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Review Article

Essential Oil Compositions of Malaysian Lauraceae: A Mini Review

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ABSTRACT

Essential oils have been largely employed for human need due to their antibacterial, antifungal and insecticidal activities. At present, approximately 3000 essential oils are known, 300 of which are commercially important. Essential oils or some of their components are used in perfumes and make-up products, sanitary products, dentistry, agriculture, as food preservers and additives, and as natural remedies. The essential oil compositions of Malaysian Lauraceae family have been investigated for many years. In the recent years, studies on the essential oils of the species have been progressing and many of them have reported interesting pharmacological activities. In this article, we summarized and updated the chemical compositions and biological activities of Malaysian Lauraceae. Throughout our literature review, only four genera which are *Lindera*, *Beilschmiedia*, *Litsea*, and *Cinnamomum* have been studied for their essential oil compositions in Malaysia. They were found to contain mainly safrole, eugenol, linalool, camphor, benzyl benzoate or cinnamaldehyde as major components. There were significant priorities to find out the details of the chemical compositions of the essential oils from Malaysian Lauraceae. Therefore, more clinical studies on the toxicity of the essential oil of the species are also crucial to ensure their safety and to assess their eligibility to be used as the sources of modern medicines.

Introduction

The Lauraceae family is by far the largest family of the order Laurales with about 50 genera and over 2000 species distributed throughout tropical to subtropical latitudes especially in Southeast Asia and tropical America.[1] Several genera have a pantropical distribution such as *Beilschmiedia*, *Cassytha*, *Cryptocarya*, *Litsea*, *Ocotea*, and *Persea*. Others are restricted to Asia and Australia which are *Alseodaphne*, *Dehaasia*, *Endiandra*, *Eusideroxylon*, *Hexapora*, and *Neolitsea*. *Eusideroxylon* is restricted to Borneo and Sumatra while *Dehaasia* and *Hexapora* are restricted to Peninsular Malaysia. Besides, *Ravensara* and *Potameia* can be found in Madagascar.[2-3]

The Lauraceae family can be recognized by its distinctive floral morphology. The bark is smooth, leathery, and has many lenticels. The inner bark is fragrant, yellow, orange, reddish, or pinkish and exudes a pale yellow to pale brown sap after incision. The leaves in this family are simple, without stipules, opposite, spiral, whorled or alternate, usually with several gland dots and often release aromatic scent when crushed. The inflorescences are racemose or in clusters. The flowers are bisexual, actinomorphic, small, regular, greenish-white or yellow, fragrant, trimerous, and the fruits are variously accrescent. The fruits are baccate or drupaceous, and often seated or enclosed in a persistent and cup-shaped corolla, the morphology which has the taxonomic value.[4]

In Malaysia, the Lauraceae family has 16 genera and 213 species, subspecies, and varieties.[5] Most of the plants are commercialized as timbers. They are suitable for plywood manufacture and decorative works such as interior, finishing, paneling, furniture, and cabinet making. The bark of various species has commercial values such as cinnamon (*Cinnamomum verum*, *C. cassia*) and massoy (*Cryptocarya massoy*). The avocado or alligator pear (*Persea americana*), a species indigenous to tropical America is now widely cultivated in tropical countries for its fruits. The species *Cinnamomum iners* (medang teja) is commonly planted as a shade tree in Malaysia.[6-7] The family has been extensively researched and in this review, different studies on the essential oil of Malaysian species of Lauraceae family will be reviewed. The available information on various species were collected via electronic search (Pubmed, SciFinder, Scopus, Google Scholar and Web of Science) and the articles published in peer-reviewed journals were collected via library search. Based on the literature review, we have

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successfully found four genera from Malaysia in which their essential oil compositions have been studied. They are *Lindera*, *Beilschmiedia*, *Litsea*, and *Cinnamomum* species. The *Cinnamomum* and *Litsea* species have been extensively studied on the essential oil composition, together with their biological activities.

Chemical composition of Lindera essential oil

The genus *Lindera* contains about 150 species in which only 11 species can be found in Malaysia.[1,8] The trees are evergreen with resinous or aromatic barks and leaves. Various parts of some of these species have been used as food or in traditional medicine.[9] The leaf oil of *L. umbellata* has been formulated in many perfume preparations and its wood fragrant is used to make toothpicks.[10] However, only one species of *Lindera* from Malaysia has been studied for their essential oil composition, which is *L. pipericarpa*. This species was found in Pahang and various parts of the tree have been used either as flavours, in traditional medicine or in the preparation of cosmetics by the local folks.[9] The leaf oil was composed predominantly of sesquiterpene hydrocarbons while the wood oil was mainly made of monoterpenes. Toxicity test of these oil against brine shrimp showed that the leaf and wood oil of *L. pipericarpa* exhibited some degree of activity which gave IC_{50} the values of 364 and 444 µg/mL, respectively.[11] Table 1 summarizes the composition of the essential oil of Malaysian *Lindera* species.

Table 1. Essential oil composition of *Lindera* species.

Species	Method	Part (Yield)	Major groups (%)	Major components (%)
L. pipericarpa	Water distillation	Leaf (1.00%)	Sesquiterpene hydrocarbons (>60.0%)	β-caryophyllene (**1**) (32.1%), α-copaene (31.4%), nerolidol (6.1%)[11]
		Wood (0.05%)	Monoterpene hydrocarbons (89.9%)	Limonene (**2**) (55.4%), linalool (6.6%), geranial (6.7%), neral (5.1%)[11]

Chemical composition of Beilschmiedia essential oil

Beilschmiedia is a pantropical genus consist about 250 species most commonly represented in tropical regions of Asia and Africa. Most of the species grow in tropical climates but few of them are native to temperate regions. They are widespread in tropical Asia, Africa, Australia, New Zealand, and Central and South America. The genus comprises of trees and rarely shrubs and is usually distinguished from other genera of the Lauraceae by the following characteristics: paniculate or racemose inflorescences that are not strictly cymose at the terminal division, bisexual and trimerous flowers with six equal to subequal tepals, six to nine fertile stamens which represent the outer two or three whorls, two-celled anthers, and fruits with lacking cupules.[12-13] Three *Beilschmiedia* species have been reported in Malaysia which were *B. madang*,[14] *B. pulverulenta*,[15] and *B. glabra*[16] in Selangor, Sarawak and Johor, respectively. Analysis of the essential oil of *B. madang* led to identification of 55 and 42 components, which represented 89.8% and 81.5% of the total oil from leaf and bark, respectively. The essential oils were screened for their antioxidant, antibacterial, antifungal, anticholinesterase and anti-tyrosinase activities. The bark oil showed the highest β-carotene/linoleic acid bleaching (90.3% ± 0.2), DPPH radical scavenging (IC_{50} 212.0 lg/mL), and antifungal assay towards *Aspergillus niger* and *Aspergillus fumigatus* (MIC 62.5 µg/mL). The leaf oil gave significant percentage inhibition on acetylcholinesterase (55.2%), butyrylcholinesterase (60.4%), and tyrosinase (53.1%).[14] The essential oil of *B. pulverulenta* was successfully identified and 42 of the components accounted for 93.8% of the total oil, dominated by phenylpropanoids. The essential oil has showed significant antityrosinase and anti-inflammatory activities with 67.6 and 62.5% inhibition, respectively. In addition, the oil had moderate AChE (56.5%) and BChE (48.2%) activities. In addition, the essential oil had shown strong antimicrobial activity against the Gram-positive bacteria with a minimum inhibitory concentration (MIC) value each of 62.5 mg/mL and moderate against the tested fungi with MIC and minimum bactericidal concentration (MBC) values each of 125 mg/mL.[15] As for *B. glabra* essential oils, 47 components were identified in the essential oils, which made up 86.8% and 89.7% of the leaf and bark oils, respectively. The essential oils were composed mainly of sesquiterpene hydrocarbons (53.1-66.4%). Antioxidant activity showed that the leaf oil has the highest phenolic content at 233.4 mg GA/g, while the bark oil showed potent activity in the β-carotene/linoleic acid bleaching assay. In the case of antimicrobial activity, the leaf and bark oils displayed strong activity against *Candida glabrata* and *Saccharomyces cerevisiae* with MIC values of 31.3 and 62.5 µg/mL, respectively. Percentage inhibitions against tyrosinase (leaf 73.7%; bark 76.0%) and acetylcholinesterase (leaf 48.1%; bark 45.2%) were tested at a concentration of 1 mg/mL, while anti-inflammatory activity (leaf 59.7%; bark 48.9%) was evaluated at a concentration of 100 µM.[16] A summary of the composition of the essential oils of Malaysian *Beilschmiedia* species is tabulated in Table 2. The leaf and bark essential oils of these Beilschmiedia species had been reported for their antioxidant, antibacterial, antifungal, anticholinesterase, anti-tyrosinase, and anti-inflammatory activities.

Table 2. Essential oil composition of *Beilschmiedia* species.

Species	Method	Part (Yield)	Major groups (%)	Major components
B. madang	Hydro-distillation	Leaf (0.45%)	Sesquiterpene hydrocarbons (63.8%)	δ-Cadinene (**3**) (17.0%), α-cubebene (11.3%), β-caryophyllene (10.3%), bicyclogermacrene (6.7%), α-cadinol (5.8%), (*E*)-nerolidol (5.0%)[14]
		Bark (0.42%)	Sesquiterpene hydrocarbons (65.3%)	δ-Cadinene (**3**) (20.5%), α-cubebene (15.6%), α-cadinol (10.6%), β-caryophyllene (6.7%) [14]
B. pulverulenta	Hydro-distillation	Leaf/bark (0.0095%)	Phenylpropanoids (51.1%)	Eugenol (**4**) (45.3%), eugenol acetate (5.6%) [15]
B. glabra	Hydro-distillation	Leaf (0.13%)	Sesquiterpene hydrocarbons (53.1%)	β-eudesmol (**5**) (15.4%), β-selinene (12.2%), caryophyllene oxide (8.1%), γ-gurjunene (5.2%)[16]
		Bark (0.04%)	Sesquiterpene hydrocarbons (66.4%)	β-eudesmol (**5**) (19.3%), β-selinene (16.9%), δ-cadinene (15.8%), germacrene D (9.5%), β-caryophyllene (5.5%) [16]

Chemical composition of Litsea essential oil

Litsea is one of the 35 genera in the family of Lauraceae. A total of 400 species is distributed throughout the tropical and subtropical Asia, the Pacific, Australia, and New Zealand. In Peninsular Malaysia, *Litsea* is represented by 54 species.[5] *Litsea* species as well as any other Lauraceae are locally known as *medang* or *tejur* and they are abundant in the forest in Sarawak.[17] *Litsea* trees have smooth bark, brown in colour, and rarely split. The leaves are arranged alternately and singly, rarely subopposite. It is characterized by its inflorescences, trimerous flowers, and 4-locular anthers.[18] Thirteen species of *Litsea* have been successfully found and their chemical compositions of the essential oil have been studied. They were *L. resinosa*,[23-25] *L. nidularis*,[23] *L. rigidularis*,[23] *L. cylindrocarpa*,[23] *L. garciae*,[23] *Litsea sp.*,[23] *L. gracilipes*,[24-25] *L. paludosa*,[24] *L. fulva*,[26] *L. sessilis*,[25] *L. megacarpa*,[25] *L. machilifolia*,[25] and *L. ferestrata*.[25] All species were collected from Sarawak, Malaysia.[23-26] A summary of the composition of the essential oil of Malaysian *Litsea* species is shown in Table 3. The pharmacological studies of Malaysia *Litsea* essential oil also have been reported. *L. elliptica* leaf oil had been traditionally used as medicinal herbs because of its antimutagenicity, chemopreventative, and insecticidal properties.[19] In addition, the essential oil was also used to study the toxic effects on the red blood cells of Sprague-Dawley rats.[20] Furthermore, the essential oil also showed potential to be used as an insecticide and the repellent properties against *Aedes aegypti* bites had also been reported.[21-22]

Table 3. Essential oil composition of *Litsea* species.

Species	Method	Part(Yield)	Major groups(%)	Major components
L. resinosa	Water distillation	Leaf (1.6%)	Sesquiterpenoids (>90.0%)	Bulnesol (**6**) (14.9%), β-caryophyllene (10.2%), β-elemene (10.2%), caryophyllene oxide (7.8%), α-copaene (6.0%), γ-muurolene (5.2%)[24]
	Hydro-distillation	Leaf (0.52%)	Alcohols (39.47%)	2-Naphthalenemethanol (**7**) (30.14%), 2*H*-benzocyclohepten-2-one (26.64%), (-)-globulol (19.33 %), 1-naphthalenemethanol (9.33%), viridiflorol (9.26%), 1*H*-benzocyclohepten-7-ol (5.29%)[25]
	Hydro-distillation	Stem/root (0.87%)	Alcohols (70.68%)	2-Naphthalenemethanol (**7**) (54.29%), 2H-benzocyclohepten-2-one (19.52%), 1-naphthalenemethanol (16.39%), agarospirol (6.82%)[25]
	Hydro-distillation	Leaf	No data	3-xo-α-ionol (**8**) (50.59%), tricosane (43.14%), acetovanillone (23.49%)[23]
L. nidularis	Hydro-distillation	Leaf	No data	Acetovanillone (**9**) (49.68%), methyl vanillate (33.40%)[23]
L. rigidularis	Hydro-distillation	Leaf	No data	Tricosane (**10**) (53.97%), methyl vanillate (32.28%), phytol (31.80%)[23]
L. cylindrocarpa	Hydro-distillation	Leaf	No data	γ-Cadinene (**11**) (55.39%), β-guaiene (46.89%)[23]
L. garciae	Hydro-distillation	Leaf	No data	Ethylfuranone (**12**) (34.71%), lauric acid (22.02%)[23]
Litsea sp.	Hydro-distillation	Leaf	No data	Lauric acid (**13**) (29.81%), (*E*,*E*)-farnesyl acetate (25.78%)[23]

Table 3 continued.

L. gracilipes	Water distillation	Leaf (0.5%)	Sesquiterpenoids (79.7%)	Ledene (**14**) (9.0%), aromadendrene (8.3%), α-copaene (6.8%), calamenene (6.7%), δ-cadinene (6.5%), globulol (6.0%)[24]
	Hydro-distillation	Stem (0.23%)	Sesquiterpenes (74.26%)	(-)-Globulol (**15**) (35.24%), hexan-3-one (25.73%), viridiflorol (11.15%), ledol (6.99%), epiglobulol (5.97%)[25]
L. paludosa	Water distillation	Leaf (4.0%)	Sesquiterpe hydrocarbons (66.6%)	Ledene (**14**) (17.8%), aromadendrene (10.3%), elemol (7.7%), globulol (6.4%)[24]
L. fulva	Hydro-distillation	Leaf	Alcohols (34.09%)	*cis*-*Z*-α-Bisabolene epoxide (**16**) (9.51%), trans-*Z*-α-bisabolene epoxide (8.36%), 1b,5,5,6a-Tetramethyl-octahydro-1-oxa-cyclopropa[a]inden-6-one (7.39%), longipinocarvone (5.68%)[26]
L. sessilis	Hydro-distillation	Leaf (0.08%)	Aldehydes/ketones (67.10%)	Pentadecanal (**17**) (23.80%), bicyclo-(4,4)-dec-1-ene (19.61%), tetradecanal (18.78%), tridecanal (8.28%), 2-nonadecanone (5.92%)[25]
L. megacarpa	Hydro-distillation	Leaf (0.30%)	Sesquiterpenes (88.38%)	Caryophyllene oxide (**18**) (56.89%), 1*H*-cycloprop(e)azulene-7-ol (29.45 %)[25]
L. machilifolia	Hydro-distillation	Stem/root (0.77%)	Sesquiterpenes (56.73%)	Cyclohexanemethanol (**19**) (42.84%), globulol (27.43%), 1*H*-cycloprop(e)azulene (8.67%), 1*H*-cycloprop(e)azulen-7-ol (6.85%), epiglobulol (6.22%), ledol (6.0%)[25]
L. ferestrata	Hydro-distillation	Leaf (0.19%)	Sesquiterpenes (83.82%)	(-)-Globulol (**15**) (28.91%), 1*H*-cycloprop(e)azulene-7-ol (18.67%), viridiflorol (17.33%), 3-Cyclohexen-1-carboxaldehyde (8.74%), ledol (7.88%), epiglobulol (5.75%)[25]

Chemical composition of Cinnamomum essential oil

The genus *Cinnamomum* contains about 250 species including 21 species are found in Peninsular Malaysia. The species are shrubs and the size of the trees is small to medium-sized.[27] They are found in tropical rain forests where they grow at various altitudes from highland slopes to lowland forests. It also can be found in both marshy places and on well-drained soils. However, at latitudes with seasonal climatic conditions, they become very rare.[28] The genus is found in eastern and southeastern Asia, through Malaysia and into the Pacific. Thirteen Cinnamomum species have been investigated for their essential oil studies which are *C. subavenium*,[40] *C. rhyncophyllum*,[27,36] *C. aureoflavum*,[37] *C. pubescens*,[36,41] *C. mollissimum*,[36,42] *C. impressicostatum*,[36] *C. cordatum*,[31,36] *C. zeylanicum*,[36] *C. parthenoxylon*,[43] *C. sintoc*,[44] *C. altissimum*,[32,45] *C. scortechinii*,[32,36] and *C. microphyllum*.[32,36] A summary of the composition of the essential oil of Malaysian *Cinnamomum* species can be seen in Table 4.

Table 4. Essential oil composition of *Cinnamomum* species.

Species	Method	Part(Yield)	Major groups (%)	Major components
C. subavenium	Water distillation	Leaf (0.8%)	Sesquiterpenoids (70.2%)	Patchouli alcohol (**20**) (27.7%), benzyl benzoate (19.6%), β-selinene (7.2%)[40]
		Bark (0.4%)	Monoterpenoids (20.5%)	Patchouli alcohol (**20**) (10.5%), α-terpineol (9.7%), linalool (7.5%), tetradecanoic acid (5.3%)[40]
C. rhyncophyllum	Hydro-distillation	Leaf (3.5%)	Esters (81.4%)	Benzyl benzoate (**21**) (77%), β-phellandrene (6.3%), methyl (*E*)-cinnamate (4.2%)[27]
		Bark (1.5%)	Phenylpropanoids (44.9%)	Safrole (**22**) (43.3%), methyl (*E*)-cinnamate (43.1%), benzyl benzoate (8.5%)[27]
		Wood (0.7%)	Phenylpropanoids (55.5%)	Safrole (**22**) (51.0%), methyl (*E*)-cinnamate (40.5%)[27]
	Water distillation	Leaf (3.5%)	Esters (70.0%)	Benzyl benzoate (**21**) (70.0%), β-phellandrene (10.0%)[36]
		Bark (1.6%)	Esters (54.7%)	Methyl (*E*)-cinnamate (**23**) (41.7%), safrole (41.5%), benzyl benzoate (13.0%)[36]

Table 4 continued.

C. aureofulvum	Hydro-distillation	Leaf (0.1%)	Sesquiterpenoids (32.9%)	Benzyl benzoate (**21**) (43.4%), benzyl alcohol (8.1%), linalool(7.3%), viridiflorol (6.9%), viridiflorene (5.4%)[37]
		Bark (0.4%)	Aldehyde (46.6%)	Cinnamaldehyde (**24**) (46.6%), linalool (14.6%), eugenol (5.0%)[37]
C. pubescens	Water distillation	Leaf (5.0-5.7%)	Esters (46.1-47.1%)	Benzyl benzoate (**21**) (46.1-47.1%), β-phellandrene (14.9-16.4%)[41]
	Hydro-distillation	Leaf (5.4%)	Esters (75.4%)	Benzyl benzoate (**21**) (50.2%), benzyl salicylate (23.4%), *p*-cymene (11.7%)[36]
		Bark (3.6%)	Esters (95.2%)	Methyl (*E*)-cinnamate (**23**) (95.2%)[36]
		Twig (1.9%)	Esters (95.1%)	Methyl (*E*)-cinnamate (**23**) (84.0%), benzyl benzoate (11.1%)[36]
C. mollissimum	Hydro-distillation	Leaf (2.8%)	Esters (87.8%)	Benzyl benzoate (**21**) (87.6%)[36]
	Water distillation	Leaf (2.65%)	Esters (78.5%)	Benzyl benzoate (**21**) (77.6%), benzyl alcohol (10.7%)[42]
		Bark (1.97%)	Phenylpropanoids (93.3%)	Safrole (**22**) (93.3%)[42]
			Wood (0.40%)	Phenylpropanoids (98.9%)
C. impressicostatum	Hydro-distillation	Leaf (4.8%)	Esters (59.4%)	Benzyl benzoate (**21**) (50.9%), α-phellandrene (12.3%), benzyl salicylate (7.5%), *p*-cymene (7.0%)[36]
		Bark (3.2%)	Esters (88.2%)	Methyl (*E*)-cinnamate (**23**) (85.9%), safrole (7.5%)[36]
		Twig (2.4%)	Esters (76.2%)	Methyl (*E*)-cinnamate (**23**) (67.6%), benzyl benzoate (8.2%), α-terpinene (7.8%)[36]
C. cordatum	Hydro-distillation	Leaf (0.8%)	Oxygented monoterpenes (30.6%)	Linalool (**25**) (17.3%), methyl (*E*)-cinnamate (17.1%), β-phellandrene (9.0%), benzyl benzoote (7.6%), terpinen-4-ol (7.0%)[36]
	Water distillation	Leaf (0.8%)	Monoterpenoids (53.8%)	Linalool (**25**) (17.3%), (*E*)-methyl cinnamate (17.1%), β-phellandrene (9.0%), terpinen-4-ol (7.0%)[31]
		Bark (0.7%)	Phenylpropanoids (21.6%)	Methyl eugenol (**26**) (92.1%)[31]
C. zeylanicum	Hydro-distillation	Leaf (5.5%)	Phenylpropanoids (90.3%)	Eugenol (**4**) (90.2%)[36]
		Bark (1.5%)	Aldehydes (44.4%)	Cinnamaldehyde (**24**) (44.2%), β-phellandrene (8.0%), β-caryophyllene (6.9%)[36]
C. parthenoxylon	Hydro-distillation	Wood (1.0%)	Phenylpropanoids (65.0%)	Methyl eugenol (**26**) (45%), safrole (20%), γ-muurolene (13.5%)[43]
C. sintoc	Water distillation	Leaf (0.1%)	Phenylpropanoids (31.0%)	Safrole (**22**) (23.4%), γ-muurolene (13.5%), eugenol (7.6%), linalool (6.5%), terpinen-4-ol (5.3%)[44]
		Bark (0.3%)	Oxygentaed monoterpenes (27.7%)	Linalool (**25**) (23.8%), tetradecanal (16.4%)[44]
		Wood (0.1%)	Aldehyde (21.6%)	Tetradecanal (**27**) (21.1%), octadecanoic acid (11.9%), safrole (8.1%), pentadecanoic acid (7.2%), hexadecanoic acid (6.5%)[44]
		Twig (0.1%)	Oxygentaed monoterpenes (66.6%)	Linalool (**25**) (52.9%), methyl (*Z*)-cinnamate (6.0%), methyl (*E*)-cinnamate (6.0%)[44]
C. altissimum	Hydro-distillation	Bark (1.9%)	Monoterpenoids (76.3%)	Linalool (**25**) (36.0%), methyl eugenol (12.8%), limonene (8.3%), α-terpineol (7.8%), terpinen-4-ol (6.4%)[45]

Table 4 continued.

	Water distillation	Leaf (0.7%)	Sesquiterpenoids (65.6%)	Spathulenol (**28**) (16.1%), β-eudesmol (8.1%), linalool (7.2%), β-selinene (7.1%), α-pinene (7.0%) [32]
		Bark (0.1%)	Sesquiterpenoids (74.5%)	Linalool (**25**) (25.3%), β-eudesmol (9.7%), spathulenol (8.9%)[32]
C. scortechinii	Water distillation	Leaf (0.5%)	Sesquiterpenoids (58.8%)	Linalool (**25**) (25.4%), δ-cadinene (6.6%), β-selinene (5.8%), α-terpineol (5.4%), β-eudesmol (5.4%), α-bisabolol (5.3%)[32]
		Bark (0.3%)	Sesquiterpenoids (71.3%)	Linalool (**25**) (10.6%), β-eudesmol (8.8%), neral (7.5%), δ-cadinene (5.2%)[32]
	Hydro-distillation	Leaf (0.5%)	Monoterpene hydrocarbons (34.0%)	Linalool (**25**) (16.4%), β-phellandrene (17.3%), benzyl benzoate (13.5%), benzyl salicylate (9.4%), limonene (6.8%), terpinen-4-ol (6.6%)[36]
C. microphyllum	Water distillation	Leaf (3.3%)	Sesquiterpenoids (93.3%)	Benzyl benzoate (**21**) (90.0%)[32]
		Bark (0.3%)	Sesquiterpenoids (94.5%)	Benzyl benzoate (**21**) (92.7%)[32]
	Hydro-distillation	Leaf (3.3%)	Esters (87.8%)	Benzyl benzoate (**21**) (87.8%)[36]

These essential oils were also investigated for their antifungal and anti-inflammatory activities. Amongst the tested essential oils, *C. subavenium*, C. *sintoc*, and *C. zeylanicum* showed moderate to strong inhibitory activity against two strains of yeast-like fungi (*Candida albicans* and *C. glabrata*) and three dermatophytes (*Microsporum cans, Trichophyton mentagrophytes and T. rubrum*). The leaf essential oil of *C. pubescens* was observed to be effective against wood-rotting fungi (*Coriolus versicolor*, *Gleophyllum trabeum*, and *Bostryodiplodia theobromea*).[33-36] The antimicrobial activities of the essential oil of several *Cinnamomum* species from peninsular Malaysia had been reported.[30,35-37] Several studies on the antioxidant activity of some *Cinnamomum* species had been extensively investigated.[38-39]

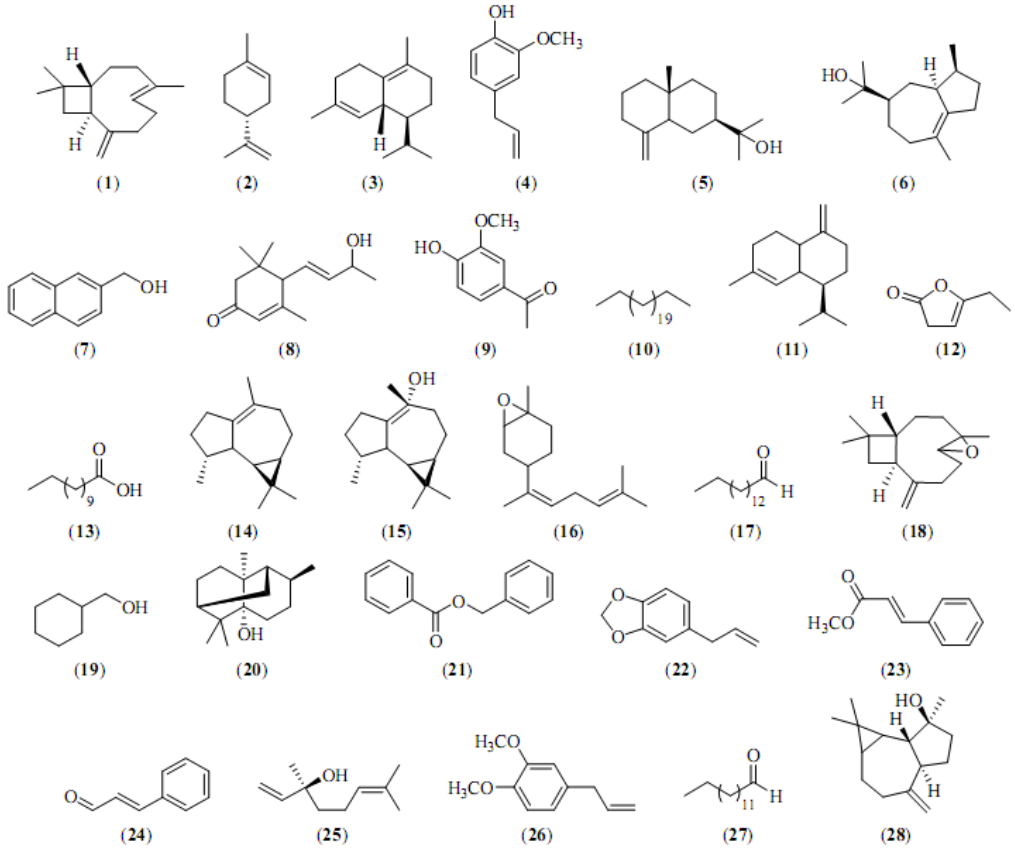

Figure 1: Chemical structures of the major components of essential oils of Malaysian Lauraceae.

Conclusion

The investigations of the essential oil compositions of *Lindera*, *Beilschmiedia*, *Litsea*, and *Cinnamomum* genera revealed the presence of various types of components (Figure 1). Sesquiterpene hydrocarbons were found as the major group components in *Beilschmiedia* species, except for *B. pulverulenta* which have phenylpropanoids. Their essential oils had showed strong to moderate activity in antioxidant, antimicrobial, anticholinesterase, antityrosinase, and anti-inflammatory assays. As for *Litsea* species, among sesquiterpenes, alcohols and aldehydes were also found in their essential oils. In the case of *Cinnamomum* species, phenylpropanoids mainly safrole, eugenol, linalool, camphor, benzyl benzoate, or cinnamaldehyde was detected as their major components. The species had also exhibited strong antifungal, antioxidant and anti-inflammatory activities due to the present of high phenolic content. Species from Lauraceae family have been widely used as a traditional medicine by indigenous groups in several countries. The leaf, stem bark, and roots of several species in the family were reported to possess medicinal properties and are used to treat a broad range of ailments. These facts open up a great opportunity to discover new pharmacological properties, as well as promising sources for drugs.

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Conflict of interests

The authors claim that there is no conflict of interest.

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