Rafiunisa *et al.* (2026) Vol. 14 No. 1: 18-24

Chimica et Natura Acta

p-ISSN: 2355-0864 e-ISSN: 2541-2574

Homepage: http://jurnal.unpad.ac.id/jcena

The Chemistry Profile of Essential Oil of the Roots, Stems, and Leaves of The Plant *Litsea firma* (Blume) Hook F.

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DOI: https://doi.org/10.24198/cna.v14.n1.62342
Article history: Received 18 March 2025 | Revised 9 August 2025 | Accepted 29 September 2025

Abstract*:* Indonesia, as an agrarian country rich in natural resources, holds enormous potential in the essential oil industry. There are approximately 150–200 species of essential oil-producing plants worldwide, 40 of which are found in Indonesia, including those from the Lauraceae family. The genus Litsea within the Lauraceae family is known for producing essential oils, with Litsea cubeba being the most popular. However, high demand for Litsea's essential oils encourages the exploration of essential oils from other Litsea species, such as Litsea firma. This study used gas chromatography-mass spectrometry to look at the chemical profile of essential oils from the roots, stems, and leaves of L. firma grown in West Kalimantan. The chemical profile data is then compared with data from other studies. The analysis results indicated that the composition of essential oils from roots is similar to the stems but differs from the leaf. The stem and root essential oils primarily consist of 4,4-diethyl-spiro[2,3]hexan-5-on, whereas the leaf essential oils mostly contain 1-cyclohexyl-ethanone. This difference in chemical constituents suggests that different parts of L. firma may have different ecological roles or therapeutic benefits. Further research could explore the implications of these findings for the plant's potential use in traditional medicine or natural product development. Therefore, we should continue exploring L. firma's essential oil to maximize its potential.

Keywords: chemical profile, essential oil, *Litsea firma*, Gas chromatography-Mass spectrometry

Abstrak: *Indonesia, sebagai negara agraris yang kaya akan sumber daya alam, memiliki potensi besar dalam industri minyak esensial. Di seluruh dunia terdapat sekitar 150–200 spesies tumbuhan penghasil minyak esensial, 40 di antaranya terdapat di Indonesia, termasuk spesies dari keluarga Lauraceae. Genus Litsea dalam keluarga Lauraceae dikenal sebagai penghasil minyak esensial, dengan Litsea cubeba sebagai yang paling populer. Namun, permintaan yang tinggi terhadap minyak esensial Litsea mendorong eksplorasi minyak esensial dari spesies Litsea lainnya, seperti Litsea firma. Studi ini menggunakan kromatografi gas-spektrometri massa untuk menganalisis profil kimia minyak esensial dari akar, batang, dan daun L. firma yang ditanam di Kalimantan Barat. Data profil kimia kemudian dibandingkan dengan data dari studi lain. Hasil analisis menunjukkan bahwa komposisi minyak esensial dari akar serupa dengan batang tetapi berbeda dengan daun. Minyak esensial batang dan akar terutama terdiri dari 4,4-diethyl-spiro[2,3]hexan-5-on, sedangkan minyak esensial daun sebagian besar mengandung 1-cyclohexyl-ethanone. Perbedaan konstituen kimia ini menyarankan bahwa bagian yang berbeda dari L. firma mungkin memiliki peran ekologi atau manfaat terapeutik yang berbeda. Penelitian lebih lanjut dapat mengeksplorasi implikasi temuan ini untuk penggunaan potensial tanaman dalam pengobatan tradisional atau pengembangan produk alami. Oleh karena itu, kita harus terus mengeksplorasi minyak esensial L. firma untuk memaksimalkan potensinya.*

Kata kunci: *profil kimia, minyak esensial, Litsea firma, kromatografi gas-spektrometri massa*

INTRODUCTION

Indonesia is an agrarian country with abundant natural resources. These natural resources are manifested in the form of vast land, superior varieties, and suitable agricultural conditions. Indonesia is rich with essential oil plants, which play an important role and are widely used in the food, cosmetics, and even pharmaceutical industries. There are 150-200 types of essential oil-producing plants, of which 40 species are found in Indonesia, including those from the Myrtaceae, Lamiaceae, Lauraceae, and Asteraceae families (Kardinan 2005).

One of the plant families that contains essential oils is Lauraceae. Among the several genera in the Lauraceae family, one of the most popular essential oil-producing genera is the Litsea genus. The essential oils reported from several Litsea plants contain key components of terpenoid compounds that are quite varied (Kusparadini *et al*. 2018).

Among several Litsea plants, *Litsea cubeba* is the most sought after by the essential oil industry market. Putri *et al*. (2015) reported that the demand for *L. cubeba* essential oil in the international market is 500 tons per year. However, only a few countries produce and cultivate it on a large scale. China is currently the largest producer of *L. cubeba* essential oil, but the high demand for *L. cubeba* essential oil within China itself has led to a shortage of the commodity in the international market. This situation presents a tremendous opportunity for Indonesia to make *L. cubeba* essential oil an export commodity. Currently, the presence of *L. cubeba* is becoming increasingly rare and endangered, particularly due to tree felling for distillation, charcoal, or the use of its bark by local communities (Baker 1997).

The exploration of essential oils from Litsea plants that grow in Indonesia, particularly on the island of Borneo, has been conducted previously (Kuspradini *et al*. 2021). One of them is *Litsea firma* (Blume) Hook F, known as medang piawas by local. Irwan (2015) reported that the Litsea plant species that dominate based on the Important Value Index (IVI) at the seedling and sapling stages in the Gunung Ambawang forest area, West Kalimantan, is *L. firma*. Meanwhile, the IVI at the seedling, sapling, pole, and tree stages found in the Sona customary forest in Gandis village, Dedai subdistrict, Sintang district, West Kalimantan, shows that *L. firma* is the most abundant Litsea species in the area.

The distillation of essential oil from *L. firma* (Blume) Hook. F in previous research produced an essential oil with a distinct aroma, a bitter taste, and was colorless (Gerina *et al*. 2024). The highest yield of *L. firma* was found in the leaves, with 2.42%, followed by the roots at 0.37% and the stems at 0.16%. Furthermore, the quality analysis of *L. firma* (Blume) Hook. F essential oil showed that it meets the standards set by the Indonesian National Standard (SNI) (Gerina *et al*. 2024).

A prior study on the chemical composition of the essential oils from the leaves and stems of *L. firma* growing in East Kalimantan showed that both parts of the plant contain the same main essential oil component, 2-undecanone, but they are present in different amounts (Jamal 2009). Although the essential oil yield from the roots of *L. firma* is twice that of the stems, the chemical composition of this oil has not been reported until now. This paper describes the analysis of the essential oil composition of the roots, leaves, and stems of *L. firma* growing in West Kalimantan and compares it with the essential oil composition of *L. firma* previously reported.

MATERIALS AND METHOD

Tools and Materials

The tools used in this study include a Gas Chromatography-Mass Spectrometry (GCMS) instrument from Agilent, USA, equipped with an HP-5S Ultra Inert column, with dimensions of 30m x 250µm x 0.25µm, and glassware. The solvent used in this study was n-hexane pro analysis. The essential oil samples examined were obtained from the roots, stems, and leaves of *L. firma*, which were collected through steam distillation. Plant materials, including leaves, stems, and roots of *L. firma*, were gathered in Sungai Pinang village, Pinoh Utara subdistrict, Melawi district, West Kalimantan. This plant has been identified as *L. firma* (Blume) Hook. f by Research Center for Plant Conservation and Botanic Gardens, LIPI, with code number B-1559/IPH.3/KS/XII/2020.

Sample Preparation

The samples used in this study were pure essential oils from the roots (3.2 mL), stems (0.9 mL), and leaves (17.8mL) of *L. firma* (Blume) Hook F, obtained through steam distillation from grinded roots (450 g), stems (600 g), and leaves (600 g) of *L. firma* (Blume) Hook F consecutively.

Analysis with Gass Chromatography-Mass Spectrometry (GC-MS)

The essential oil was analyzed using GC-MS to identify the chemical compound components present in *L. firma* essential oil. The mass spectrum data obtained were compared with the mass spectrum data of reference compounds listed (NIST14.L) in the instrumentation database of the GC-MS system (Pratama *et al*. 2016). The data obtained from the GC-MS analysis include chromatograms, retention times, signal complexity, peak signal heights, percentage area of each signal peak, and the database, which were then compared with the literature (Fitri 2020).

The GC-MS instrument was operated at a temperature of 50°C for 5 minutes, then the temperature was increased to 220°C with a temperature ramp rate of 5°C per minute. The total gas flow rate used was 26.2 mL per minute, with a slit ratio of 20:1 and an injector temperature of 270°C. The mass range detected by the MS was between 60-600 m/z. The sample volume injected into the instrument was 1 µL.

RESULT AND DISSCUSION

Analysis with Gass Chromatography-Mass Spectrometry (GC-MS)

The chemical profile analysis of the essential oil from the roots, stems, and leaves of *L. firma* in this study was conducted based on data from the GC-MS instrument chromatogram.

The GC-MS chromatogram analysis of the essential oil from *L. firma* roots revealed 20

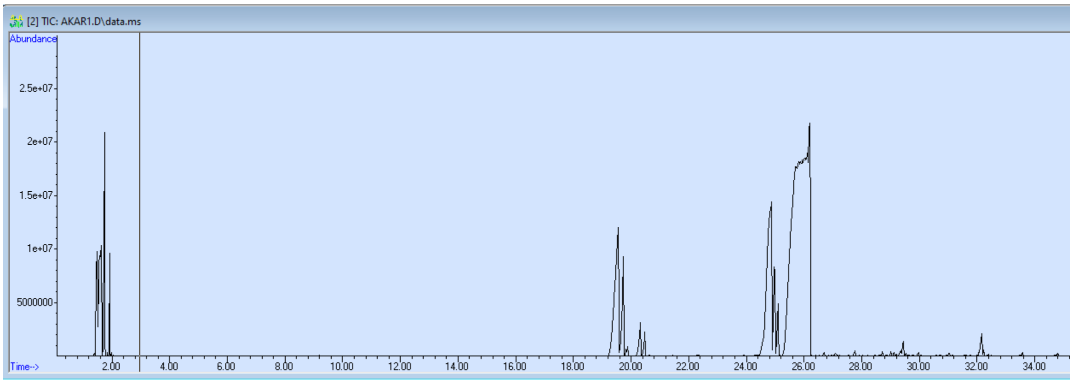

Figure 1. GC-MS chromatogram of *L. firma* root essential oil

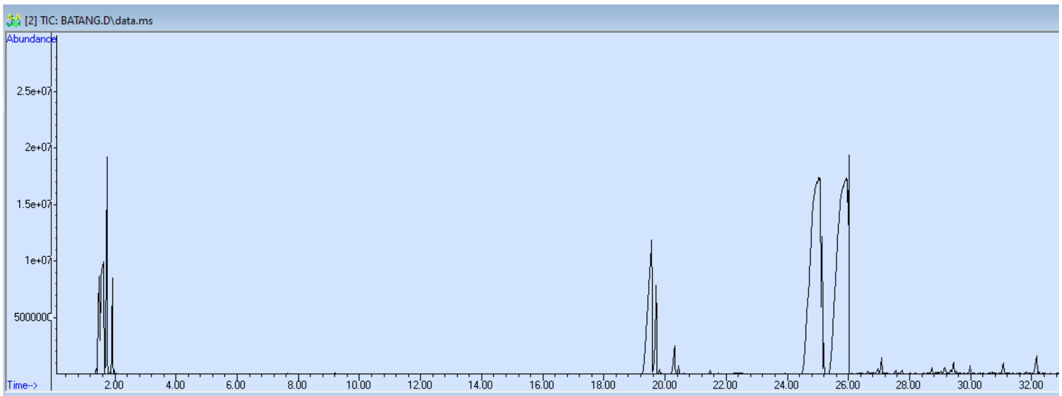

Figure 2. GC-MS chromatogram of *L. firma* stem essential oil

identified compounds, appearing in three different retention time groups (Figure 1). The relative percentage of each compound detected in the root essential oil of *L. firma* (Blume) Hook F was calculated based on the the area under each peak in the total area of all peaks. Therefore, the dominant compound identified in the first retention time range (minutes 1.3-1.9) was 3-methylene-pentane (2.97%). In the second retention time range (minutes 19-22), the dominant compound detected was citronellol (8.58%). The dominant compound identified in the third retention time range (minutes 25-26) was 4,4-diethyl-spiro[2,3]hexan-5-one (51.41%) (Table 1).

Based on the area under the curve, the main component of the essential oil from *L. firma* roots (Blume) Hook.f is 4,4-diethyl-spiro[2,3]hexan-5-one. This compound has previously been reported in green tea and acai berry seeds (*Euterpe oleracea*) (Valois *et al*. 2024; Yang *et al*. 2018).

The classification of detected compounds in the roots essential oil was analyzed based on their structural skeleton. All detected compounds consisted of isoprene (C5) moieties as structural backbones were identified as terpenes. On the other hand, compounds with no isoprene moieties in their structure were classified as non-terpenes. Based on the isoprene number in the structure of the detected compound in this study, terpenes were divided into hemiterpenes (C5), monoterpenes (C10), and sesquiterpenes (C15). Thus, the compounds detected in the essential oil from *L. firma* roots were classified into non-terpene compounds (76.06%), hemiterpenes (2.73%), monoterpenes (21.46%), and sesquiterpenes (0.05%). The percentage of each group was determined by summing the area percentage of each compound within the group.

The comparison of the GC-MS data for the essential oil from the stems and roots of *Litsea firma* shows nearly identical chromatogram patterns, with peaks occurring in the retention time ranges of 1.3-1.9 minutes, 19-22 minutes, and 24-35 minutes (Figure 2). The dominant compound in the stem essential oil within the 1.3-1.9 minute range was pentane, 3-methylene- (5.1%). The dominant compound in the stem essential oil in the 19-22 minute range was citronellol (8.87%) (Table 2). Meanwhile, the dominant compound in the stem essential oil in the 24-35 minute range was 4,4-diethylspiro[2.3]hexan-5-one (33.93%), followed by levomenthol (33.06%).

The results of this analysis differ from the study on the essential oil of *L. firma* stems from East Kalimantan (Jamal, 2009), which stated that the main component was 2-undecanone. However, 2-undecanone was not detected in the essential oil from the stems of *L. firma* growing in West Kalimantan.

The essential oil of *L. firma* leaves contains 22 identified compounds, with the main compound

Table 1. Compounds Identified in the Essential Oil of *L. firma* Roots

Peak	Real time	Compounds	Area (%)	Class	Peak	Real time	Compounds	Area (%)	Class
1.	1.492	prenol	2.73	Monoterpene	11.	20.484	methyl 10,11- tetradecadienoate	0.51	Non-terpene
2.	1.582	2-pentanone	2.34	Non-terpene	12.	24.873	neoisomenthol	12.02	Monoterpene
3.	1.634	2-ethyl-5-methyl-tetrahydrofuran	2.10	Non-terpene	13.	24.974	2-tridecanone	2.30	Non-terpene
4.	1.740	3-methylene- pentane	2.97	Non-terpene	14.	25.104	4,9-decadienoic acid, 2-nitro-, ethyl ester	1.07	Non-terpene
5.	1.918	cyclohexane	0.85	Non-terpene	15.	25.715-26.126	4,4-diethyl-spiro[2,3]hexan-5-one	51.41	Non-terpene
6.	19.550-19.571	citronellol	8.58	Monoterpene	16.	26.210	(*R*)-(-)-14-methyl-8-hexadecyn-1-ol	7. 45	Non-terpene
7.	19.734	2-undecanone	2.62	Non-terpene	17.	27.772	cyclopropanecarboxylic acid, 2,2-dimethyl-3-(1-propenyl)-, methyl ester, [1.α.,3β.(Z)]-	0.10	Sesquiterpene
8.	19.837	(*E*)-5-octadecene	0.13	Non-terpene	18.	29.351	5-pentadecen-7-yne, (*Z*)-	0.10	Non-terpene
9.	19.886	7-propylidene-bicyclo[4.1.0]heptane	0.13	Sesquiterpene	19.	29.451	5-dodecyne	0.31	Non-terpene
10.	20.325	4-hexadecen-6-yne, (*E*)-	0.86	Non-terpene	20.	32.178	bicycle[4.1.0]heptane, 7-(1-methylethylidene)-	0.66	Sesquiterpene

Table 2. Compounds Identified in the Essential Oil of L. firma Stem

Peak	Real time	Compounds	Area (%)	Class	Peak	Real time	Compounds	Area (%)	Class
1	1.492	prenol	2.69	Hemiterpene	11	25.193-25.974	4,4-diethyl-spiro[2,3]hexan-5-one	33.93	Non- terpene
2	1.594	heptane, 2,4-dimethyl-	5.1	Non-terpene	12	26.014	(R)-(-)-14-methyl-8-hexadecyn-1-ol	3.22	Non- terpene
3	1.742	pentane, 3-methylene-	3.23	Non-terpene	13	26.971	(-)-spathulenol	0.13	Sesquiterpene
4	1.924	cyclohexane	1.07	Non-terpene	14	27.090	caryophyllene oxide	0.31	Sesquiterpene
5	19.564	citronellol	8.87	Monoterpene	15	28.741	7-oxabicyclo[4.3.0] nonane, cis-	0.11	Non- terpene
6	19.712	3,4-dimethylcyclohexanol	2.02	Non-terpene	16	29.158	4-t-pentylcyclohexene	0.17	Non-terpen
7	20.310	4-hexadecen-6-yne, (E)-	0.73	Non- terpene	17	29.450	tridecanedial	0.25	Non- terpene
8	20.447	9-tetradecynoic acid, methyl ester	0.14	Non-terpene	18	31.076	nonyl tetradecyl ether	0.24	Non- terpene
9	24.958	levomenthol	33.06	Monoterpene	19	32.176	bicyclopentylidene	0.56	Non- terpene
10	25.318	hexadecanal, 2-methyl-	2.86	Non-terpene	20	33.632	9-eikosyne	0.17	Non- terpene
					21	34.869	n-hexadecanoic acid	0.13	Non- terpene

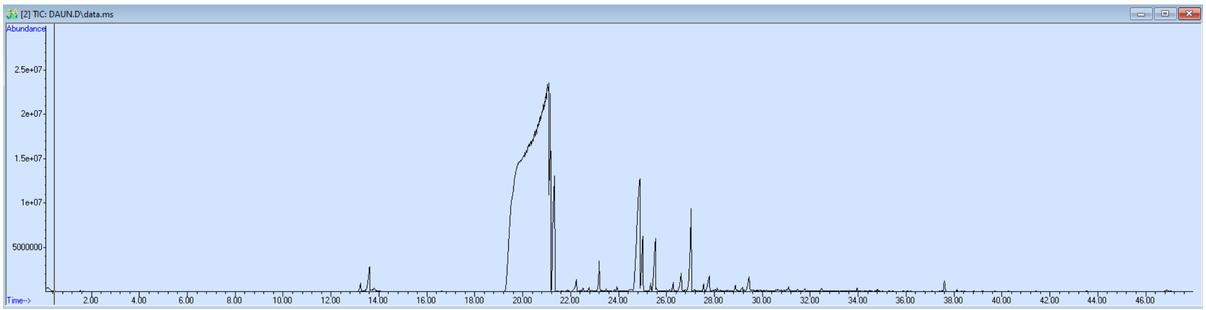

Figure 3. GC-MS chromatogram of *L. firma* leaf essential oil

Table 3. Compounds Identified in the Essential Oil of *L. firma* Leaves

Peak	Real time	Compounds	Area (%)	Class
1	13.233	oxyrane, tetradecyl-	0.16	Non-terpene
2	13.607	2-nonanone	0.60	Non-terpene
3	19.545	citronellol	4.37	Monoterpene
4	19.836	pentyl octadecyl ether	10.87	Non-terpene
5	19.857	carbonic acid, eicosyl vinyl ester	1.32	Non-terpene
6	19.936-20.757	1-cyclohexylethanone	44.43	Non-terpene
7	20.812	3,4-dimethylcyclohexanol	12.39	Monoterpene
8	20.980	1,7-octadien-3-ol, 2,6-dimethyl-	5.37	Monoterpene
9	21.160	5-nonadecen-1-ol	3.00	Non-terpene
10	21.328	limonene oxcide, trans-	3.19	Monoterpene
11	22.234	copaene	0.27	Sesquiterpene
12	23.196	caryophyllene	0.46	Sesquiterpene
13	24.888	butanoic acid, 1-cyclopenthylethyl ester	5.21	Non-terpene
14	25.010	2-tridecanone	1.06	Non-terpene
15	25.351	2,7-octadiene-1,6-diol, 2,6-dimethyl-	0.12	Monoterpene
16	25.537	cyclopentaneacetaldehyde, 3-formyl-3-methyl-α-methylene-	1.16	Non-terpene
17	26.278	1,8-nonadiene, 2-methyl-5,7-dimethylene-	0.12	Non terpene
18	26.628	phytol	0.58	Diterpene
19	27.033	caryophyllene oxide	1.71	Sesquiterpene
20	27.167	Ledol	0.03	Sesquiterpene
21	27.778	5,10-undecadienoic acid, 2-methylene-, methyl ester	0.36	Non terpene
22	29.249	(Z)-cis-9-hexadecenal cyclopentadecanone 7-tetradecenal	0.02	Non terpene

appearing at a retention time of 19.936-20.757 minutes (Table 3). The compound identified at this retention time was 1-cyclohexylethanone (44.43%). The compounds detected consist of several different compound groups, with the chromatogram predominantly showing non-terpene compounds (78.30%), monoterpenes (13.06%), diterpenes (0.62%), and sesquiterpenes (8.01%). The GC-MS chromatogram analysis of the *L. firma* leaf essential oil shows a different chromatogram pattern compared to the roots and stems (Figure 3). This indicates that the composition of the essential oil compounds in the leaves differs from that in the roots and stems. Nevertheless, there are some compounds in common between the essential oils of the leaves, roots, and stems of *L. firma* (Table 4).

The results of this analysis differ from previous studies (Jamal 2009) which stated that the main component of the essential oil from *L. firma* leaves growing in East Kalimantan was 2-undecanone. However, 2-undecanone was not detected in the essential oil from the leaves of *L. firma* growing in West Kalimantan, but was detected in the essential oil from the roots. Another study mentions that the main component of the essential oil from *L. firma* leaves growing in Vietnam is nerol at 14.4% (Dai *et al*. 2020). However nerol was not detected in the essential oil from the leaves of *L. firma* in West Kalimantan (Table 5). Furthermore, ledol, which was

Table 4. Comparison of common compounds in the essential oils of *L. firma* roots, stems, and leaves

No	Compounds	Area (%)[a]		
		Root	**Stem**	**Leaf**
1.	4,4-diethyl-spiro[2,3]hexan-5-one	51.41	33.93	-
2.	citronellol	8.58	8.87	4.37
3.	3,4-dimethylcyclohexanol	0.02	2.02	12.39
4.	phytol	-	0.05	0.58
5.	caryophyllene oxide	0.05	-	1.71
6.	2-tridecanone	2.30	-	1.06

[a]Area percentage is based on area percentage from each source of essential oil

reported to be detected in the essential oil from *L. firma* leaves in Vietnam (0.6%), was also found in the essential oil from *L. firma* leaves in West Kalimantan (0.03%). The ecological differences are believed to influence the variation in the production of *L. firma* essential oil.

Mahalwal & Ali (2003) explained that the components citronellal, geraniol, and citronellol in essential oils can inhibit bacterial activity. Citronellol has also been reported to have termite repellent activity (Lima *et al*. 2013). Based on the analysis of the essential oil from the leaves, roots, and stems of *L. firma* growing in West Kalimantan, citronellol was found in all three parts of the plant. This explains the reported termite repellent activity of *L. firma* leaf essential oil by Gerina (2024). Currently, *L. cubeba* is a commercially important essential oil-producing plant in Indonesia. The main component of *L. cubeba* is eucalyptol (Putri *et al*. 2015; Suwandhi *et al*. 2014). Meanwhile, the essential oils from the leaves, stems, and roots *of L. firma* have been reported to have qualities similar to *L. cubeba* essential oil (Gerina *et al*. 2024). Thus, although the main compound components differ from those of *L. cubeba* essential oil, *L. firma* essential oil has the potential to be further developed in the same way as *L. cubeba* essential oil.

CONCLUSION

This study analyzes the chemical profile of the essential oil from the roots, stems, and leaves of Litsea firma using GC-MS chromatogram data. The results indicated that the chromatogram pattern of the root essential oil is similar to that of the stem oil but different from that of the leaf oil. A substance called 4,4-diethyl-spiro[2,3]hexan-5-one is the main part of both the root and stem essential oils. It is present in 51.4% and 33.9% concentrations, respectively. Meanwhile, the main component of the leaf essential oil is 1-cyclohexylethanone (44.43%). The fact that these results are different from earlier research on L. firma essential oils from places like East Kalimantan and Vietnam suggests that the essential oil composition of L. firma may change depending on where it grows. Furthermore, although the main components of L. firma essential oil differ from those of L. cubeba essential oil, L. firma essential oil has the potential to be further developed as an alternative to L. cubeba essential oil.

ACKNOWLEDGMENT

The author would like to thank Petronius Henry, S.Pd., for assisting with the GC-MS measurements at the Forensic Laboratory of the West Kalimantan Regional Police.

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