Bioedukasi
Jurnal Biologi dan Pembelajarannya
Vol. 23 No 2, June 2025, page 251-256
e-ISSN: 2580-0094; p-ISSN:1693-3931
DOI: 10.19184/bioedu.v23i2.53699
bioedukasi.jurnal.unej.ac.id/index.php/BIOED/submissions

Identification of Essential Oils of *Cinnamomum burmannii* Essential Oil using Gas Chromatography-Mass Spectrometry (GC-MS)

Ance Tenouye[1], Yelfi Anwar [2], Muryanto[3], Egi Agustian[4]
[1,2]Faculty of Pharmacy, University of 17 August 1945 Jakarta, Indonesia
[3]Chemical Engineering Department, Faculty of Engineering, University of Pamulang, South Tangerang, Indonesia
[4]Research Centre for Chemistry, National Research and Innovation Agency, Region Puspiptek Serpong, 15314 Indonesia

Article Info
Article history:
Received June 6, 2025
Revised June 23, 2025
Accepted June 23, 2025

Keywords: (A-Z)
Chemical Compounds
Cinnamomum burmannii
Cinnamaldehyde

ABSTRACT
Cinnamon is known as an aromatic spice plant, as it contains essential oils in all parts of the plant from roots, stem, bark, leaves, flowers. Cinnamon bark is widely utilized by the community due to its numerous health benefits and antibacterial properties. This study aimed to identify the chemical composition of essential oil extracted from cinnamon bark (*Cinnamomum burmannii*) sourced from farmers and processors in Wonorejo Village, Gondangrejo, Karanganyar, Central Java. The research design used in this study is an experimental research design. The analysis of Cinnamomum burmanni essential oil components using gas chromatography-mass spectrometry (GC-MS) revealed that the primary compound was cinnamaldehyde, accounting for 92.46%. Cinnamon, also known as *Cinnamomum burmanni*, is one of the main components of cinnamon bark. Further research is recommended to explore the variability of the chemical composition of *Cinnamomum burmannii* essential oil from different regions of Indonesia and its correlation with its pharmacological potential.

Corresponding Author:
Yelfi Anwar,
Faculty of Pharmacy, University of 17 August 1945 Jakarta Jakarta, Nort Jakarta, Indonesia
Email: yelfi.anwar@uta45jakarta.ac.id

1. INTRODUCTION

Indonesia is one of the world's leading producers of *Cinnamomum burmannii*, a high-value spice plant known as a major source of essential oils containing biologically active compounds such as cinnamaldehyde, eugenol, and cinnamic acid (Handayani et al., 2024). In recent years, essential oil derived from *C. burmannii* bark has garnered significant attention due to its pharmacological properties, including antidiabetic, antioxidant, antibacterial, and anti-inflammatory activities (Liu et al., 2023; lumeriastuti et al., 2019). Amid growing concerns over antimicrobial resistance and the demand for safe, natural therapeutics, essential oils from this plant have emerged as promising candidates for the development of pharmaceutical products and health-based bioindustries (Chairunnisa et al., 2017). A key scientific issue is the limited availability of data regarding the variation in chemical composition of *C. burmannii* essential oil sourced from different regions of Indonesia, despite well-established evidence that such composition is influenced by genetic, geographic, climatic, and extraction-related factors (Wang et al., 2009). This inconsistency affects the quality and biological efficacy of derivative products, both in clinical and industrial settings. On the ground, many herbal producers and traditional medicine practitioners struggle to ensure consistency and stability of active compounds in C. burmannii-based products due to the lack of localized and comprehensive chemical characterization data.

Previous attempts to identify active compounds in *C. burmannii* essential oil have utilized analytical methods such as FTIR and UV spectrophotometry (Bai et al., 2021; Djarot et al., 2023). However, these techniques are limited in their ability to resolve and detect minor constituents, which often contribute significantly to the oil's bioactivity. Moreover, most earlier studies have focused on other species such as C. cassia or C. zeylanicum, with limited research on C. burmannii itself and often based on non-representative sample sources (Shan et al., 2007).The identified research gap lies in the absence of comprehensive studies utilizing advanced analytical techniques such as Gas Chromatography-Mass Spectrometry (GC-MS) to characterize the chemical constituents of C. burmannii essential oil, particularly from locally-sourced samples in Indonesia. Additionally, there is a lack of systematic mapping of chemical variability based on geographic origin, which is essential for standardization and future product development. Compounds such as cinnamaldehyde, eugenol, and borneol have demonstrated substantial antibacterial, antifungal, and antidiabetic potential (Lewa & Gugule, 2022); (Liang et al., 2025).

This research aims to fill that gap by identifying the chemical constituents of C. burmannii bark essential oil using GC-MS, focusing on samples collected directly from local farmers in Central Java. GC-MS is a highly sensitive and selective technique capable of detecting volatile compounds within complex mixtures and identifying molecular fingerprints based on unique mass spectra (Anwar et al., 2022). This approach is expected to generate robust compositional data that may serve as a scientific foundation for quality control, pharmacological validation, and evidence-based herbal product development.

The strength of this study lies in its use of internationally standardized GC-MS instrumentation and reference databases (e.g., NIST), as well as its focus on locally-sourced plant material—an aspect rarely addressed systematically in previous research. The study also has practical relevance in strengthening the national phytopharmaceutical ecosystem by mapping the bioactive compound potential of indigenous plant resources. Theoretically, it contributes to a deeper understanding of the correlation between specific active constituents and the biological functions of C. burmannii essential oil, which is crucial for the development of more precise and targeted natural therapies.

This research carries significant urgency from scientific, social, and policy perspectives. Scientifically, it contributes to the expanding body of phytochemical knowledge and supports the evidence-based advancement of traditional medicines. From a regulatory and societal standpoint, the findings may inform policies on quality assurance and safety standards for herbal raw materials, while also supporting the integration of traditional remedies into national healthcare frameworks. The explicit objective of this study is to comprehensively identify the primary and secondary constituents of C. burmannii bark essential oil using GC-MS, compare these findings against national quality standards (SNI), and contextualize them within the global scientific literature. The expected contribution of this study is the provision of validated and standardized chemical data on C. burmannii essential oil composition, which can be utilized for further pharmacological investigations, formulation development, and national policy formulation in the field of herbal medicine and bioindustry.

2. RESEARCH METHOD

This study employs an experimental research design. The material used is cinnamon bark essential oil produced through distillation by farmers in Wonorejo, Gondangrejo, Karanganyar, Central Java. The obtained essential oil was analyzed at the BRIN chemical laboratory in Serpong, South Tangerang, Banten, using the Gas Chromatography-Mass Spectrometry (GC-MS) method with 3 repetitions (triplo). The essential oil components were identified using a GC- MS system, specifically the 7890B Gas Chromatograph (GC) and the 5977A Mass Selective Detector (MSD), with referencce to the NIST 20 database. The mobile and stationary phases utilized in the GC-MS analysis were of the Agilent 1909IS-433 type: 93.92873 DB-5MS UI 5% Phenyl Methyl Siloxane, with an injection volume of 1 mL. The GC method allows the separation of volatile compounds in the sample based on differences in retention time, while MS is used to identify these compounds based on the resulting mass patterns. In the GC phase, the essential oil sample was introduced into a chromatography column coated with a stationary phase that has specific affinities for different compounds, allowing separation based on solubility and volatility. The column temperature was maintained between 50–300°C, with a programmed temperature ramp to ensure optimal separation of various components. The analysis time for each sample may vary depending on the complexity of the oil's components, with the total analysis time typically ranging from 30 to 60 minutes. After the compounds are separated, MS identifies the compounds based on the mass patterns generated, with ionization performed using the Electron Impact (EI) mode at 70 eV. The mass data obtained are then compared with international mass spectrometry databases such as NIST 20 for compound identification.

3. RESULT AND DISCUSSION

Results The chemical composition of essential oil from cinnamon bark (*Cinnamomum burmannii*) is presented in Figure 1.

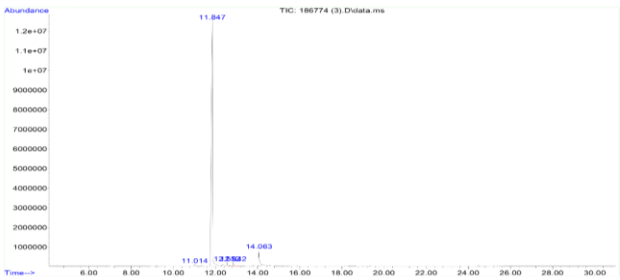

Figure 1. Chromatogram of (*Cinnamomum burmannii*).

In reference to the identification in Figure 1, the essential oil of cinnamon bark obtained from local distillation in Wonorejo Village, Gondangrejo, Karanganyar, Central Java, identified as 5 peak, it has a relatively large content (%) shown in Table 1, where there is 1 compound that has a high content marked with red color, namely Cinnamaldehyde (92.46%). Cinnamaldehyde compounds have potential as antibacterials (Intan et al., 2021). This observation aligns with the study by Herdwiani et al. (2016), which reported a cinnamaldehyde content of 71.8% in *C. burmannii* essential oil using GC-MS analysis (Herdwiani et al., 2016).

Table 1. Chemical Components of (*Cinnamomum burmannii*)

Peak	Retention Time (RT)	Area (%)	Compound	Qual
1.	11.019	0.64	2-propenal, 3-phenyl, Cinnamaldehyde	97
2.	**11.851**	**92.46**	**Cinnamaldehyde**	**97**
3.	12.556	1.39	Triacetin	80
4.	12.846	1.15	Eugenol	98
5.	14.069	4.37	Acetic acid	98

The quality standards for cinnamon bark essential oil are outlined in SNI number 06-3734-2006, as shown in Table 2. This essential oil has a light yellow to light brown color and a typical cinnamon bark odor. It is soluble in 70% ethanol at a ratio of 1:3, with a specific gravity of 1.0338, a refractive index of 1.5967, and an optical rotation of -0.80 (Sohipah E, 2023). Chairunnisa et al. (2017) identified key components in *Cinnamomum burmannii* oil such as trans-cinnamaldehyde (56.1%), 1,8-cineole (16.5%), and α-terpineol (3.05%), showing similar chromatographic patterns. Xie et al. (2024) highlighted that the composition of the essential oil in *C. burmannii* varies depending on the genotype and environment, identifying chemotypes rich in borneol and eucalyptol through GC-MS analysis. Liu et al. (2023) studied oils from different plant organs and found eucalyptol and α-terpineol as major components, confirming their presence in the bark samples analyzed via GC-MS. Liang et al. (2025) used SPME-GC-MS to identify 10 key compounds in *C. burmannii* leaf essential oil, including borneol and terpinen-4-ol, which showed antifungal and anti-aflatoxin activities. Zhang et al. (2024) analyzed 32 GC-MS compounds in *C. burmannii* oil and confirmed the wound-healing properties of borneol and α-terpineol through both in vitro and in vivo assays, further validating the bioactivity of the compounds shown in Table 1. Lewa and Gugule (2022) found cinnamaldehyde and linalool as major components in *C. burmannii* oil for cosmetic use, demonstrating its antibacterial properties, which aligns with the antimicrobial relevance of the compounds listed in Table 1. Liu et al. (2021) showed that enzyme-assisted microwave extraction enhanced the oxygenated compounds (like 1,8-cineole and borneol) in *C. burmannii* oil, as confirmed by GC-MS data. Lastly, Hou et al. (2023) linked the biosynthesis of borneol, α-terpineol, and other related terpenes to specific gene expressions during leaf development in *C. burmannii*, confirming the molecular basis for the compounds shown in Table 1.

Several key compounds identified through GC-MS analysis of *Cinnamomum burmannii* essential oil including 2-propenal, 3-phenyl (cinnamaldehyde), cinnamaldehyde, triacetin, eugenol, and acetic acid have been extensively studied for their pharmacological properties. Cinnamaldehyde (2-propenal, 3-phenyl) exhibits a wide range of pharmacological activities, including antimicrobial, antioxidant, and anticancer effects. A structure– activity relationship study by (Gan et al., 2009) demonstrated that specific modifications to the phenyl ring and propenal group significantly enhanced cinnamaldehyde’s antiproliferative and pro-apoptotic effects on cancer cells via both caspase-dependent and independent cell death pathways (Gan et al., 2009). These results support cinnamaldehyde as a promising natural anticancer agent. A study by (Silva e Silva Figueiredo et al., 2023) demonstrated that cinnamaldehyde exhibits extensive antimicrobial activity against bacterial and fungal pathogens such as Escherichia coli, Staphylococcus aureus, and Candida albicans. It also inhibits microbial virulence and biofilm formation, making it a strong candidate for the development of novel antimicrobial agents (Silva e Silva Figueiredo et al., 2023). Triacetin (glycerol triacetate), while commonly used as a solvent or pharmaceutical excipient, has also demonstrated biological functionality. (Wolfson et al., 2012) showed that triacetin serves as a green solvent for the sustainable synthesis of bioactive cinnamyl acetate with high yield and recyclability, indicating its potential in pharmaceutical formulation technologies and biocatalysis systems (Wolfson et al., 2012). Eugenol has been shown to possess strong anti-inflammatory, antioxidant, and cytotoxic properties. Sharma et al. (2017) reported that eugenol exhibited significant free radical scavenging activity, improved cellular antioxidant defense, and demonstrated cytotoxic effects on prostate cancer cell lines. it showed moderate antileishmanial activity, highlighting its therapeutic versatility (Sharma et al., 2017).

Peker and Kaltalioglu (2021) showed that eugenol significantly reduces the expression of inflammatory mediators such as TNF-α, IL-1β, and IL-6, while enhancing the activity of antioxidant enzymes like superoxide dismutase (SOD) and catalase in lipopolysaccharide (LPS)-stimulated macrophage cells (Gulec Peker & Kaltalioglu, 2021). Acetic acid, while structurally simple, exerts antimicrobial activity by altering pH and disrupting bacterial membrane proteins. In a study by Takeda et al. (1968), acetic acid participated in electrochemical transformations of cinnamic acid derivatives, suggesting its chemical and potential biological relevance in oxidative pathways and antimicrobial mechanisms Takeda et al., 1968).

The combined use of cinnamaldehyde and eugenol has shown synergistic anti-inflammatory and antioxidant effects. (Mateen et al., 2019) demonstrated in a collagen-induced arthritis model in rats that both compounds significantly reduced oxidative stress biomarkers (e.g., ROS, lipid peroxidation), improved enzymatic antioxidant levels (SOD, catalase), and decreased inflammatory cytokines (TNF-α, IL-6). Eugenol was found to be more effective than cinnamaldehyde in reducing joint inflammation and tissue damage (Mateen et al., 2019).

Table 2. Comparison of inspection of the yield of cinnamon bark essential oil and SNI standards. Number 06-3734-200606-3734-2006

No	Parameter	Result	SNI. 06-3734-2006
1.	Color	Light yellow	Light yellow to light brown
2.	Smell	Cinnamon flavor	Cinnamon flavor
3.	Solubility in 70% ethanol	Dissolved substance	Soluble 1:3
4.	Cinnamaldehyde	92,46%	Minimum 50%

Cinnamaldehyde is the basic component in cinnamon bark essential oil. The identification results of this study are also supported by previous studies which also found the chemical content of cinnamon bark essential oil contains Cinnamaldehyde (65-75%) (Emilda, 2018). While the findings of this study obtained the highest compound is Cinnamaldehyde (92.46%). Research conducted previously by (Onder et al., 2019) found that the cinamaldehyde content reached 96.9%, this shows Cinamaldehyde is an important compound in increasing antioxidant defense in body protection. Cinamaldehyde activity can also relieve coronary vasospasm and therapeutic drug delivery thus providing a protective effect. Cinnamaldehyde which is a food component provides many benefits in blood glucose regulation due to its high Cinnamaldehyde content.

Previous research found 72.67% Cinamaldehyde in cinnamom bark essential oil. Each cinnamom spesies has different compound content and total content. This can be influenced by the type of spesies, planting area, environmental factors, harvesting age, solvent, and extraction method used so that it can affect the amount of volatile compounds contained in each spesies. Cinamaldehyde in cinnamon essential oil has a role as an inhibitor of cariogenic bacteria so that the levels contained therein are high (Ilmi et al., 2022).

Other studies mention the activity of giving essential oils can also be done as aromatherapy against insomnia in the elderly. This is in line with previous research conducted, namely there are differences in insomnia in the elderly before and after being given essential oil aromatherapy. Aromatherapy on relaxation techniques from essential oils and classified as nonpharmacological therapy is the first line in recommendations for overcoming insomnia, especially in the elderly (Sheila et al., 2021).

From the result obtained there is a difference in percent on the discovery of cinnamon bark essential oil samples taken from Wonorejo village, Gondangrejo, Karanganyer, Central Java Indonesia. The diffrence in percent in some chemical content is influenced by several factors such as climate, soil type affects chemical composition, and altitude. (Kurniawati, 2017)K Cinnamon bark contains compounds that have potensia as antibacterial bacause it has cinnamaldehyde chimical content in essentail oil (Zaki Mubarak, 2016).

4. CONCLUSION

In reference to the results of research that has been done, essential oil obtained from essential oil distillation in Wonorejo Village, Gondangrejo, Karanganyar, Central Java. From the GC-MS results, the predominant essential oil identified is Cinnamaldehyde, with a concentration of 92.46%. In comparison, the SNI 06-3734-2006 standard sets the percentage at 50%. Further research is necessary to enhance the quality of essential oils, ensuring an increased percentage. Based on the findings of this study, it is recommended to conduct further research to explore the variation in the chemical composition of *Cinnamomum burmannii* essential oil from different regions in Indonesia, as climatic and geographical factors may influence the content of bioactive compounds. Future studies could also examine the relationship between the chemical composition of the essential oil and its pharmacological potential, particularly for applications in the development of biopharmaceutical and cosmetic products. Additionally, research into the impact of different extraction methods on the quality of the essential oil could provide further insights into optimizing the production process.

5. ACKNOWLEDGEMENT

Thanks to BRIN for facilitating GC-MS testing, Farmers and managers for providing cinnamon bark essential oil, as well as to the supervisors and colleagues who have assisted in the preparation and publication of this journal.

6. REFERENCES

Anwar, Y., Putri, D., & Putra, A. (2022). Antioxidant Activity and Characterizations of Cinnamon (Cinnamomum Burmannii) Essential Oil from Lampung. *Proceedings of the 3rd International Seminar and Call for Paper (ISCP) UTA '45 Jakarta*, 376–380. https://doi.org/10.5220/0012025800003582

Bai, M., Jin, X., Cen, Z., Yu, K., Yu, H., Xiao, R., Deng, J., Lai, Z., Wu, H., & Li, Y. (2021). GC–MS and FTIR spectroscopy for the identification and assessment of essential oil components of five cinnamon leaves. *Brazilian Journal of Botany*, *44*(3), 525–535. https://doi.org/10.1007/s40415-021-00751-7

Chairunnisa, Tamhid, H. A., & Nugraha, A. T. (2017). *Gas chromatography – Mass spectrometry analysis and antibacterial activity of Cinnamomum burmanii essential oil to Staphylococcus aureus and Escherichia coli by gaseous contact*. 020073. https://doi.org/10.1063/1.4978146

Djarot, P., Yulianita, Y., Utami, N. F., Putra, A. M., Putri, Y. I. M., Muhardianty, S. M., Suciyani, T. A., & Syaepulrohman, A. (2023). Bioactivities and Chemical Compositions of Cinnamomum burmannii Bark Extracts (Lauraceae). *Sustainability*, *15*(2), 1696. https://doi.org/10.3390/su15021696

Emilda. (2018). Efek Senyawa Bioaktif Kayu Manis (Cinnamommum burmanii) Terhadap Diabetes Melitus. *Jurnal Fitofarmaka Indonesia*, *5*(1), 246–252.

Filianty, F., Ilmi, I. N., & Yarlina, V. P. (2022). Kajian Proses Penyeduhan Teh Herbal Daun Kelor (Moringa oleifera) dan Kayu Manis (Cinnamomum cassia) sebagai Minuman Fungsional. *Teknotan*, *16*(3), 155. https://doi.org/10.24198/jt.vol16n3.4

Gan, F. F., Chua, Y. S., Scarmagnani, S., Palaniappan, P., Franks, M., Poobalasingam, T., Bradshaw, T. D., Westwell, A. D., & Hagen, T. (2009). Structure–activity analysis of 2′- modified cinnamaldehyde analogues as potential anticancer agents. *Biochemical and Biophysical Research Communications*, *387*(4), 741–747. https://doi.org/10.1016/j.bbrc.2009.07.104

Gulec Peker, E. G., & Kaltalioglu, K. (2021). Cinnamaldehyde and eugenol protect against LPS-stimulated oxidative stress and inflammation in Raw 264.7 cells. *Journal of Food Biochemistry*, *45*(12). https://doi.org/10.1111/jfbc.13980

Handayani, A., Lailaty, I. Q., Rosyidah, A., Sari, D. R. T., Yunarto, N., & Suherman, D. (2024). Indonesian Cinnamon (Cinnamomum burmanni (Nees & T. Nees) Blume) as Promising Medicinal Resources: A Review. *Jurnal Sylva Lestari*, *12*(3), 610–633. https://doi.org/10.23960/jsl.v12i3.1014

Hou, C., Zhu, L., Zheng, Y., Shi, L., Tan, B., & Zhang, S. (2023). Effects of dietary peptidoglycan on Litopenaeus vannamei: Growth performance, disease resistance, non-specific immunity and transcriptome analysis of immune response. *Aquaculture Reports*, *31*(July), 101676. https://doi.org/10.1016/j.aqrep.2023.101676

Intan, K., Diani, A., & Nurul, A. S. R. (2021). Aktivitas Antibakteri Kayu Manis (Cinnamomum burmanii) terhadap Pertumbuhan Staphylococcus aureus. *JURNAL KESEHATAN PERINTIS (Perintis's Health Journal)*, *8*(2), 121–127. https://doi.org/10.33653/jkp.v8i2.679

Lewa, S., & Gugule, S. (2022). Cinnamon (Cinnamomum burmannii) Bark Essential Oil as Raw Material for Skin Cream and Anti-Bacterial. *Acta Chimica Asiana*, *5*(1), 158–165. https://doi.org/10.29303/aca.v5i1.80

Liang, H., Lv, F., Xian, M., Luo, C., Zhang, L., Yang, M., Li, Q., & Zhao, X. (2025). Inhibition Mechanism of Cinnamomum burmannii Leaf Essential Oil Against Aspergillus flavus and Aflatoxins. *Foods*, *14*(4), 682. https://doi.org/10.3390/foods14040682

Liu, X., Zhou, S., Huang, Y., Chen, M., Wang, W., Wang, J., Hao, E., Wu, H., & Li, Y. (2023). Chemical composition, antioxidant activity, and anti-bacterial activity of essential oils from different organs of *Cinnamomum burmanni*. *Journal of Essential Oil Bearing Plants*, *26*(3), 787–801. https://doi.org/10.1080/0972060X.2023.2239847

Mateen, S., Shahzad, S., Ahmad, S., Naeem, S. S., Khalid, S., Akhtar, K., Rizvi, W., & Moin,

S. (2019). Cinnamaldehyde and eugenol attenuates collagen induced arthritis via reduction of free radicals and pro-inflammatory cytokines. *Phytomedicine*, *53*, 70–78. https://doi.org/10.1016/j.phymed.2018.09.004

Onder, A., Yilmaz-Oral, D., Jerkovic, I., Akdemir, A. O., & Gur, S. (2019). Evaluation of relaxant responses properties of cinnamon essential oil and its major component, cinnamaldehyde on human and rat corpus cavernosum. *International Braz J Urol*, *45*(5), 1033–1042. https://doi.org/10.1590/S1677-5538.IBJU.2019.0016

Plumeriastuti, H., Budiastuti, B., Effendi, M., & Budiarto, B. (2019). Identification of bioactive compound of the essential oils of Cinnamomum burmannii from several areas in Indonesia by gas chromatography-mass spectrometry method for antidiabetic potential. *National Journal of Physiology, Pharmacy and Pharmacology*, *0*, 1. https://doi.org/10.5455/njppp.2019.9.1236702022019

Shan, B., Cai, Y.-Z., Brooks, J. D., & Corke, H. (2007). Antibacterial Properties and Major Bioactive Components of Cinnamon Stick (*Cinnamomum burmannii*): Activity against Foodborne Pathogenic Bacteria. *Journal of Agricultural and Food Chemistry*, *55*(14), 5484–5490. https://doi.org/10.1021/jf070424d

Sharma, U. K., Sharma, A. K., Gupta, A., Kumar, R., Pandey, A., & Pandey, A. K. (2017). Pharmacological activities of cinnamaldehyde and eugenol: antioxidant, cytotoxic and anti-leishmanial studies. *Cellular and Molecular Biology*, *63*(6), 73–78. https://doi.org/10.14715/cmb/2017.63.6.15

Silva e Silva Figueiredo, C. S., de Oliveira, P. V., dos Reis Ferreira, L., de Sousa, T. J. D., de Santana do Nascimento, M., dos Santos, J. R. A., Zagmignan, A., de Holanda, R. A., de Carvalho Galvão, L. C., & da Silva, L. C. N. (2023). Cinnamaldehyde for the Treatment of Microbial Infections: Evidence Obtained from Experimental Models. *Current Medicinal Chemistry*, *30*(31), 3506–3526. https://doi.org/10.2174/0929867329666221005105108

Takeda, A., Torii, S., & Oka, H. (1968). The Anodic Oxidation of trans-Cinnamic Acid. I. The Formation of Ketone and Aldehyde Derivatives. *Memoirs of the School of Engineering, Okayama University*, *3*, 107–112.

Wang, R., Wang, R., & Yang, B. (2009). Extraction of essential oils from five cinnamon leaves and identification of their volatile compound compositions. *Innovative Food Science & Emerging Technologies*, *10*(2), 289–292. https://doi.org/10.1016/j.ifset.2008.12.002

Wolfson, A., Dlugy, C., Karanet, A., & Tavor, D. (2012). A sustainable one-pot synthesis of cinnamyl acetate in triacetin. *Tetrahedron Letters*, *53*(34),4565–4567. https://doi.org/10.1016/j.tetlet.2012.06.066

Zhang, X., Lin, X., Cao, J., Xie, G., Yang, X., Liu, B., Xu, X., Cheng, F., Chen, H., & Pang, Y. (2024). Application of Cinnamomum burmannii Essential Oil in Promoting Wound Healing. *Molecules (Basel, Switzerland)*, *29*(9), 1–18. https://doi.org/10.3390/molecules290920