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Extraction methods, yield, and chemical composition of essential oils from *Baeckea frutescens* L. leaves: A brief review

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Abstract
Sapu-sapu (*Baeckea frutescens* L.) is a medicinal plant broadly recognized for its essential oils, which contain diverse volatile compounds. Various extraction techniques have been employed to obtain these oils, ranging from conventional techniques, namely steam distillation and hydro distillation to the advanced ones, including the enzymatic, ultrasound- and microwave-assisted extraction techniques. Depending on the technique applied, extraction time, and geographical origin, the yield obtained varies from 0.0037 - 2.28%. The most commonly identified compounds in the essential oil derived from the Sapu-sapu plant are α-pinene, β-pinene, 1,8-cineole, p-cymene, linalool, and caryophyllene. Recent findings reveal that the hybrid and assisted extraction methods result in improved efficiency and selectivity. This review elaborates on the extraction strategies, yield variations, and chemical profiles of *Baeckea frutescens* L. essential oils, supporting future research and industrial applications.

Keywords: *Baeckea Frutescens* L., essential oil, extraction methods, oil yield, volatile compounds

Introduction

Baeckea frutescens L. is a flowering plant species in the *Myrtacea*e family. It is native to Australia, New Guinea, and the eastern regions of Southeast Asia. This plant is characterized as a shrub with arching branches, narrow linear leaves, and white flowers bearing 7 to 13 stamens [1]. So far, this plant is well-known for their aromatic foliage, which releases a unique citrus-like fragrance upon physical breakage of the leaves [2]. Many investigations have documented the presence of various important compounds isolated from *Baeckea frutescens* L. leaf extracts, such as flavonoids, chromones, sterols, and flavonol glycosides [3]. Additionally, the leaves of *Baeckea frutescens* L. have been acknowledged for its anti-inflammatory [1], antioxidant [4, 5], antibacterial [3, 6, 7], antifungal [8], larvicidal [9], and cytotoxic properties [10, 11]. The chemical composition of *Baeckea frutescens* L. leaves is highly diverse, in which numerous bioactive compounds have been identified. As expected, phytochemical studies have disclosed that essential oils, terpenoids, phloroglucinols, chromones, flavonoids, and their derivatives present as the primary active constituents of the plant [12]. To obtain these compounds, various extraction methods have been implemented, such as steam distillation [7, 9, 13, 14], hydro distillation [3, 15, 16, 17], supercritical CO_2 extraction [8], and more recently, the enzyme-assisted ultrasonic-microwave techniques [12]. Previous studies reported that the oil yields vary widely (0.0037 - 2. 28%) with the value depending on some influential factors, such as extraction method, characterization of plant [18], and geographical origin [19]. This review provides a concise overview of the extraction methods, oil yields, and chemical composition of the *Baeckea frutescens* L. essential oil, offering insights for future research and practical applications of this underutilized medicinal plant.

2. Extraction and Yield Comparison

Previous studies applied various extraction methods to obtain essential oils from *Baeckea frutescens* L. with the yields varying depending on the extraction method, plant material, and operating conditions. For instance, Jemi *et al.* [9] found essential oil yields of 0.12% from fresh leaves and 0.29% from dried leaves using steam distillation. This difference is most probably due to abundant ruptured oil cells in dried leaves allowing intensive steam penetration to them, which facilitates more efficient release of essential oils during steam distillation [9].

In a separate study, Murningsih [17] reported a relatively high essential oil yield of 2.13% from extraction of essential oil from *Baeckea frutescens* L. leaves using hydrodistillation. Although the yield was considered to be competitive, the process required a lengthy extraction time of about 4 hours. Conversely, Wahyuni *et al.* [7] reported an extremely low oil yield of only 0.0037% from steam distillation of *Baeckea frutescens* L. leaves. However, Elicia *et al.* [13] obtained a substantially higher yield of 0.74% using the same technique, suggesting that steam distillation efficiency may vary depending on factors, such as distillation duration [20] and geographical origin of the plant [21]. Meanwhile, Jantan *et al.* [14] achieved essential oil yields ranging from 1.89% to 2.28% from the same plant using hydrodistillation over an 8-hour period. Although the yield was relatively high, the extraction process requires a considerably longer duration and possesses a risk of volatile compound degradation due to prolonged heat exposure [22]. A study by Jiang *et al.* [8] applied supercritical fluid extraction using carbon dioxide (SFE-CO_2) and obtained a yield of 2.2%. However, this method involves high operating pressures and expensive equipment, making it less cost-effective. Wan *et al.* [12] developed a hybrid technique combining enzyme pretreatment with ultrasonic-microwave-assisted extraction (ES-UME), which yielded 0.638% in only 1.5 hours. Despite its promising efficiency, the use of enzymes, surfactants, and dual energy sources renders the method complicated and costly, thus limiting its practical application.

Overall, the yield of essential oils extracted from *Baeckea frutescens* L. varies depending on the extraction method [23] and operating conditions. While conventional extraction methods, such as hydrodistillation and steam distillation remain widely applied, they often require long durations and are susceptible to thermal degradation of the valuable volatile compounds [22, 24]. On the other hand, modern extraction methods such as SFE-CO_2 and ES-UME methods offer improved efficiency, but come with higher operational complexity and cost. These differences underscore the importance of selecting appropriate extraction conditions not only to maximize yield, but also minimize energy use and preserve the integrity of the essential oil's chemical composition, which will be discussed in the following section.

3. Essential Oil Composition

The essential oil of *Baeckea frutescens* L. comprises a complex mixture of volatile compounds, predominantly monoterpenes and sesquiterpenes [1]. Several studies have demonstrated that the chemical composition of this oil varies considerably, influenced by factors, such as extraction method [23], the physiological stage or maturity of the plant material, and environmental cultivation conditions including geographical location, climate, and soil characteristics [19]. Generally reported main constituents include α-pinene, β-pinene, 1,8-cineole, p-cymene, linalool, and caryophyllene, although their relative abundance differs across studies. This component variability is considered a key factor in determining the biological activity and potential industrial applications of *Baeckea frutescens* L. essential oils.

Across various studies, the essential oil composition of *Baeckea frutescens* L. has demonstrated considerable variability in its dominant constituents. For instance, Jemi *et al.* [9] reported that fresh leaves from Central Kalimantan contained high levels of β-pinene (36.5%) and α-pinene (32.5%), while dried leaves exhibited increased concentrations of α-pinene (41.2%), β-pinene (33.3%), along with eucalyptol (5.8%). Jiang *et al.* [8], used SFE-CO_2 on *Baeckea frutescens* L. samples from Guangxi, China, identified β-caryophyllene (28.05%), α- caryophyllene (24.02%), and δ-cadinene (6.29%) as the primary constituents. In contrast, Vietnamese samples analyzed by Toan *et al.* [3] revealed a broader spectrum of components, including tasmannone (21.46%), β-pinene (15.64%), and 1,8-cineole (11.32%). Similarly, Mat Saad *et al.* [16] found that oils extracted from Malaysian samples were dominated by p-cymene (31.06%) and α-pinene (24.53%). In West Kalimantan, Wahyuni *et al.* [7] observed high content of β-ocimene (24.04%) and eucalyptol (20.78%). Meanwhile, Murningsih [17] reported distinct profiles in samples from Yogyakarta and Semarang Central Java. The Yogyakarta sample was characterized by relatively high levels of 1,8-cineole (22.08%), 3-pinene (17.98%), and ocimene (8.88%). In contrast, the Semarang sample exhibited a markedly different profile, with β-pinene (29.22%) and linalool (7.49%) being the dominant constituents. These findings highlight the potential influence of geographical origin, even within the same country, on the essential oil composition of *Baeckea frutescens* L. Dai *et al.* [15] also identified various monoterpenes and sesquiterpenes in Vietnamese samples, including α-thujene, p-cymene, limonene, and terpinolene.

In addition to extraction methods and geographic, harvest time has also been investigated as a factor influencing essential oil composition of *Baeckea frutescens* L [13]. Elicia *et al.* [13] analyzed the chemical profiles of leaves harvested at different growth stages in Bangka, Indonesia, using steam distillation. Chromatography-Mass Spectrometry (GC-MS) analysis revealed that α-pinene, β-pinene, and 1,8-cineole were the predominant constituents across all samples. However, slight variations in their concentrations were observed. Sample A1 (harvested one month after planting, in the morning) exhibited the highest total content of these major compounds, with α-pinene at 43.84%, β-pinene at 13.56%, and 1,8-cineole at 24.26%. A2 (one month, afternoon) contained α-pinene at 39.21%,13.44% β-pinene, and 26.14% 1,8-cineole. In A3 (two months, morning), α-pinene decreased to 38.08%, while β-pinene and 1,8-cineole were recorded at 13.46% and 27.09%, respectively. Sample A4 (two months, afternoon) showed further reduction in α-pinene (36.03%), β-pinene (13.59%), and 1,8-cineole (25.46%). At three months of age, sample A5 (morning) presented α-pinene at 35.12%, β-pinene at 14.11%, and 1,8-cineole at 27.94%. Meanwhile, A6 (afternoon) showed the lowest α-pinene level (33.47%) among all samples, while β-pinene remained relatively stable at 14.41%, and 1,8-cineole peaked at 29.29%. These results suggest that while α-pinene generally declines with plant maturity and later harvest times, 1,8-cineole tends to increase, particularly in samples collected in the afternoon. Such fluctuations indicate that both harvest age and diurnal timing may subtly shape the essential oil profile of *Baeckea frutescens* L.

4. Biological Activities

Recent studies have confirmed several bioactivities of *Baeckea frutescens* L., supporting its traditional use in treating infections and inflammation. One of the active natural compounds, Frutescone O, which is structurally related to terpenoids, was isolated from the aerial parts of the plant and exhibited strong anti-inflammatory effects. It works by inhibiting TLR4-mediated NF-κB and MAPK signalling pathways in LPS-induced macrophages, and significantly reduces the expression of pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α [25].

Meanwhile, the ethanolic leaf extract of *Baeckea frutescens* L. exhibited antibacterial activity against methicillin-resistant *Staphylococcus aureus* (MRSA), attributed to the presence of flavonoids, phenolics, and alkaloids [26]. In addition, several compounds classified as phloroglucinol-terpene adducts, isolated from the leaves and twigs of *Baeckea frutescens* L., demonstrated antifeedant effects against *Plutella xylostella* larvae, indicating potential for natural pest control [27].

Beyond its antibacterial and antifeedant effects, *Baeckea frutescens* L. has also demonstrated notable antioxidant, cytotoxic, and wound-healing activities. Both ethanolic and methanolic extracts exhibit strong 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging and ferric reducing antioxidant power (FRAP), supported by high levels of flavonoids and phenolics [4, 6]. In cytotoxicity assays, methanolic extracts selectivity inhibited HL-60 leukemia cells with moderate IC_{50} values while exhibiting minimal toxicity toward normal cell lines [28]. Moreover, *in vitro* studies confirmed that the ethanolic extract enhances the proliferation and migration of keratinocytes and fibroblasts, suggesting its potential for promoting wound repair [4]. These findings highlight the multifunctional bioactivity of *Baeckea frutescens* L. and support its potential application in pharmaceutical and cosmeceutical formulations.

5. Conclusion

Baeckea frutescens L. has demonstrated considerable promise as a natural source of bioactive essential oils. Variations in extraction methods, plant parts, and harvest conditions greatly influence oil yield and chemical composition, particularly levels of monoterpenes such as α-pinene, β-pinene, 1,8-cineole. These constituents are associated with notable pharmacological activities, including anti-inflammatory, antibacterial, and insecticidal effects. Although several bioactive compounds have been identified and characterized, further studies are required to explore their action mechanisms, clinical efficacy, and safety. The findings reviewed here highlight the need for standardized extraction approaches and deeper investigation into the therapeutic and industrial potential of *Baeckea frutescens* L.

6. References

1. Huong DTL, Duc DX, Son NT. *Baeckea frutescens* L.: A review on phytochemistry, biosynthesis, synthesis, and pharmacology. Natural Product Communications. 2023 Jul;18(7):1934578X231189143. DOI:10.1177/1934578X231189143.
2. Aizo AI, Adnan LA, Ahmad R, Shaffie AH, Nurdalila AA. Screening of active compounds of *Baeckea frutescens* using attenuated total reflectance-fourier transform infrared spectroscopy (ATR-FTIR) and its saponification process. Malaysian Journal of Chemistry. 2024 Jun;26(3):56-61. DOI:10.55373/mjchem.v26i3.56.
3. Toan TQ, Nguyen TH, Vu AT, *et al*. Chemical composition of the essential oil extracted from *Baeckea frutescens* L. harvested in Hai Duong Province, Vietnam using GC-MS. Asian Journal of Chemistry. 2020;32(9):2251-2254. DOI:10.14233/ajchem.2020.22451.
4. Kamarazaman IS, Othman R, Mohd S, *et al*. *In vitro* wound healing evaluation, antioxidant and chemical profiling of *Baeckea frutescens* leaves ethanolic extract. Arabian Journal of Chemistry. 2022 Jun;15(6):103871. DOI:10.1016/j.arabjc.2022.103871.
5. Legowo WP, Herawati IE, Dewi L. Determination antioxidant activity, total phenolics, flavonoids content, of Jungrahab leaves (*Baeckea frutescens* L.). Medika Sains: Jurnal Ilmiah Kefarmasian. 2024 Jan;9(1):49-58. DOI:10.37874/ms.v9i1.1082.
6. Nisa K, Nurhayati S, Apriyana W, Indrianingsih AW. Investigation of total phenolic and flavonoid contents, and evaluation of antimicrobial and antioxidant activities from *Baeckea frutescens* extracts. IOP Conference Series: Earth and Environmental Science. 2017 Dec;101:012002. DOI:10.1088/1755-1315/101/1/012002.
7. Wahyuni E, Wibowo MA, Sapar A. Identifikasi komponen utama minyak atsiri daun ujung atap (*Baeckea frutescens* L.) dan uji aktivitas antibakteri terhadap bakteri *Escherichia coli*. Indonesian Journal of Pure and Applied Chemistry. 2022 Jul;5(2):80. DOI:10.26418/indonesian.v5i2.55595.
8. Jiang H, Zhao X, Wang X, *et al*. Chemical composition of a supercritical fluid (SFE-CO2) extract from *Baeckea frutescens* L. leaves and its bioactivity against two pathogenic fungi isolated from the tea plant (*Camellia sinensis* (L.) O. Kuntze). Plants. 2020 Aug;9(9):1119. DOI:10.3390/plants9091119.
9. Jemi R, Simanullang S, Sarinah, Nuwa, Luhan G, Koroh DN. *Baeckea frutescens* L. essential oil was tested with *Aedes aegypti* larvae at various concentration levels. IOP Conference Series: Materials Science and Engineering. 2021 Jan;1011(1):012002. DOI:10.1088/1757-899X/1011/1/012002.
10. Ito T, Nisa K, Rakainsa SK, Lallo S, Morita H. New phloroglucinol derivatives from Indonesian *Baeckea frutescens*. Tetrahedron. 2017 Feb;73(8):1177-1181. DOI:10.1016/j.tet.2017.01.016.
11. Shahruzaman SH, Yusof FZ, Maniam S, Fakurazi S. The cytotoxic effect of *Baeckea frutescens* extracts in eliminating hypoxic breast cancer cells. BMC Complementary Medicine and Therapies. 2021 Dec;21(1):245. DOI:10.1186/s12906-021-03417-9.
12. Wan N, Liang Y, Wang Y, *et al*. Enzyme pretreatment combined with ultrasonic-microwave-assisted surfactant for simultaneous extraction of essential oil and flavonoids from *Baeckea frutescens*. Industrial Crops and Products. 2021 Dec;174:114173. DOI:10.1016/j.indcrop.2021.114173.
13. Elicia R, Roanisca O, Asriza RO. The effect of harvest time of Sapu-Sapu leaves (*Baeckea frutescens* L.) on the yield, characteristics and composition of essential oils extracted using steam-hydro distillation method. Indonesian Journal of Chemical Analysis. 2024 Sep;7(2):132-141. DOI:10.20885/ijca.vol7.iss2.art10.
14. Jantan I, Ahmad AS, Bakar SAA, Ahmad AR, Trockenbrodt M, Chak CV. Constituents of the

essential oil of *Baeckea frutescens* L. from Malaysia. Flavour and Fragrance Journal. 1998 Jul;13(4):245-247. DOI:10.1002/(SICI)1099-1026(1998070)13:4<245:AID-FFJ736>3.0.CO;2-J.
15. Dai D, Thang T, Olayiwola T, Ogunwande I. Chemical composition of essential oil of *Baeckea frutescens* L. International Research Journal of Pure and Applied Chemistry. 2015 Jan;8(1):26-32. DOI:10.9734/IRJPAC/2015/17199.
16. Mat Saad H, Alwi NA, Zulkifli NA, *et al*. Evaluation of antioxidant activity and phytochemical composition of *Baeckea frutescens* and *Leptospermum javanicum* essential oils. South African Journal of Botany. 2021 Sep;141:474-479. DOI:10.1016/j.sajb.2021.06.005.
17. Murningsih T. Studi fitokimia *Baeckea frutescens* L: Pengaruh faktor lingkungan terhadap komposisi kimia minyak atsiri. Berita Biologi. 2009 Aug;9(5):569-576.
18. Joukar M, Larijani K, Farjam MH, Givianrad MH, Nematollahi F. A comparative study of microwave-assisted and conventional hydro distillation methods for extracting essential oils and evaluating their antimicrobial activity from *Cleome khorassanica*: Novel research. Revue Roumaine de Chimie. 2024 Feb;69(1-2):41-48. DOI:10.33224/rrch.2024.69.1-2.05.
19. Yu J. Chemical composition of essential oils and their potential applications in postharvest storage of cereal grains. Molecules. 2025 Feb;30(3):683. DOI:10.3390/molecules30030683.
20. Palmieri S, Braca A, D’Agostino A, *et al*. Effect of the distillation time on the chemical composition, antioxidant potential and antimicrobial activity of essential oils from different *Cannabis sativa* L. cultivars. Molecules. 2021 Aug;26(16):4770. DOI:10.3390/molecules26164770.
21. Sá Filho JCFD, Oliveira FO, De Andrade MA, Hodel KVS, Lepikson H, Machado BAS. Geographic location and seasonality affect the chemical composition of essential oils of *Lippia alba* accessions. Industrial Crops and Products. 2022 Nov;188:115602. DOI:10.1016/j.indcrop.2022.115602.
22. Haro-González JN, Castillo-Herrera GA, Martínez-Velázquez M, Espinosa-Andrews H. Clove essential oil (*Syzygium aromaticum* L. Myrtaceae): Extraction, chemical composition, food applications, and essential bioactivity for human health. Molecules. 2021 Oct;26(21):6387. DOI:10.3390/molecules26216387.
23. Bolouri P, Hadipanah A, Shamsudin R, *et al*. Applications of essential oils and plant extracts in different industries. Molecules. 2022 Dec;27(24):8999. DOI:10.3390/molecules27248999.
24. Machado CA, Oliveira FO, De Andrade MA, *et al*. Steam distillation for essential oil extraction: An evaluation of technological advances based on an analysis of patent documents. Sustainability. 2022 Jun;14(12):7119. DOI:10.3390/su14127119.
25. Lin X, Wang H, Zhang H, *et al*. Frutescone O from *Baeckea frutescens* blocked TLR4-mediated Myd88NF-κB and MAPK signaling pathways in LPS-induced RAW264.7 macrophages. Frontiers in Pharmacology. 2021 Apr 27. DOI:10.3389/fphar.2021.643188.
26. Razmavar S, Abdulla MA, Ismail SB, Hassandarvish P. Antibacterial activity of leaf extracts of *Baeckea frutescens* against methicillin-resistant *Staphylococcus aureus*. BioMed Research International. 2014;2014:1-5. DOI:10.1155/2014/521287.
27. Luo S, Zhang Y, Wang X, *et al*. Discovery and biomimetic synthesis of a phloroglucinol-terpene adduct collection from *Baeckea frutescens* and its biogenetic origin insight. Chemistry - A European Journal. 2020 Sep;26(49):11104-11108. DOI:10.1002/chem.202001111.
28. Ahmad NS, Ghani MNA, Ali AM, Johari SAT, Harun MH. High performance liquid chromatography (HPLC) profiling analysis and bioactivity of *Baeckea frutescens* L. (Myrtaceae). Journal of Plant Studies. 2012 Aug;1(2):101. DOI:10.5539/jps.v1n2p101.