



REVIEW ARTICLE

Essential oils of Lauraceae species from Vietnam: An overview chemical profiles and biological activity

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Abstract

Lauraceae is a large family widely distributed in subtropical and tropical regions of the world. More than 250 species belonging to 18 genera of Lauraceae have been recorded in Vietnam. The essential oils (EOs) of some species belonging to genera such as *Cinnamomum*, *Litsea*, *Phoebe*, *Machinus*, *Neolitsea*, *Dehaasia*, *Caryodaphnopsis*, *Lindera* etc. collected from Vietnam have been reported to contain many bioactive compounds and possess biological agents. The aim of the present review is to provide comprehensive information on the chemical compositions, larvicidal and antimicrobial activities of the essential oils obtained from Lauraceae plants grown in Vietnam, with the objective of facilitating their further application in pharmaceutical and industrial contexts.

Keywords

essential oils, chemical constituents, antimicrobial, larvicidal activities, Vietnam

Introduction

Lauraceae is a large family with 55 genera and 3000 species widely found in subtropical and tropical regions, predominantly in the tropical forests of Asia and America. Members of Lauraceae have been used in industrial areas, including pharmaceutical, timber, perfumery and food industries (1). The species of this family were known for its traditional medicine to treat analgesic, malaria, female genital infections, gastrointestinal infections and rheumatism (2). The EOs extracted from species within the Lauraceae were distinguished by a various chemical constituents, including terpene alcohols, esters, organic acids, ketones, terpene hydrocarbons, aldehydes, phenols, lactones and ethers (3).

In Vietnam, more than 250 species belonging to 18 genera of Lauraceae have been recorded and found in many regions of the country (4), many of which also have been used for EOs, timber and traditional remedies (5, 6). The research on the chemical components of the EOs isolated from Lauraceae species collected from Vietnam mainly focused on some species belonging to several genera, including *Cinnamomum*, *Litsea*, *Phoebe*, *Machinus*, *Neolitsea*, *Dehaasia*, *Caryodaphnopsis* and *Lindera* etc. In addition, the biological properties of many Lauraceae plants from Vietnam have been reported (7-11). Furthermore, studies have emphasized the widespread utilization of certain *Cinnamomum* species, found in Vietnam, China and India, in traditional and local medicinal practices. Specifically, *Cinnamomum camphora* was recognized for its efficacy in treating a spectrum of ailments including common colds, arthritis, bronchitis,

indigestion and diarrhea (12, 13). Cinnamomum cassia, particularly its leaves, was employed for alleviating headaches, chills, dysentery, colic, chest tightness, diarrhea and coughs, while its branches are utilized for diabetes, indigestion and gastric inflammation (14). Cinnamomum subavenium was utilized for relieving abdominal pain, chest pain, hernia, diarrhea, arthritis, nausea and vomiting, utilizing its bark, fruit and leaves (15). Additionally, C. camphora and C. longipaniculatum play a crucial role in the extraction of camphor and camphor oil, serving as indispensable sources of raw materials for spices, food products, pharmaceuticals and the chemical industry (16, 17). Moreover, Litsea species, which are extensively found across Asia, are known for their traditional medicinal applications in addressing a range of common health issues including influenza, diarrhea, diabetes, nausea, skeletal pain inflammation (18). Nevertheless, to date, the overall information about chemical constituents and biological effects of the EOs isolated from Lauraceae plants in Vietnam are limited (19). The objective of this review, thus, provides comprehensive summary on the chemical compositions, larvicidal and antimicrobial activities of the EOs obtained from Lauraceae species collected from

Volatile compounds of Lauraceae plants

Cinnamomum species

Cinnamomum, commonly known as "Qué", is a large genus belonging to Lauraceae family with about 300 species found in tropical and subtropical regions of Oceania and Australia, Asia and Americas (20). It is known for their traditional medicine to cure indigestion, cough, cold and microbial infections. Many studies showed that stem barks and leaves possess the biological properties, including antifungal, antidiabetic, anticancer, larvicidal, antibacterial, antioxidant, antitermitic, anticholinesterase, hypouricemic xanthine oxidase inhibitory immunemodulatory activities (21). In Vietnam, more than 45 Cinnamomum species have been recorded (4). According to some reports on chemical patterns of Cinnamomum species from Vietnam, the samples were mainly collected from several regions of central to north of Vietnam. Leaves were the most frequently utilized plant part for EO extraction, succeeded by stem bark, stem, root bark and wood (7-11). The EOs derived from Cinnamomum species predominantly comprised oxygenated monoterpenes. This was followed by a composition of monoterpene hydrocarbons, oxygenated sesquiterpenes, sesquiterpene hydrocarbons, diterpenoids and various aliphatic compounds (7-11).

A large number of *Cinnamomum* plants collected from Bach Ma National Park were reported to to exhibit a wide range of chemical compositions in their EOs. As a result, the principal constituents of the leaf EOs in *C. sericans* were identified as spathulenol, α -pinene and caryophyllene oxide. In contrast, the EO of *C. durifolium* was predominantly composed of ρ -cymene, limonene and α -phellandrene (22). The EOs of *C. magnificum* were characterized by a high concentration of

bicyclogermacrene, caryophyllene oxide and caryophyllene. Conversely, the EOs of C. iners predominantly contained β-caryophyllene, caryophyllene oxide and spathulenol (22). Furthermore, the chemical compounds of the leaf EOs from C. damhaensis collected at various times throughout the year from Bach Ma National Park, displayed considerable variability. Specifically, the oil extracted in July was distinguished by a predominance of linalool, β -selinene, selin-11-en-4 α -ol and an intermedeol isomer. In contrast, the EO gathered in August was primarily composed of linalool, α -pinene, 1,8cine ole and β -pinene (23, 24). The EOs isolated from the leaves and stem bark of C. kunstleri were identified as being particularly abundant in methyl eugenol, 1,8cineole, terpinen-4-ol and α -pinene. Conversely, the EOs derived from the leaves and stem barks C. cambodianum were primarily composed of linalool and terpinen-4-ol (23, 25). Similarly, aromadendrene and α -seliene were the most component in the EOs of C. kunstleri leaves and stem barks respectively, followed by β -caryophyllene and α -copaene (23, 25). The leaf EOs obtained from another Cinnamomum plants grown in Bach Ma National Park, C. curvifolium contained benzyl cinnamate, benzyl benzoate and hexadecanoic acid as the main compounds while eugenol and 1,8-cineole were the most constituent in the leaf EOs of C. mairei and C. caryophyllus respectively (23).

Pu Huong Nature Reserve was a location which also had various Cinnamomum species. Accordingly, the leaf EOs of C. ovatum leaves and stem barks were mainly composed of eugenol, eugenyl acetate, linalool and α pinene (24) while 1,8-cineole, α -pinene, β -pinene and α copaene were the major components in the oils of the same plant parts of C. mairei (26). Moreover, the leaf EO of C. tetragonum mainly contained (E)-cinnamaldehyde, cisgeraniol and cinnamyl acetate whereas the stem bark oil was characterized by the predominance of cis-geraniol, geranyl acetate and (E)-β-farnesene (27). The main components of the EOs of C. curvifolium leaves were β pinene, sabinene, camphene and (E)-cinnamaldehyde while α -copaene, 1,8-cineole, α -pinene and δ -cadinene were recorded as the major components in the stem bark oil towards the same species (26). Finally, the leaf oil of C. tonkinense collected from Pu Huong Nature Reserve to was mainly composed of linalool, β-phellandrene and 1,8cineole (24).

Other studies have also reported the chemical components of EOs extracted from some Cinnamomum species collected from other regions of Vietnam. Accordingly, the leaf EOs of *C. doederleinii* var. raoanensis from Pu Hoat Nature Reserve mainly possessed linalool, (E)-nerolidol, caryophyllene oxide and y-cadinene while the leaf oil of C. scalarinervium was found to be rich in sabinene, α-pinene, artemisia triene bicyclogermacrene (7). The main components of C. longipetiolatum EOs from Pu Hoat Nature Reserve were composed of linalool, hotrienol and cis-linalool oxide whereas camphor, geranial and neral were the major constituents in the EO of C. polyadelphum from the same

location (24). The EOs of C. glaucescens and C. verum from Ben En National Park contained geraniol and bicyclogermacrene respectively as the riches component (28). In addition, the leaf and bark oils of C. cassia from Ben Tre and Yen Bai provinces were characterized by the predominance of (E)-cinnamyl acetate and (E)cinnamaldehyde (29, 30) while the bark oil of C. illicioides grown in Thai Nguyen Province contained a mixture of eugenol, terpinen-4-ol, δ -cadinene and α -copaene (31). The major constituents of the EO of the C. parthenoxylon Root bark from Lam Dong province were benzyl benzoate, cadinene and δ -cadinol while safrole, elemicin and methyl eugenol were the main constituents in the wood oils (32). The leaf oil of C. camphora from Ha Tay province was found to be abundant in linalool, camphor and α terpineol. Finally, 2-methylene-3-buten-1-yl benzoate was the most abundant component in the leaf, stem and wood EOs of Cinnamomum sp. grown in Ha Bac province while safrole and camphor were the main components in the root EOs isolated from this plant (33).

Litsea species

Litsea, commonly known as "Bời lời" in Vietnamese, includes deciduous or evergreen trees or shrubs belonging to Lauraceae family (4). The genus contains about 200 species, which are major found in subtropical and tropical regions throughout the world (34). Some plant parts of Litsea species were broadly used as traditional medicine. Barks, roots, stems, velamina and leaves of *Litsea* plants were used to treat cold, stoma chache, pain, arthritis, traumatic injury and diarrhea while fruits were used to cure gastrointestinal diseases pain and asthma (34). Furthermore, Litsea plants have been reported to contained various bioactive constituents belonging to alkaloids, flavonoids, butenolactones, terpenoids, butanolides amides, fatty acids, lignans, steroids and megastigmane have been reported (34, 35).

EOs extracted from predominantly consist of oxygenated monoterpenes and monoterpene hydrocarbons along with sesquiterpene hydrocarbons. Subsequently, these are followed by oxygenated sesquiterpenes and non-terpene compounds in their chemical compositions (8, 36). The chemical constituents of the EOs of some Litsea species from Bach Ma National Park have been reported (8, 36). Accordingly, the leaf and stem EOs of L. eugenoides from Bach Ma National Park were found to be rich in limonene and α phellandrene (36). Moreover, the major component in the EO of L. helferi leaves mainly contained limonene, βcaryophyllene, bicyclogermacrene and bicycloelemene whereas sabinene, along with α -pinene, γ -terpinene, limonene and terpinen-4-ol were the main constituents in the EO of L. ferruginea leaves. The EOs extracted from the L. verticillata leaves contained linalool, α -pinene and β pinene as the major compounds while the leaf EO of L. glutinosa was found to be abundant in (E)- β -ocimene, α pinene and β-pinene. Significantly, (Z)-citral emerged as the predominant constituent in the EOs derived from the stem, leaf, root and fruit of L. cubeba, followed by sabinene, limonene and linalool (8).

The chemical compositions of $L.\ cubeba$ collected from seven regions of northern Vietnam have been reported (37, 38). Accordingly, 1,8-cineole, sabinene and α -terpineol were the major constituents in the leaf EOs of the species grown in Lang Son, Thanh Hoa and Yen Bai provinces whereas the sample from Thai Nguyen province was found to be rich in 1,8-cineole, geranial and neral (37). The leaf oil of $L.\ cubeba$ collected from Dien Bien province were mainly composed of sabinene, linalool and α -pinene (37) while linalool was the riches component in the leaf oils of $L.\ cubeba$ from Phu Tho province (38) and Ba Vi mountain (37).

The major volatile components of 2 *Litsea* species, including *L. umbellata* and *L. iteodaphne* from Pu Hoat Nature Reserve contained β -caryophyllene, β -pinene, germacrene D and α -pinene (39) while bicyclogermacrene, decanal and α -pinene were the major components on the leaf oil of *L. viridis* collected from the same location (40). The leaf EO of *Litsea* acutivena collected from Pu Huong Nature Reserve was mainly composed of α -phellandrene, α -pinene and β -pinene (41) while the leaf oil of another *Litsea* species, *Litsea* firma var. austroannamensis, grown in this region was indicated by the predominance of nerol, (E)- β -ocimene and cis-geraniol (42). Finally, the EO of *L. euosma* leaves from Pu Mat National Park contained sabinene, β -pinene and α -pinene as the major components (43).

Phoebe species

The chemical components of the leaf EOs of 2 *Phoebe* plants collected from Central of Vietnam such as *Phoebe* paniculata and *Phoebe tavoyana*. Accordingly, the oil of the first species grown in Pu Mat National Park was found to be abundant in β -caryophyllene, germacrene D and sabinene while the EO of the later plant from Vu Quang National Park included bicyclogermacrene, germacrene D and sabinene as the main compounds. Notably, the stem EO of *P. tavoyana* was made of o-cymene, ar-turmerone, spathulenol and α -pinene (11). Finally, the leaf EO of *P. angustifolia* grown in Sao La Nature Reserve was found to be rich in spathulenol, n-hexadecanoic acid and sabinene (44) while α -pinene, β -pinene and camphene were the major compounds in the EO of *P. angustifolia* leaves from Pu Hoat Nature Reserve (40).

Neolitsea species

The chemical constituents of EOs obtained from 3 species belonging to the genus *Neolitsea* collected from Vu Quang National Park and Nghe An province have been reported. Accordingly, the leaf EO of *N. buisanensis* from Vü Quang National park contained hexadecanoic acid, (Z)-13-docosenamide and limonene as the major constituents. The stem EO was mainly consisted of phytol, (Z)-13-docosenamide and limonene while the fruit oil was found to be abundant in 1,8-cineole, (Z)-13-docosenamide and sabinene (9). Finally, the leaf EOs of 2 *Neolitsea* plants from Vu Quang National park and Nghe An province, *N. ellipsoidea* and *Neolitsea polycarpa*, mainly contained (E)- β -ocimene and linalool (40).

Machinus species

The chemical profiles of the leaf EOs extracted from some *Machinus* plants have been reported by previous studies. The oil of *M. Japonica* from Ba Vi mountain was indicated by the predominance of α -phellandrene, p-cymene and β -phellandrene (10) while (E)-nerolidol, globulol and selin-11-en-4 α -ol were the major components in the EO of *Machilus grandifolia* grown in Thua Thiên Hue province (40). The main components of *M. velutina* EO from Nghe An province was found to be (E)- β -ocimene, (Z)- β -ocimene and bicycloelemene (36) whereas the oil of *M. balansae* from Pu Mat National Park was mainly composed of bicyclogermacrene, (E)-nerolidol and (E)-caryophyllene (40).

Other Lauraceae species

The leaf EO of Cryptocarya concinna collected from Thua Thien Hue province mainly contained caryophyllene oxide, (E)-caryophyllene and spathulenol whereas the leaf EO of this species from Pu Hoat Nature Reserve was found to be abundant in β -pinene, α -pinene and myrcene (40). The chemical compositions of the leaf EOs from Cryptocarya impressa from Pu Hoat Nature Reserve was indicated by the predominance of bicyclogermacrene, dodecanal and (E)caryophyllene while germacrene D, bicyclogermacrene and δ -elemene were the major compounds in the leaf oil of Cryptocarya infectoria collected from the same location (40). The diversity of the chemical profiles in the leaf EOs of Actinodaphne pilosa collected from different locations in Pu Hoat Nature Reserve. Accordingly, the sample collected from 870 m in elevation contained β-caryophyllene, (Z)-βocimene and germacrene as the main compounds while the quantitatively significant constituents of the sample from 640 m in elevation were germacrene D, bicyclogermacrene and (Z)-β-ocimene (45). Moreover, the leaf EO of another Actinodaphne species, A. velutina from Central of Vietnam was found to be abundant in patchoulene. **β-**caryophyllene and 1-methyl-6-(1methylethylidene)-bicyclo[3.1.0]hexane (46).

The chemical constituents of the leaf EOs of three Beilschmiedia plants from North Central of Vietnam have been also investigated (40). As a result, the oil of Beilschmiedia yunnanensis from Vu Quang National Park dominated by 9-epi-(E)-caryophyllene, caryophyllene and α -humulene. The oil of *Beilschmiedia* erythrophloia from Pu Hoat Nature Reserve was found to be abundant in Bicyclogermacrene, (Z)-β-Ocimene, (E)-Caryophyllene while (E)-Caryophyllene, Germacrene D, α-Humulene were the prominent constituents in the oil of Beilschmiedia robusta from the same area (40). In addition, α -pinene, camphene, β -pinene and bicyclogermacrene were the major components in the EOs isolated from Dehaasia cuneata and Caryodaphnopsis tonkinensis grown in Pu Mat and Ben En National Park (47) whereas the leaf EO of *Lindera rufa* from Nghe An province was found to be rich in camphor, limonene and α -pinene (48).

The chemical constituents of the EOs obtained from Lauraceae plants grown in Vietnam are listed in Table 1.

Biological activities of Lauraceae plants from Vietnam

Antimicrobial activity

The antimicrobial effects of the EOs of 5 Cinnamomum species collected from north central Vietnam have been reported (24). Accordingly, the leaf and stem EOs of C. ovatum from Pu Huong Nature Reserve showed antimicrobial activities against 3 Gram-possitive, 3 Gramnegative bacteria and 1 yeast, including E. faecalis, S. aureus, B. cereus, E. coli, P. aeruginosa, S. enterica and C. albicans with MIC values of 64 and 64, 64 and 64, 128 and 64, 64 and 64, 128 and 16, 64 and 64, 64 and 32 µg/mL respectively whereas 64, 128, 128, 256, 256, 128, 256 µg/ mL respectively were shown by the leaf oil of C. longipetiolatum from Pu Hoat Nature Reserve was also active against seven towards the same microorganisms. In addition, the leaf EO of C. polyadelphum grown in Pu Hoat Nature Reserve was active against 5 microorganisms such as E. faecalis, S. aureus, B. cereus, S. enterica and C. albicans with MIC values of 32, 64, 64, 128 and 256 µg/mL. Meanwhile, the leaf oil of C. tonkinense from Pu Huong Nature Reserve was found to be effective against three Gram-possitive, including E. faecalis, S. aureus, B. cereus with MIC values of 32, 128, 128 µg/mL. Finally, all studied strains were not inhibited by the EO isolated from C. damhaensis leaves grown in Bach Ma National Park (24). In addition, the antibacterial and antifungal activities of the leaf and bark EOs of Cinnamomum cassia collected from southern Vietnam (Ben Tre province) have been investigated. As a result, the bark oil of this plant was found to be effective against S. aureus and Saccharomyces cerevisiae with MIC values of 200 µg/mL whereas the leaf oil was inactive against these microorganisms (30). Meanwhile, Listeria innocua, a Gram-positive bacterium, was sensitive to the leaf oil of Cinnamomum cassia grown in northern Vietnam (Yen Bai province) with MIC values of 315 µg/mL (29).

The antimicrobial activities of leaf EOs of eleven Lauraceae species collected from north central Vietnam (40). Accordingly, the leaf oils of 2 Cryptocarya plants such as C. concinna and C. infectoria grown in Pu Hoat Nature Reserve were found to be effective against six microorganisms, including E. faecalis, S. aureus, B. cereus, P. aeruginosa, S. enterica and C. albicans with MIC values of 32 and 128, 128 and 64, 64 and 128, 128 and 64, 256 and 128, 64 and 64 µg/mL respectively while the leaf EO of another Cryptocarya species from the same location, C. impressa, had an inhibitory effect on E. faecalis, S. aureus, Escherichia coli (MICs = 64 µg/mL), B. cereus (MIC = 128 µg/ mL) and C. albicans (MIC = $16 \mu g/mL$) (40). In addition, the leaf oils of Beilschmiedia erythrophloia (Pu Hoat Nature Reserve) and B. yunnanensis (Vu Quang National Park) possessed antimicrobial effects against E. faecalis, S. aureus, B. cereus and C. albicans with MIC values of 32 and 64, 64 and 64, 64 and 64, 128 and 256 µg/mL respectively whereas the leaf oil of Beilschmiedia robusta from Pu Hoat Nature Reserve displayed activity against E. faecalis, S. aureus and E. coli with MIC values of 64 µg/mL (40).

The EO from the leaves of *Machilus balansae* from Pu Mat National Park showed antimicrobial activities

 $\textbf{Table 1}. \ \mathsf{Major} \ \mathsf{components} \ \mathsf{identified} \ \mathsf{from} \ \mathsf{essential} \ \mathsf{oils} \ \mathsf{of} \ \mathsf{Lauraceae} \ \mathsf{from} \ \mathsf{Vietnam}$

Scientific name	Origin	Part	Major compositions	Bioactivity	Ref.
Actinodaphne pilosa	Pu Hoat Nature Reserve (870m in elevation)	Leaf	β-Caryophyllene (14.9%), (Z)-β-ocimene (14.3%), germacrene D (12%), bicyclogermacrene (11%), (E)-β-ocimene (10.4%)	larvicidal	(45)
Actinodaphne pilosa	Pu Hoat Nature Reserve (640m in elevation)	Leaf	Germacrene D (16.2%), bicyclogermacrene (15.9%), (Z)-β-ocimene (10.1%), β-caryophyllene (9%), α-pinene (7.2%)	antimicrobial	(45)
Alseodaphne velutina	Central of Viet Nam	Leaf	β-patchoulene (25.74%), β-caryophyllene (12.81%), 1-methyl-6-(1-methylethylidene)-bicyclo[3.1.0]hexane (7.82%)	-	(46)
Beilschmiedia erythrophloia	Pu Hoat Nature Reserve	Leaf	Bicyclogermacrene (30.5%), (Z)-β-ocimene (26.1%), (E)-caryophyllene (18.3%), (E)-β-ocimene (3.6%), α-pinene (3.2%)	antimicrobial	(40)
Beilschmiedia robusta	Pu Hoat Nature Reserve	Leaf	(E)-Caryophyllene (22.5%), germacrene D (20.3%), α-humulene (13.4%), bicyclogermacrene (8.6%)	antimicrobial larvicidal	(40)
Beilschmiedia yunnanensis	Vu Quang National park	Leaf	9-epi-(E)-caryophyllene (21.2%), (E)- Caryophyllene (16.2%), α-humulene (9.9%), bicyclogermacrene (8.4%), α-pinene (6%)	antimicrobial	(40)
Caryodaphnopsis tonkinensis	Ben En National Park	Leaf	α-pinene (26.8%), β -pinene (23.0%), bicyclogermacrene (8.5%)	antimicrobial	(47)
Cinnamomum sericans	Bach Ma National park	Leaf	Spathulenol (14.5%), α-pinene (9.3%), caryophyllene oxide (9.3%), sabinene (8.0%), β-caryophyllene (7.1%)	-	(22)
Cinnamomum durifolium	Bach Ma National park	Leaf	ρ-Cymene (15.6%), limonene (13.9%), α- phellandrene (9.2%), spathulenol (7.4%), benzyl benzoate (6.5%)	-	(22)
Cinnamomum magnifium	Bach Ma National park	Leaf	Bicyclogermacrene (33.9%), β-caryophyllene (25.5%), caryophyllene oxide (7.5%), bicycloelemene (7.2%), α-copaene (6.4%)	-	(22)
Cinnamomum iners	Bach Ma National park	Leaf	β-Caryophyllene (35.9%), caryophyllene oxide (12.6%), spathulenol (5.2%)	-	(22)
Cinnamomum doederleinii var. raoanensis	Pù Hoạt Natural Reserve	Leaf	Linalool (41.7%), (E)-nerolidol (12.4%), caryophyllene oxide (8.5%), γ-cadinene (4.4%)	-	(7)
Cinnamomum scalarinervium	Pu Hoat Natural Reserve	Leaf	Sabinene (26.6%), α-pinene (8.8%), artemisia triene (7.1%), bicyclogermacrene (6.6%), β-pinene (6.1%)	-	(7)
Cinnamomum glaucescens	Ben En National Park	Leaf	Geraniol (36.2%), terpinen-4-ol (19.7%), α-pinene (6%), sabinene (6%), limonene (5.2%)	-	(28)
Cinnamomum verum	Ben En National Park	Leaf	Bicyclogermacrene (11.2%), β-bisabolene (7.7%), Caryophyllene oxide (5.6%), cadinene (4%), linalool oxide (3.8%)	-	(28)
Cinnamomum curvifolium	Pu Huong Natural Reserve	Leaf	β-Pinene (23.8%), sabinene (14%), camphene (12.1%), (E)-cinnamaldehyde (8.9%), cis-geraniol (7.3%)	-	(26)
Cinnamomum curvifolium	Pu Huong Natural Reserve	Stem bark	α-Copaene (14.2%), 1,8-cineole (10%), α- pinene (6.4%), δ-cadinene (5.9%), τ-cadinol (5.7%), α-santalol (5.7%)	-	(26)
Cinnamomum curvifolium	Bach Ma National Park	Leaves	Benzyl cinnamate (29.9%), benzyl benzoate (22.1%), hexadecanoic acid (7.5%), tetradecanol (5.5%), dodecanoic acid (4.6%)	-	(23)
Cinnamomum mairei	Pu Huong Natural Reserve	Leaf	1,8-Cineole (23.1%), α-pinene (13.1%), β- pinene (9%), α-copaene (7.1%),	-	(26)
Cinnamomum mairei	Pu Huong Natural Reserve	Stem bark	α-Pinene (15.5%), 1,8-cineole (14.6%), β-pinene (10.5%), α-copaene (7.5%), (E)-cinnamaldehyde (6.5%)	-	(26)

Cinnamomum mairei	Bach Ma National Park	Leaf	Eugenol (39.7%), neryl acetate (14.9%), eugenol acetate (13.7%), 1,8-cineole (13%)	-	(23)
Cinnamomum kunstleri	Bach Ma National Park	Stem bark	1,8-Cineole (25.3%), α-terpineol (10.7%), terpinen-4-ol (6.7%), α-pinene (5.3%)	-	(25)
Cinnamomum kunstleri	Bach Ma National Park	Leaf	Methyl eugenol (22.5%), terpinen-4-ol (19.2%), 1,8-cineole (7.4%),	-	(23)
Cinnamomum rigidifolium	Bach Ma National Park	Stem bark	Aromadendrene (26%), β-caryophyllene (17.2%), α-copaene (5.7%), caryophyllene oxide (5.6%)	-	(25)
Cinnamomum rigidifolium	Bach Ma National Park	Leaf	α-Seliene (24.5%), β-caryophyllene (23%), α-copaene (7.2%), germacrene D (5%)	-	(23)
Cinnamomum cambodianum	Bach Ma National Park	Leaf	Linalool (33.1%), terpinen-4-ol (12.3%), cis-sabinene hydrate (6.2%), santolina triene (4.9%), α-terpienol (4.6%)	-	(23)
Cinnamomum cambodianum	Bach Ma National Park	Stem bark	Linalool (27%), limonene (23.4%), terpinen-4-ol (9.8%), α-phellandrene (9.5%), (Ε)-β-ocimene (5.9%)	-	(25)
Cinnamomum ovatum	Pu Huong Nature Reserve	Leaf	Eugenol (70.5%), eugenyl acetate (9.5%), linalool (5.9%), α-pinene (2.1%)	antimicrobial larvicidal	(24)
Cinnamomum ovatum	Pu Huong Nature Reserve	Stem	Eugenol (71.2%), eugenyl acetate (9.3%), linalool (8.3%), α-pinene (1.6%)	-	(24)
Cinnamomum tonkinense	Pu Huong Nature Reserve	Leaf	Linalool (32.2%), β -phellandrene (23.1%), 1,8-cineole (9.8%), α -phellandrene (4.8%)	antimicrobial larvicidal	(24)
Cinnamomum damhaensis	Bach Ma National Park	Leaf	Linalool (44.8%), β-selinene (19.1%), selin-11-en-4α-ol (7.3%), intermedeol isomer (5.8%)	larvicidal	(24)
Cinnamomum damhaensis	Bach Ma National Park	Leaf	Linalool (13.3%), α-pinene (12.7%), 1,8-cineole (8.5%), β-pinene (8.4%)	-	(23)
Cinnamomum longipetiolatum	Pu Hoat Nature Reserve	Leaf	Linalool (75.7%), hotrienol (3.2%), cis-linalool oxide (3.2%), α-pinene (2.9%)	antimicrobial larvicidal	(24)
Cinnamomum polyadelphum	Pu Hoat Nature Reserve	Leaf	Camphor (32.2%), geranial (16.6%), neral (11.7%), limonene (5.4%),	antimicrobial larvicidal	(24)
Cinnamomum caryophyllus	Bach Ma National Park	Leaf	1,8-Cineole (22.4%), α-pinene (11%), camphene (10%), p-cymene (8.7%),	-	(23)
Cinnamomum camphora	Ha Tay province	Leaf	Linalool (91.1%), camphor (2.3%),	-	(56
Cinnamomum parthenoxylon	Lam Dong province	Root bark	Benzyl benzoate (52%), cadinene (5.4%), δ -cadinol (5%), calamenene (4.5%)	-	(32)
Cinnamomum parthenoxylon	Lam Dong province	Wood	Safrole (90.3%), elemicin (2.6%), methyl eugenol (1.3%)	-	(32)
Cinnamomum cassia	Ben Tre province	Bark	(E)-Cinnamaldehyde (91.5%), (E)-cinnamyl acetate (6.5%) (22)	antimicrobial	(30)
Cinnamomum cassia	Ben Tre province	Leaf	(E)-Cinnamyl acetate (62.8%), (E)-cinnamaldehyde (28.2%), 2-methylbenzofuran (7.3%)	antimicrobial	(30)
Cinnamomum cassia	Yen Bai province	Leaf	Trans-cinnamaldehyde (90.08%), trans-cinnamyl acetate (4.69%)	antimicrobial	(29)
Cinnamomum illicioides	Thai Nguyen province	bark	Eugenol (41.2%), terpinen-4-ol (10.4%), δ-cadinene (5.6%), α-copaene (4.1%)		(31
Cinnamomum tetragonum	Pu Huong Nature Reserve	Leaf	(E)-Cinnamaldehyde (41.0%), cis-geraniol (33.8%), cinnamyl acetate (3.5%)	-	(27)
Cinnamomum tetragonum	Pu Huong Nature Reserve	Stem bark	cis-Geraniol (65.1%), geranyl acetate (14.8%),	-	(27)
Cinnamomum sp.	Ha Bac province	Leaf	2-Methylene-3-buten-1-yl benzoate (85.9%), spathulenol (1.3%)	-	(33)
Cinnamomum sp.	Ha Bac province	Stem	2-Methylene-3-buten-1-yl benzoate (92.4%), linalool (2.2%)		(33
Cinnamomum sp.	Ha Bac province	Wood	2-methylene-3-buten-1-yl benzoate (44.2%), camphor (13%), α-terpineol (3.7%), safrole (3.5%), linalool (3.4%)	-	(33)
Cinnamomum sp.	Ha Bac province	Root	Safrole (63.8%), camphor (17.9%), 2-methylene-3-buten-1-yl benzoate (7.8%), 1,8-cineole (3.6%), α-terpineol (1.2%)	-	(33)

Cryptocarya concinna	Nam Dong district, Hue province	Leaf	Caryophyllene oxide (21.2%), (E)-caryophyllene (12.2%), spathulenol (12.3%), β-pinene (9%), α-pinene (8.2%)	larvicidal	(40)
Cryptocarya concinna	Pu Hoat Nature Reserve	Leaf	β-Pinene (31.3%), α-pinene (26.7%), myrcene (11.1%), (E)-β-ocimene (8.8%), (E)-caryophyllene (5.3%)	antimicrobial larvicidal	(40)
Cryptocarya impressa	Pu Hoat Nature Reserve	Leaf	Bicyclogermacrene (18.7%), dodecanal (10.8%), (E)-caryophyllene (10.8%), (E,E)-α-farnesene (7.9%), α-humulene (6.3%)	antimicrobial	(40)
Cryptocarya infectoria	Pu Hoat Nature Reserve	Leaf	Germacrene D (55.5%), bicyclogermacrene (11.4%), δ-elemene (5.1%), linalool (3.4%)	antimicrobial larvicidal	(40)
Dehaasia cuneata	Pu Mat National	Leaf	α-pinene (49.0%), camphene (19.5%), β-pinene (15.6%) limonene (7.5%)	antimicrobial	(47)
Lindera rufa	Nghe An province	Leaf	Camphor (67.5%), limonene (6.9 %), α-pinene (6.7%), camphene (4.7 %), β-myrcene (3.8 %)	-	(48)
Litsea firma var. austroannamensis	Pu Huong Nature Reserve	Leaf	Nerol (14.4%), (E)-β-ocimene (10.2%), cis-geraniol (10.2%), (E)-nerolidol (8.9%), β-caryophyllene (6.7%)	-	(42)
Litsea acutivena	Pu Huong Natural Reserve	Leaf	α-Phellandrene (30.4%), α-pinene (14.2%), β-pinene (7.3%)	-	(41)
Litsea cubeba	Phu Tho province	Leaf	Linalool (94.93%), D-limonene (1.52%), isocaryophyllene (1.27%)	antimicrobial	(38)
Litsea cubeba	Ba Vi mountain	Leaf	Linalool (91.1%), cis-linalool oxide (1.3%), trans-linalool oxide (1.2%)	-	(37)
Litsea cubeba	Lang Son province	Leaf	1,8-Cineole (47.6%), sabinene (12.5%), α-terpineol (11.9%), β-pinene (3.8%), α-pinene (3.7%)	-	(37)
Litsea cubeba	Thai Nguyen province	Leaf	1,8-Cineole (23.4%), geranial (9.7%), neral (7.4%), linalool (6.4%).	-	(37)
Litsea cubeba	Thanh Hoa province	Leaf	1,8-Cineole (44.8%), sabinene (12.1%), α-terpineol (10.5%), limonene (4.4%), α-pinene (4.2%)	-	(37)
Litsea cubeba	Yen Bai province	Leaf	1,8-Cineole (51.7%), sabinene (14.8%), α-terpineol (9.8%), α-pinene (4.6%), β-pinene (4.3%)	-	(37)
Litsea cubeba	Dien Bien province	Leaf	Sabinene (48.1%), linalool (10.1%), α-pinene (8.4%), β-pinene (7.8%), 1,8-cineole (7.5%)	-	(37)
Litsea cubeba	Bach Ma National Park	Leaf	(Z)-Citral (32.9%), sabinene (14.2%), linalool (9.5%), limonene (9.2%), terpinen-4-ol (4.0%)	-	(8)
Litsea cubeba	Bach Ma National Park	Stem	(Z)-Citral (53.2%), limonene (13.2%), sabinene (10.2%), terpinen-4-ol (5.3%), myrcene (3.3%)	-	(8)
Litsea cubeba	Bach Ma National Park	Fruit	(Z)-Citral (66.1%), allo-ocimene (7.9%), limonene (7.0%), citronellol (3.4%)	-	(8)
Litsea cubeba	Bach Ma National Park	Root	(Z)-Citral (60.0%), limonene (13.6%), α-pinene (3.6%), camphene (2.7%), β-pinene (2.7%)	-	(8)
Litsea eugenoides	Bach Ma National Park	Leaf	Limonene (25.1%), α-phellandrene (11.99%), Methyl eugenol (7.44%), (E)-β-ocimene (6.33%), α-pinene (5.18%)	-	(36)
Litsea eugenoides	Bach Ma National Park	Stem	Limonene (35.44%), α-phellandrene (16%), (E)-β-ocimene (10.78%), o-cymene (10.67%), β-myrcene (2.63%)	-	(36)
Litsea euosma	Pu Mat National Park	Leaf	Sabinene (24.9%), β-pinene (19.5%), α-pinene (11.8%), β-caryophyllene (10.8%)	-	(43)
Litsea umbellata	Pu Hoat Natural Reserve	Leaf	β-pinene (18.8%), β-caryophyllene (16.2%), α-pinene (10.4%), germacrene D (9.1%)	larvicidal	(39)
Litsea iteodaphne	Pu Hoat Natural Reserve	Leaf	β-caryophyllene (21.4%), germacrene D (15.5%), α-pinene (8.7%), β-pinene (6.6%).	larvicidal	(39)
Litsea viridis	Pu Hoat Nature Reserve	Leaf	Bicyclogermacrene (25.5%), decanal (14.4%), α-pinene (11.1%), β-pinene (8.3%)	antimicrobial	(40)

Litsea glutinosa	Bach Ma National Park	Leaf	(E)-β-Ocimene (57.4%), α-Pinene (7.8%), β-pinene (7.3%), Limonene (2.4%)	-	(8)
Litsea helferi	Bach Ma National Park	Leaf	Limonene (17.5%), β-caryophyllene (14.2%), bicyclogermacrene (13.1%), bicycloelemene (12.4%), α-phellandrene (8.0%)	-	(8)
Litsea ferruginea	Bach Ma National Park	Leaf	Sabinene (34.5%), α-pinene (10.1%), γ-terpinene (7.8%), limonene (6.9%), terpinene-4-ol (6.6%)	-	(8)
Litsea verticillata	Bach Ma National Park	Leaf	α-Pinene (26.1%), linalool (23.4%), β-pinene (11.7%), (E)-nerolidol (4.9%)	-	(8)
Machilus Japonica	Ba Vi mountain	Leaf	α-Phellandrene (60.2%), p-cymene (20.3%), β-phellandrene (10.5%)	-	(10)
Machinus velutina	Nghe An province	Leaf	(E)-β-Ocimene (9.5%), (Z)-β-ocimene (8.2%), bicycloelemene (7.1%), germacrene D (6.8%), allo-ocimene (6.4%)	-	(44)
Machilus balansae	Pu Mat National Park	Leaf	Bicyclogermacrene (41.5%), (E)-nerolidol (8.7%), (E)-caryophyllene (8.5%), (E)-β-ocimene (4.5%)	antimicrobial	(40)
Machilus grandifolia	Thua Thien Hue province	Leaf	(E)-Nerolidol (22.7%), globulol (10.2%), selin-11-en-4α-ol (6.7%), caryophyllene oxide (3.7%)	larvicidal	(40)
Neolitsea buisanensis	Vu Quang National park	Leaf	Hexadecanoic acid (11.8%), (Z)-13-docosenamide (8.4%), limonene (4.7%), α-terpinolene (4.7%), β-caryophyllene (4.7%)	-	(9)
Neolitsea buisanensis	Vu Quang National park	Stem	Phytol (12.9%), (Z)-13-docosenamide (12.5%), limonene (10.2%), α-terpinolene (4.9%)	-	(9)
Neolitsea buisanensis	Vu Quang National park	Fruit	1,8-Cineole (28.5%), (Z)-13-docosenamide (21%), sabinene (14.7%), α-terpineol (8.8%), hexadecanoic acid (5.6%)	-	(9)
Neolitsea ellipsoidea	Vu Quang National park	Leaf	(E)-β-ocimene (87.6%), (Z)-β-ocimene (3.7%), linalool (1.3%)	antimicrobial larvicidal	(40)
Neolitsea polycarpa	Nghe An province	Leaf	(E)-β-ocimene (85.6%), limonene (6.5%), allo-ocimene (1.8%)	-	(44)
Phoebe angustifolia	Pu Hoat Nature Reserve	Leaf	α-pinene (26.9%), β-pinene (20.8%), camphene (6.1%), spathulenol (5.4%), (E)-caryophyllene (5.3%)	larvicidal	(40)
Phoebe angustifolia	Sao La Nature Reserve	Leaf	Spathulenol (17%), n-hexadecanoic acid (13%), sabinene (6.4%), bicyclogermacrene (5.9%), artemisia triene (5.1%)	-	(44)
Phoebe paniculata	Pu Mat National Park	Leaf	β-Caryophyllene (12.1%), germacrene D (9.2%), sabinene (8.8%), β-cubebene (7.5%)	-	(11)
Phoebe tavoyana	Vu Quang National park	Leaf	Bicyclogermacrene (15.5%), germacrene D (13.9%), sabinene (7.0%), β-caryophyllene (7.0%)	-	(11)
Phoebe tavoyana	Vu Quang National park	Stem	o-Cymene (6.9%), ar-turmerone (6.8%), spathulenol (5.6%), α-pinene (4.1%), δ-elemene (3.4%)	-	(11)

[&]quot;-": No reported data for the species mentioned in Vietnam

against Enterococcus faecalis (MIC = 64 µg/mL), Staphylococcus aureus, Bacillus cereus (MICs = $128 \mu g/mL$) while the leaf oil of Neolitsea ellipsoidea from Vu Quang National Park was active against E. faecalis, S. aureus, B. cereus, E. coli and C. albicans 16, 32, 16, 128, 128 µg/mL respectively (40). The 4 microorganisms such as Enterococcus faecalis, Staphylococcus aureus, Bacillus cereus and Candida albicans were inhibited by the leaf EO of Litsea viridis collected from Pu Hoat Nature Reserve with MIC values of 16, 64, 16 and 128 µg/mL respectively (40). Meanwhile, the leaf EO of another Litsea plant, L. cubeba grown in Phu Tho province had an inhibitory effect on 6 pathogenic bacteria, including Aeromonas hydrophila, E. coli (MICs = 0.96 mg/mL), Salmonella typhimurium (MICs = 2.89 mg/mL), Vibrio parahaemolyticus (MICs = 1.93 mg/mL), V. furnissii, Edwardsiella tarda (MICs = 0.72 mg/mL) and Lactococcus garvieae (MICs = 2.41 mg/ mL) (38).

The leaf EOs of *Actinodaphne pilosa* collected from different locations in Pu Hoat Nature Reserve (870 and 640 m in elevation) possessed antimicrobial activities against *E. faecalis, S. aureus, B. cereus, E. coli, P. aeruginosa and C. albicans* with MIC values ranging from 16 to 128 μg/mL (45). Furthermore, the leaf EOs of 2 Lauraceae species such as *Dehaasia cuneata* and *Caryodaphnopsis tonkinensis* collected from Pu Mat and Ben En National Park have been reported to possess the antimicrobial activities against *E. faecalis, S. aureus, B. cereus, P. aeruginosa* and *C. albicans* with MIC values of 16.72 and 15.99, 21.56 and 56.78, 23.45 and 56.54, 5.37 and 57.78, 65.5 and 33.68 μg/mL respectively (47).

The chemical components of the EOs isolated from the members of Lauraceae family in Vietnam could be the major factor contributing their antimicrobial properties. For instance, trans-cinnamaldehyde was active against Listeria innocua, Bacillus subtilis, Klebsiella oxytoca, Listeria monocytogenes, Pseudomonas putida, E. coli and S. aureus (29). Linalool had an inhibitory effect on a large number of bacterial strains, including S. aureus, P. aeruginosa, E. coli, Streptococcus mutans, S. sobrinus, Porphyromonas gingivalis, Prevotella intermedia, P. nigrescens, Fusobacteriumnucleatum subsp. fusiforme, F. nucleatum subsp. polymorphum, F.nucleatum subsp. vince ntii, nucleatum subsp. nucleatum, nucleatum subsp. animalis, Pasteurella multocida, Aggregatibacter actinomycetemcomitans, Listeria monocytogenes (49-51), A. hydrophila, S. typhimurium, V. parahaemolyticus, V. furnissii, E. tarda and L. garvieae (38).

Furthermore, α-pinene had an inhibitory effect on some pathogenic bacteria, including *E.* coli, Sclerotinia sclerotiorum, S. faecalis, S. aureus, S. pneumonia, S. pyogenes, aeruginosa, Cylindrocarpon mali, Mycobacterium smegmatis, Asperaillus niger and Stereum purpureum, S. epidermidis and several fungal strains, including C. albicans, Cryptococcus neoformans and Rhizopus oryzae (52). Meanwhile, β-pinene possessed the antimicrobial effects against S. aureus, S. epidermidis, Streptococcus pyogenes and S. pneumonia, C. neoformans, C. albicans and R. oryzae (53). 1,8cineole has been reported to display activity against some bacterial and fungal strains such as *P. aeruginosa, S. aureus, E. coli* and *C. albicans* (54). Furthermore, some bacterial and fungal strains, including *E. coli, S. aureus, B. subtilis, B. cereus, K. pneumonia, P. aeruginosa, S. cerevisiae, A. niger, Penicillium citrinum, Rhizopus oryzae and Trichoderma reesei were inhibited by β-caryophyllene (55). Terpinen-4-ol was found to be effective against 10 strains of <i>Staphylococcus aureus* such as ATCC-13150, ATCC-25923, LM-40, LM-02, LM-314, LM-45, LM-116, LM-232, LM-222 and LM-297 (55). Camphor and *p*-cymene had an inhibitory effect on *E. coli, Cylindrocarpon mali, Mycobacterium smegmatis, S. faecalis, S. aureus, P. aeruginosa, C. albicans, Sclerotinia sclerotiorum, A. niger, Stereum purpureum and Sotlyfis cinerea (52).*

Larvicidal activity

The EOs of 5 Cinnamomum species from north central Vietnam have been reported to screen for larvicidal effects against three mosquitos, including Aedes albopictus, Culex quinquefasciatus and A. aegypti (24). Accordingly, after 24 h of its application, the stem oil of *C. ovatum from Pu* Huong Nature Reserve was found to be effective against A. aegypti, A. albopictus and C. quinquefasciatus with LC50 values of 52.51, 61.45 and 28.79µg/mL respectively while LC₅₀ values of 46.74, 50.18 and 20.54 respectively were shown by the larvicidal effects of the leaf EO towards the same mosquitos after 48 h (24). The leaf EO of C. tonkinensis from Pu Huong Nature Reserve had an inhibitory effect on A. aegypti, A. albopictus and C. quinquefasciatus with LC₅₀ values of 17.44, 42.89 and 14.05 $\mu g/mL$ respectively after 24 hours of its application while the LC₅₀ values of C. tonkinensis oil after 48h were 15.83, 42.47 and 8.72 µg/mL (24). In addition, the leaf oils of *C. damhaensis* from Bach Ma National Park and C. polyadelphum from Pu Hoat Nature Reserve possessed larvicidal effects against these mosquitos with LC₅₀ values of 21.43 and 23.41, 43.91 and 20.66, 46.74 and 18.33 µg/mL respectively after 48h whereas 17.36 and 17.3, 39.85 and 20.79, 18.63 and 11.03 respectively were shown by the larvicidal effects of the EOs of these plants towards the same mosquitos after 48 h (24). After 24 or 48 h, the leaf oils of C. ovatum displayed activity against A. aegypti and C. quinquefasciatus with LC₅₀ values of 14.12 or 13.76, 34.19 or 30.48 µg/mL respectively whereas LC₅₀ values of 62.2 or 39.5, 126.8 or 76.88 µg/mL respectively shown by the larvicidal activities of the EO of C. longepetiolatum leaf towards the same mosquitos after 24 or 48 h (24).

After 24 h of its application, the leaf EO of Beilschmiedia robusta, Cryptocarya concinna, C. infectoria, Phoebe angustifolia from Pu Hoat Nature Reserve, C. concinna, Machilus grandifolia from Thua Thien Hue province and Neolitsea ellipsoidea from Vu Quang National park was found to be effective against Aedes aegypti with LC₅₀ values of 24.29, 23.01, 21.43, 24.29, 32.54, 20.23 and 6.57 μg/mL respectively whereas LC₅₀ values of 22.0, 16.22, 18.94, 22.46, 32.03, 16.17, 4.03 μg/mL respectively were shown by the larvicidal activities of these oil samples towards the same mosquito after 48 h (40). Moreover, after 24 h, Aedes albopictus were inhibited by the leaf oils of C. concinna, C. infectoria, M. grandifolia

and *P. angustifolia* with LC₅₀ values of 34.21, 61.34, 16.48 and 40.18 μ g/mL respectively while these oil samples possessed larvicidal activities against *A. albopictus* LC₅₀ values of 30.19, 58.8, 15.45 and 35.28 μ g/mL respectively after 48 h (40). Furthermore, after 24 h of its application, the leaf EOs of *C. concinna, C. infectoria, M. grandifolia,_N. ellipsoidea* and *P. angustifolia* had an inhibitory effect on *Culex quinquefasciatus* with LC₅₀ values of 50.28, 10.82, 13.59, 7.46 and 20.7 μ g/mL respectively while those displayed activity against this mosquito after 48 h with LC₅₀ values of 41.89, 0.4, 11.56, 4.45 and 12.21 μ g/mL respectively (40).

In addition, the leaf EOs of Actinodaphne pilosa collected from different locations in Pu Hoat Nature Reserve (870 and 640 m in elevation) had larvicidal effects against 3 mosquitos such as A. aegypti, A. albopictus and C. quinquefasciatus (45). Accordingly, A. aegypti was inhibited by the EO obtained from 2 samples (870 and 640 m in elevation) of this plant with LC₅₀ values of 19.02 and 14.78 µg/mL (45). Only sample oil collected from 870 in elevation possessed the larvicidal activities against A. albopictus and C. quinquefasciatus with LC₅₀ values of 24.74 and 48.06 µg/mL respectively (45). The leaf EO of 2 Litsea species, L. umbellata and L. iteodaphne, collected from Pu Hoat Natural Reserve displayed larvicidal effects against Culex guinguefasciatus and Aedes albopictus. As a result, the oil of L. umbellata was found to be effective against A. albopictus with 40.09 and 27.33 µg/mL respectively at 24 and 48 h of application while 36.19 µg/mL was the LC₅₀ value of this sample towards the same mosquito at both 24 and 48 h (39). Meanwhile, C. quinquefasciatus was sensitive to the *L. iteodaphne* EO with LC₅₀ values of 37.2 and 20.21 µg/mL respectively at 24 and 48 h while this oil was found to be effective against A. albopictus after 24 and 48 h of application with LC₅₀ values of 40.04 and 16.63 µg/ mL respectively (39).

Conclusion

The present review provides an overview of the chemical constituents, larvicidal and antimicrobial properties of EOs derived from Lauraceae plants in Vietnam. The EOs and their bioactive compounds isolated from various members of the Lauraceae family in Vietnam indicate the presence of promising biological agents to be applied in the near future. Antimicrobial activity and larvicidal actions of the EOs and their bioactive components from Lauraceae needs to be extensively explored to find its further application in pharmaceutical industry.

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Authors' contributions

DHT and NTAH designed this study, drafted the manuscript. DHT, NHN and NTAH resolved all the queries of reviewers.

Compliance with ethical standards

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