical structure and biological activity for the optimization of cinnamon-based phytopharmaceuticals (Qarani et al., 2023; Tenouye et al., 2025).

Determination of Active Compound Content

The results of measurements of the concentration of bioactive components in *Cinnamomum burmannii* show quite wide fluctuations, which are highly dependent on the extraction technique and the type of solvent used. Data collected from various studies indicate that the total flavonoid concentration ranges from 15.15 to 55.76 mg of quercetin equivalents per gram of extract, with the extraction process using ethanol showing the most optimal yield. The total phenolic content is recorded in the interval of 31.33 to 89.79 mg of gallic acid equivalents per gram of extract, indicating very adequate antioxidant potential. The total tannin concentration varies from 89.34 to 217.13 µg of catechin equivalents per mg of extract, which is influenced by the plant segment used and the extraction process parameters (Lopes et al., 2022).

Cinnamaldehyde, a characteristic marker component, has a concentration of 65-75% in the volatile oil from the stem bark, while coumarin content ranges from 0.5-2.1% of the dry weight of the herbal medicine. This concentration variation is influenced by various factors such as geographic location, plant maturity, climate variation, harvesting period, and most crucially, the extraction procedure used. This quantitative information provides a fundamental reference for product standardization and quality control in the herbal-based industry (Emilda, 2018).

The procedure for analyzing total flavonoid concentration through UV-Vis spectrophotometry using aluminum chloride reagent is based on the formation of colored complex compounds resulting from the interaction of Al^{3+} ions with the ketone group at position C-4 and the hydroxyl group at position C-3 or C-5 of the flavone and flavonol molecular framework. The resulting complex compounds exhibit a bathochromic shift phenomenon in the absorbance spectrum, namely a shift from around 360 nm to the 415-430 nm range accompanied by an increase in intensity that is linearly correlated with the flavonoid concentration. The construction of a standard curve was carried out by preparing a series of quercetin solutions at a concentration interval of 10-100 µg/mL, where the results of the total flavonoid concentration

measurements were expressed in quercetin equivalent units. This technique shows good sensitivity with a detection limit reaching around 0.5 µg/mL, however, it does not provide specificity for individual flavonoids because various flavonoid subgroups show varying responses to the same reagent (Haresmita & Pradani, 2022).

The Folin-Ciocalteu technique for analyzing total phenolic content is based on the reduction process of phosphomolybdate-phosphotungstate reagents triggered by phenolic groups in alkaline conditions, producing a blue molybdenum-tungsten complex whose absorbance is detected at 765 nm. Gallic acid was selected as a reference compound based on its structural simplicity, availability with a high degree of purity, and consistency of response to analytical reagents. It should be understood that this technique quantifies the overall reduction capacity in a sample, so it does not exclusively measure phenolic compounds alone, considering that other reducing components such as vitamin C, sugars with aldehyde groups, and amino acids with aromatic rings also contribute to the measured absorbance value. Interference from impurity compounds can be reduced through careful sample preparation and the application of adequate blank correction. Wide variations in total phenolic concentrations from various types of extracts reflect differences in the effectiveness of various solvent systems in extracting phenolic compounds with varying polarity characteristics (Qarani et al., 2023).

The determination of total tannin content can be carried out using various analytical methods, one of the most commonly used being the vanillin–HCl test for condensed tannins. This colorimetric technique is based on a condensation reaction catalyzed by acid between the flavan-3-ol group and vanillin, producing a red chromophore with an intensity proportional to the tannin concentration (Fraga-corral et al., 2020; Lopes et al., 2022). This analysis shows that the tannin content in various Cinnamomum species has a fairly wide range, with *C. burmannii*, which is classified as false cinnamon, showing values between 89.34 and 217.13 mg CE/g, while true cinnamon (*C. verum*) has a content between 72.04 and 234.9 mg CE/g. This variation in tannin content is influenced by differences in species, geographical conditions, harvest time, and storage, which can alter the proanthocyanidin composition. Although some studies report that *Cinnamomum cassia* and *C. burmannii* have higher tannin content than *C. verum*, the results of Lopes et al. show that the difference is not statistically significant. This indicates that the distribution of type A and type B proanthocyanidin compounds can vary between samples without necessarily reflecting lower or higher quality (Lopes et al., 2022). This method has good sensitivity and is widely used for *C. burmannii* bark extract because it can provide quantitative estimates of proanthocyanidin content, which plays an important role in antioxidant activity and free radical scavenging ability (Lopes et al., 2022). However, the vanillin–HCl method has limitations because it can only detect condensed tannins, while hydrolyzed tannins do not give the same response to the vanillin reagent. In addition, the analysis results may vary due to interference from other phenolic compounds with similar structures that also react in the analysis system (Fraga-corral et al., 2020). Therefore, interpretation of the quantification results needs to consider the possible contribution of other interfering compounds. Overall, this method is still recommended because it is simple, efficient,

and provides consistent results for the purposes of standardizing tannin content and assessing biological activity in *C. burmannii*-based herbal products.

Tabel 3. Total Compound Content of *Cinnamomum burmannii*

No.	Compound Content	Analysis Methods	Standard	Values	Reference
1	Fenolik Total (TPC)	Folin–Ciocalteu	Gallic acid	66.34 g GAE/100 gram	(Qarani et al., 2023)
2	Flavonoid Total (TFC)	Aluminium Klorida ($AlCl_3$)	Quercetin	80.52 g QE/100 gram	(Qarani et al., 2023)
3	Tanin Total (TTC)	Vanillin–HCl (Julkunen-Tiitto, 1985)	(+)-Catechin (CE)	89.34 - 217.13 mg CE/gram	(Lopes et al., 2022)
4	Fenolik Total (TPC)	Folin–Ciocalteu	Gallic acid (GAE)	31.33- 89.79 g GAE/100 gram	(Lopes et al., 2022)
5	Flavonoid Total (TFC)	Aluminium Klorida ($AlCl_3$)	Quercetin	15.15- 55.76 g QE/100 gram	(Lopes et al., 2022)

In relation to extraction efficiency, the reviewed studies indicate that solvent polarity plays a crucial role in determining active compound content. Ethanol-based extracts consistently demonstrated higher total flavonoid and phenolic contents compared to non-polar solvents, suggesting that ethanol is the most effective solvent for obtaining a broad spectrum of bioactive compounds from *Cinnamomum burmannii*. This effectiveness is attributed to ethanol's ability to solubilize both moderately polar and polar phytochemicals, resulting in higher extraction yields and more representative phytochemical profiles.Regarding extraction techniques, conventional maceration emerged as the most consistently applied method across studies, providing reproducible results with relatively minimal methodological variation. While advanced techniques such as ultrasonic-assisted extraction showed potential for enhancing compound recovery, differences in extraction parameters limited comparability between studies. Therefore, based on cross-study consistency and reproducibility, maceration using ethanol can be considered the most reliable approach for determining active compound content in *C. burmannii*.

Pure Compound of *Cinnamomum burmannii*

These pure compounds were isolated through extraction, column chromatography fractionation, and purified to obtain pure crystals or solids which were then characterized using modern spectroscopic techniques. Burmanoside is a new compound isolated from *C. burmannii* flowers by Yang et al., (2024). This compound has a molecular formula of $C_{14}H_{26}O_{11}$ with a skeletal structure of dioxane and tetrahydro-2H-pyran-3,4,5-triol which has never been reported before from the genus

Cinnamomum. Isolation produced 13 mg of pure compound from 304 g of dried flowers. Characterization was carried out by HR-ESI-MS which showed the $[M+Na]^+$ ion at m/z 393.1377, as well as 1D and 2D NMR techniques (^{1}H-NMR, ^{13}C-NMR, COSY, NOESY, HSQC, HMBC) for complete structure determination. The unique structure of burmanoside enriches the phytochemical database of Indonesian cinnamon (Yang et al., 2024).

Burmafuranic acid is a new tetrahydrofuran lignan derivative isolated from the stem of *C. burmannii*. This compound has the formula $C_{14}H_{18}O_7$ with a molecular weight of 298. A total of 4 mg of the pure compound was successfully isolated from 2.12 kg of dried stems by methanol extraction and stepwise column chromatography. The structure was confirmed using HR-EIMS ($[M+Na]^+$ m/z 321.0947), 1H-NMR (600 MHz) which showed an AX doublet pattern on the aromatic ring, and 1C-NMR which identified a carbonyl signal at δ 178.0. Burmafuranic acid is a phenolic lignan with a carboxylic acid group that provides unique structural characteristics (Yang et al., 2023). Burmannic acid is a novel apocarotenoid isolated from the roots of *C. burmannii*. This compound was characterized using 2D NMR spectroscopy (HSQC, HMBC, COSY) and mass spectrometry. Burmannic acid exhibits significant pharmacological activity as a selective antiproliferative agent against oral cancer cells (Ca9-22, CAL 27, OC-2) with an IC_{50} ranging from 7.5-10 μM. Its mechanism of action involves the induction of oxidative stress through increased MitoSOX, mitochondrial membrane depolarization, caspase 3/8/9 activation, and DNA damage characterized by increased γH2AX and 8-OHdG. This compound has minimal toxicity to normal cells (HGF-1), providing potential as a candidate anticancer agent (Liu et al., 2021).

O-hydroxycinnamic acid or 2-propenoic acid, 3-(2-hydroxyphenyl)-, (E)- was isolated from the bark of *C. burmannii*. This compound with the formula $C_9H_8O_3$ is a cinnamic acid derivative with a hydroxyl group substitution at the ortho position of the benzene ring. Isolation was carried out using ethyl acetate extraction and gravity column chromatography of 15.8 g of crude extract. Characterization by 1H-NMR showed trans aromatic and olefinic proton signals, 1C-NMR confirmed 9 carbons including conjugated carbonyls, and MS showed 97% similarity to the target structure. This pure compound showed sunscreen activity with a Sun Protection Factor (SPF) value of 33.62 ± 0.62, equivalent to commercial sunscreen products. The mechanism of action involves the absorption of UV light through a conjugated double bond system. The lotion formulation containing this compound produces an SPF of 32.14 ± 0.97 with physical properties that meet SNI standards (Nasution et al., 2022).

The four pure compounds isolated from *C. burmannii* exhibit high structural diversity, ranging from complex glycosides (burmanosides), lignans (burmafuranic acid), apocarotenoids (burmannic acid), to cinnamic acid derivatives (o-hydroxycinnamic acid). This diversity reflects the richness of secondary metabolite biosynthesis pathways in the Cinnamomum genus. Proven biological activities such as anti-cancer proliferative effects and sunscreen activity provide added value for the development of Indonesian cinnamon-based pharmaceutical and cosmetic products. These pure compounds also serve as reference standards for quality control of herbal extracts and provide molecular templates for structure-activity relationship studies in the design of new drugs.

Evaluation of Potential Biological Activity

Evaluation of the potential biological activity of phytochemical constituents of *Cinnamomum burmannii* through structure-activity relationship analysis showed a significant correlation between molecular architecture and its pharmacological effects (Sharifi-Rad et al., 2021). Aromatic aldehyde compounds such as cinnamaldehyde exhibit strong antimicrobial capacity through protein denaturation and disruption of the integrity of microorganism cell membranes (Zhang et al., 2024). Phenolic groups such as cinnamic acid with aromatic rings and hydroxyl substituents exhibit antioxidant activity through their ability to scavenge free radicals (Lopes et al., 2022). Coumarin with a lactone structure shows anticoagulant potential but is hepatotoxic in excessive doses (Qarani et al., 2023). Flavonoids such as quercetin, catechin, and procyanidin exhibit anti-inflammatory activity through inhibition of cyclooxygenase and lipoxygenase enzymes (Ahmed et al., 2021). The aromatic alcohol cinnamyl alcohol provides antimicrobial and anti-inflammatory effects (Liang et al., 2019). Terpenoids such as eugenol, α-pinene, and β-caryophyllene exhibit analgesic and antiseptic activities through modulation of ion channels (Maslahah & Hera, 2023). Aromatic esters such as methyl cinnamate, linalyl propionate, and isobornyl acetate exhibit antimicrobial activity and aromatherapy effects (Zhang et al., 2024). The synergistic effect between compounds in the complex extract produces superior activity compared to single compounds, supporting the concept of multi-target therapy in herbal medicine (Muslikh et al., 2025). Table 4 shows a summary of documented biological activities for each group of compounds, providing a scientific basis for the development of more targeted and safer therapeutic applications.

Tabel 4. Biological Activities of Phytochemical Constituents of *C.burmannii*

Compound Groups	Main Compound	Biological Activity	Mechanism	Application Potential	Reference
Aromatic aldehyde	Cinnamaldehyde	Antimicrobial, Antidiabetic, Antioxidant	Denaturation of cell membrane proteins, inhibition of α-glucosidase, scavenging of free radicals	Natural food preservative, antidiabetic, antioxidant	(Wang et al., 2023; Zhang et al., 2024)
Coumarin	Coumarin	Anticoagulant, Anti-inflammatory, Hepatotoxic	Vitamin K inhibition, NF-κB pathway modulation, CYP450 metabolism	Controlled antithrombotic, health supplement	(Liang et al., 2019; Qarani et al., 2023)
Flavonoid	Quercetin, Catechin, Procyanidi	Antioxidant, Anti-inflammator	Radical scavenging, COX-2 and	Nutraceutical supplements	(Handayani et al., 2024; Sharifi-Rad

Compound Groups	Main Compound	Biological Activity	Mechanism	Application Potential	Reference
	n	y, Anticancer	LOX inhibition, metal chelation, apoptosis induction	, chemopreventive agents	et al., 2021; Utami et al., 2022)
Terpenoid	Eugenol, α-Pinene, β-Caryophyllene	Analgesic, Antiseptic, Antimicrobial, Anti-inflammatory	Na^+ channel modulation, microbial cell membrane disruption, inflammatory mediator inhibition	Dental care, topical medication, aromatherapy	(Maslahah & Hera, 2023; Zhang et al., 2024)
Phenolic acid	Cinnamic acid	Antimicrobial, Photoprotective, Antioxidant	Photostabilization, UV absorption, microbial cell membrane disruption	Cosmetics, sunscreen, preservatives	(Amin et al., 2025; Lopes et al., 2022)
Aromatic alcohol	Cinnamyl alcohol	Antimicrobial, Anti-inflammatory, Fragrance	Inhibition of microbial growth, modulation of inflammatory response	Flavor and fragrance industry, cosmetics	(Liang et al., 2019)
Aromatic esters	Methyl cinnamate, linalyl propionate, isobornyl acetate	Antimicrobial, Therapeutic aroma	Microbial membrane disruption, CNS relaxation effect	Food flavoring, aromatherapy, cosmetics	(Liang et al., 2019; Zhang et al., 2024)

Based on the data summarized in Table 3, the biological activity of the phytochemical constituents of *Cinnamomum burmannii* shows a close correlation between their chemical structure and their pharmacological mechanisms of action. The aromatic aldehyde group, represented by cinnamaldehyde as the major component, shows significant antimicrobial and antidiabetic potential. The antimicrobial mechanism of cinnamaldehyde works through protein denaturation and microbial membrane permeability, thereby disrupting cell homeostasis and killing various Gram-positive and Gram-negative bacteria, as well as pathogenic fungi. In addition, cinnamaldehyde consistently inhibits biofilm activity and reduces bacterial virulence, confirming its effectiveness as a natural food preservative (Panjaitan et al., 2022). The antidiabetic activity of cinnamon works mainly through inhibition of the α-glucosidase enzyme which lowers postprandial blood glucose levels, as confirmed through various in vitro and in vivo tests and a number of pre-clinical data (Silva et al., 2022). This

potential hypoglycemic effect encourages the use of cinnamon as an additional therapy in type 2 diabetes mellitus. The coumarin group identified in cinnamon also contributes to anticoagulant activity by inhibiting vitamin K, which is important for the synthesis of blood clotting factors (Sharifi-Rad et al., 2021). The coumarin content in cinnamon must be considered due to the risk of hepatotoxicity due to reactive metabolites via the cytochrome P450 pathway (Nabavi et al., 2015).

Flavonoids such as quercetin and catechin in cinnamon are known to have strong antioxidant and anti-inflammatory activity, with mechanisms of action through scavenging free radicals and inhibiting cyclooxygenase enzymes, as well as reducing the activation of the NF-κB pathway, which plays a role in the inflammatory process. The antioxidant capacity of cinnamon flavonoids acts as a protector against oxidative stress and can therefore help prevent degenerative diseases, including cancer and cardiovascular disease. Furthermore, the anti-inflammatory effects of cinnamon flavonoids have been shown to reduce COX-2 expression and reduce the risk of gastrointestinal side effects common with synthetic anti-inflammatory drugs, thus providing great potential for the development of supplement and nutraceutical products (Pagliari et al., 2023). Meanwhile, terpenoids such as eugenol which is also found in cinnamon exhibit analgesic and antiseptic activity by modulating sodium channels and disrupting microbial cell membranes (Silva et al., 2024). For the organic acid group, especially cinnamic acid, this component provides antimicrobial and photoprotective effects, and can absorb UV radiation so that it is widely applied in cosmetic formulations and sunscreen products as a photostabilizer agent, while preventing microbiological contamination (Nunes et al., 2018).

An integrative analysis of the biological activity profiles summarized in Table 2 highlights the synergistic effects among the phytochemical compounds in the complex extract of *C. burmannii*. The combination of antimicrobial activity from aromatic aldehydes and terpenoids, antioxidant activity from flavonoids and phenolic acids, and anti-inflammatory activity from flavonoids provides a broad and mutually reinforcing pharmacological spectrum. This synergistic phenomenon supports the finding that the total extract often provides better efficacy than the use of single compounds, thus strengthening the multi-target therapy paradigm in traditional herbal medicine (Khedkar et al., 2023). A structured understanding of the biological activity, molecular mechanisms, and potential applications of each class of compounds in *C. burmannii* provides an essential foundation for the development of standardized herbal products and optimal formulations, including the selection of appropriate extraction methods and stringent quality parameters to ensure product consistency. To advance clinical use, further research is needed on genomics, pharmacokinetics, and bioavailability, as well as clinical trials to ensure the safety and long-term efficacy of Indonesian cinnamon-based products (Andini et al., 2020).

CONCLUSION

This quantitative literature review synthesizes existing evidence on the active compound content of *Cinnamomum burmannii* and highlights consistent phytochemical patterns across studies. Overall, phenolic compounds, including flavonoids and related constituents, emerge as the dominant bioactive components reported in the literature.

The findings further indicate that solvent polarity plays a crucial role in extraction outcomes, with ethanol-based solvents demonstrating greater effectiveness in capturing a broad range of active compounds.In terms of methodology, conventional maceration appears as the most consistently applied extraction technique, offering reproducible results across different studies. The primary contribution of this review lies in its comparative synthesis of quantitative data, providing a structured overview of compound dominance, solvent effectiveness, and methodological consistency. These insights may serve as a reference for future experimental studies and support the optimization of extraction strategies for *C. burmannii*–derived bioactive compounds.

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