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Review article

Chemical characteristics of the sesquiterpenes and diterpenes from Lauraceae family and their multifaceted health benefits: A review

Haowei Feng [a,1], Yiping Jiang [b,1], Huihui Cao [a,c], Yuqi Shu [a], Xiaoyu Yang [a], Daoqi Zhu [d,*], Meng Shao [a,e,**]

[a] Guangdong Provincial Key Laboratory of Chinese Medicine Pharmaceutics, School of Traditional Chinese Medicine, Southern Medical University, Guangzhou 510515, China
[b] Department of Pharmacy, Zhuhai People's Hospital (Zhuhai Hospital Affiliated with Jinan University), Zhuhai 519000, China
[c] Traditional Chinese Pharmacological, Third Level Research Laboratory of State Administration of Traditional Chinese Medicine, School of Traditional Chinese Medicine, Southern Medical University, Guangzhou 510515, China
[d] School of Traditional Chinese Medicine, Southern Medical University, Guangzhou 510515, China
[e] Tumushuke Hospital, The Third Division Hospital of Xinjiang Production and Construction Crops, Tumushuke 843900, China

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ABSTRACT

Lauraceae is a large family with significant economic and medicinal value. Bioactive ingredients from Lauraceae plants have contributed greatly to medicines, food nutrients and fine chemical products. In recent years, quite a few sesquiterpenes and diterpenes with unique structures have been achieved from Lauraceae and their potential benefits are embodied in a wide range of health areas. To our knowledge, there is no review to summarizes these constituents and their biological effects systematically. This current work aims to classify and ascribe the structural types and bioactivities of the identified sesquiterpenes and diterpenes. Herein, a total of 362 sesquiterpenes and 69 diterpenes were comprehensively complied. The various bioactivities could be recognized as cytotoxicity, anti-proliferation and/or anti-apoptosis, anti-inflammation, anti-oxidation, anti-bacterium, etc. This updated data could serve as a catalysis of these sesquiterpenes and diterpenes for the future medical and industrial applications.

1. Introduction

Lauraceae, a large family belonging to Magnoliidae, comprises 2000–2500 species grouped to 45 genera. Most plants of Lauraceae are pantropic evergreen arbor, distributed natively in mountain and rainforests of southern and southeastern Asian, Australia, Africa and Southern America (Figure 1). In China, there are 25 genera, 445 species spreading across the middle and low altitude mountains from Southwest to South region. Among them, *Sinosassafras* and *Sinopora* are endemic to China, while *Laurus* and *Persea* are the commercially cultivated genera (Figure 2A–C) [1].

Due to the multifaceted importance of Lauraceae plants, a broad range of studies on comprehensive phytochemical and bioactive of Lauraceae plants are carried out. Our literature retrieval manifested that the genera of *Cinnamomum*, *Persea*, *Laurus*, *Litsea*, *Lindera*, *Neolitsea* and *Ocotea* were intensively studied, while *Nectandra*, *Caryodaphnosis*, *Beilschmiedia*, *Machilus*, *Crytocarya* and *Pleurothyrium* barely had a handful of scientific investigations. Terpenes (monoterpenes, sesquiterpenes and diterpenes), phenylpropanoids, polyphenols (lignans, flavonoids, dibenzocycloheptanoids, coumarins and their glycosides), alkaloids, polysaccharides and aliphatics [2, 3, 4, 5] encompassed the predominant constituents of this family, and which pharmacological activities covering the antioxidation, antibiosis, anti-inflammation, cytotoxicity, neuroprotection, hepatoprotection, cytokine modulation and pain soothing [6, 7, 8, 9]. Although phenylpropanoids and polyphenols are the perceived best-known ingredients, sesquiterpenes and diterpenes have become the emerging representative constituents, as for their various unprecedent structures, multiple health-beneficial bioactivities and potential chemotaxonomic significance in the phytology study.

Up to now, there are several reviews concluded the traditional uses, phytochemistry and pharmacological activities of genus *Cinnamomum*, *C.*

* Corresponding author.
** Corresponding author.
E-mail addresses: zhudaoqi@163.com (D. Zhu), shaomeng_smu@163.com (M. Shao).
[1] Equal contributions.

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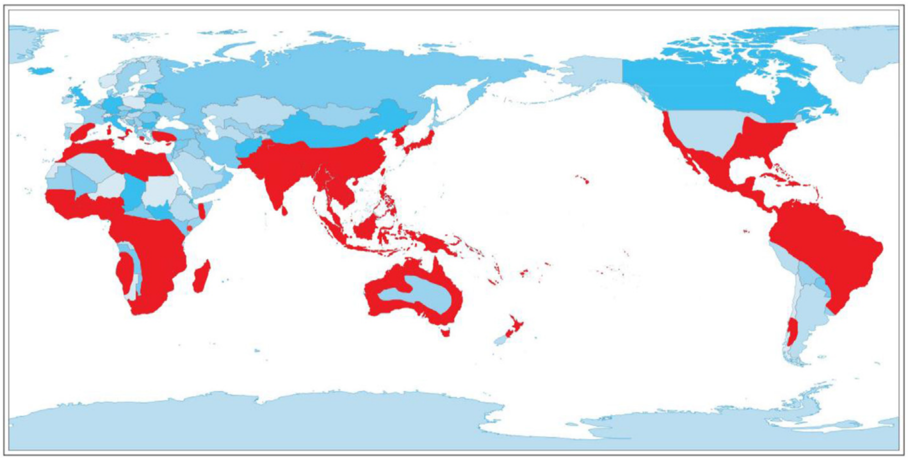

Figure 1. Distribution of Lauraceae plants around the world (the red zone, original map downloaded from http://bzdt.ch.mnr.gov.cn/index.html).

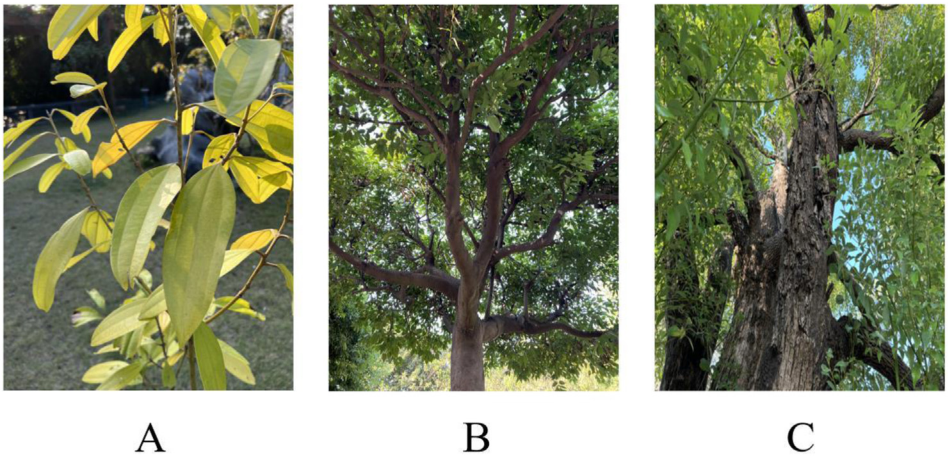

Figure 2. Three representative Lauracea plants in China. (A) *Cinnamomum cassia* Presl; (B) *Cinnamomum burmannii* (Nees) BL; (C) *Cinnamomum camphora* (L.); Presl.

Table 1. Examples of classic TCM prescriptions of Lauraceae plants.

Herbal	Prescription name	Traditional and clinical uses	Documentation
Barks of *C. cassia*	You Gui Pills	Treating deficiency of kidney Yang, sour and cold waist and knees, low spirit, fear of cold, impotence, spermatorrhea, frequent and clear urination	Jing Yue Quan Shu
	Su Zi Jiang Qi Soup	Treating the reducing of Qi and relieving asthma, stuffy chest and diaphragm, eliminating phlegm and relieving cough	Tai Ping Hui Min He Ji Ju Fang
	Shi Quan Da Bu Soup	Treating lack of Qi and blood, fatigue, cough, ulcers and ulcers, metrorrhagia and leakage	Tai Ping Hui Min He Ji Ju Fang
	Gui Fu Du Zhong Soup	Treating cold, backache, green tongue, contraction of scrotum and trembling	Hui Yue Yi Jing
Twigs of *C. cassia*	Shen Qi Pills	Treating backache, soft feet, adverse urination or excessive urination, impotence, premature ejaculation, light and fat tongue	Jin Gui Yao Lue
	Gui Zhi Fu Zi Soup	Dispel wind, warm meridians, help Yang and remove dampness	Shang Han Lun
	Ma Huang Soup	Treating cold and aversion, fever, headache and body pain, panting without sweat	Shang Han Lun
Root tubers of *Lindera aggregata*	Si Mo Soup	Treating Qi descending, distended and stuffy of chest and diaphragm, short of breath	Ji Sheng Fang
	Suo Quan Pills	Nourishing Yin and kidney, treating frequency of urination and nocturnal enuresis caused by kidney deficiency	Fu Ren Liang Fang
	Ge Xia Zhu Yu Soup	Promoting blood circulation and removing blood stasis, treating accumulation of mass caused by blood stasis	Yi Lin Gai Cuo
Fruits of *L. cubeba*	Bi Cheng Qie Powder	Treating stabbing pain and cold on abdomen and heart, soft limbs	Bian Que Xin Shu
	Bi Cheng Qie Pills	Treating weakness of spleen and stomach, discomfort of chest and diaphragm, anorexia	Ji Sheng Fang

Table 2. Sesquiterpenoids from the family Lauraceae.

No.	Name	Species	Botanical parts	Ref.
Chain sesquiterpenoids				
	Butanolides			
1	(+)-(2*E*,3*R*,4*S*)-2-(Dodec-11-ynylidene)-3-hydroxy-4-methylbutanolide	*Machilus wangchiana*	Barks	[29]
2	(+)-(2*E*,3*R*,4*S*)-2-(Dodec-11-enylidene)-3-hydroxy-4-methylbutanolide	*Machilus wangchiana*	Barks	[29]
3	(+)-(2*Z*,3*R*,4*S*)-2-(Dodec-11-enylidene)-3-hydroxy-4-methylbutanolide	*Machilus wangchiana*	Barks	[29]
4	(+)-(2*Z*,3*R*,4*S*)-2-(Dodec-11-ynylidene)-3-hydroxy-4-methylbutanolide	*Machilus wangchiana*	Barks	[29]
5	(-)-(2*Z*,3*S*,4*S*)-2-(Dodec-11-ynylidene)-3-hydroxy-4-methylbutanolide	*Machilus wangchiana*	Barks	[29]
6	*ent*-Litsenolide C_1	*Machilus wangchiana*	Barks	[29]
7	2-(1-Methoxy-11-dodecenyl)-penta-2,4-dien-4-olide	*Lindera obtusiloba*	Stems	[30]
8	(2*Z*,3*S*,4*S*)-2-(11-Dodecenylidene)-3-hydroxy-4-methylbutanolide	*Lindera obtusiloba*	Stems	[30]
9	(2*E*,3*R*,4*R*)-2-(11-Dodecenylidene)-3-hydroxy-4-methoxy-4-methylbutanolide	*Lindera obtusiloba*	Stems	[30]
10	Isoreticulide	*Cinnamomum reticulatum*	Leaves	[31]
11	Tenuifolide A	*Cinnamomum tenuifolium*	Stems	[32]
12	Isotenuifolide A	*Cinnamomum tenuifolium*	Stems	[32]
13	Tenuifolide B	*Cinnamomum tenuifolium*	Stems	[32]
14	Secotenuifolide A	*Cinnamomum tenuifolium*	Stems	[32]
15	Litseasesquibutenolide	*Litsea verticillata*	Leaves, Twigs	[33]
	Other chain sesquiterpenoids			
16	(2*E*,6*E*)-2,6-Dimethyl-10-methylene-dodecatrienoic acid	*Ocotea minarum*	Leaves	[34]
17	Caparratriene	*Ocotea caparrapi*	Oil extract	[35]
18	3*S*-(+)-9-Oxonerolidol	*Cinnamomum camphora*, *Cinnamomum chartophyllum*	Aerial parts	[36, 37]
19	Nerolidol	*Ocotea caparrapi*	Oil extract	[35]
Monocyclic sesquiterpenoids				
	Litseane-type sesquiterpenoids			
20	Litseaverticillol L	*Litsea verticillata*	Leaves, Twigs	[33]
21	Litseaverticillol M	*Litsea verticillata*	Leaves, Twigs	[33]
22	Litseaverticillol A	*Litsea verticillata*	Leaves, Twigs	[38]
23	Litseaverticillol B	*Litsea verticillata*	Leaves, Twigs	[38]
24	Litseaverticillol C	*Litsea verticillata*	Leaves, Twigs	[38]
25	Litseaverticillol D	*Litsea verticillata*	Leaves, Twigs	[38]
26	Litseaverticillol E	*Litsea verticillata*	Leaves, Twigs	[38]
27	Litseaverticillol F	*Litsea verticillata*	Leaves, Twigs	[38]
28	Litseaverticillol G	*Litsea verticillata*	Leaves, Twigs	[38]
29	Litseaverticillol H	*Litsea verticillata*	Leaves, Twigs	[38]
30	Litseachromolaevane B	*Litsea verticillata*	Leaves, Twigs	[39]
31	Isolitseane A	*Litsea verticillata*	Leaves, Twigs	[40]
32	Isolitseane B	*Litsea verticillata*	Leaves, Twigs	[40]
33	Isolitseane C	*Litsea verticillata*	Leaves, Twigs	[40]
	Megastigmane-type sesquiterpenoids			
34	Turpenionoside A	*Cinnamomum cassia*	Immature buds	[41]
35	Wilsonol A	*Cinnamomum wilsonii*	Leaves	[42]
36	(3*S*,4*S*,5*S*,6*S*,9*S*)-3,4-Dihydroxy-5,6-dihydro-*β*-ionol	*Cinnamomum wilsonii*	Leaves	[42]
37	(3*S*,5*R*,6*R*,7*E*,9*S*)-3,5,6,9-Tetrahydroxy-7-ene-megastigmane	*Cinnamomum cassia*	Leaves	[43]
38	(3*S*,5*R*,6*S*,7*E*)-Megasfifigma-7-ene-3,5,6,9-tetrol	*Cinnamomum subavenium*	Leaves	[44]
39	Wilsonol B	*Cinnamomum wilsonii*	Leaves	[42]
40	Wilsonol D	*Cinnamomum wilsonii*	Leaves	[42]
41	Wilsonol G	*Cinnamomum wilsonii*	Leaves	[42]
42	Wilsonol H	*Cinnamomum wilsonii*	Leaves	[42]
43	(3*S*,5*S*,6*S*,9*R*)-3,6-Dihydroxy-5,6-dihydro-*β*-ionol	*Cinnamomum wilsonii*	Leaves	[42]
44	(3*S*,5*R*,6*S*,7*E*,9*R*)-7-Megastigmene-3,6,9-triol	*Cinnamomum cassia*	Leaves	[43]
45	Wilsonol E	*Cinnamomum wilsonii*	Leaves	[42]
46	Wilsonol F	*Cinnamomum wilsonii*	Leaves	[42]
47	Wilsonol C	*Cinnamomum wilsonii*	Leaves	[42]
48	Lasianthionoside A	*Cinnamomum wilsonii*	Leaves	[42]
49	(3*S*,5*R*,6*S*,7*E*)-3,5,6-Trihydroxy-7-megastigmen-9-one	*Cinnamomum cassia*	Barks	[45]
50	Wilsonol I	*Cinnamomum wilsonii*	Leaves	[42]
51	Wilsonol J	*Cinnamomum wilsonii*	Leaves	[42]
52	(3*R*,9*S*)-Megastigman-5-ene-3,9-diol 3-*O*-*β*-D-glucopyranoside	*Cinnamomum wilsonii*	Leaves	[42]

(*continued on next page*)

Table 2 (*continued*)

No.	Name	Species	Botanical parts	Ref.
53	(3*S*,4*R*,9*R*)-3,4,9-Trihydroxymegastigman-5-ene	*Cinnamomum wilsonii*	Leaves	[42]
54	(1*R*,2*R*)-4-[(3*S*)-3-Hydroxybutyl]-3,3,5-trimethylcyclohex-4-ene-1,2-diol	*Cinnamomum cassia*	Leaves	[43]
55	(1*R*,2*R*)-4-[(3*R*)-3-Hydroxybutyl]-3,3,5-trimethylcyclohex-4-ene-1,2-diol	*Cinnamomum cassia*	Leaves	[43]
56	Wilsonol K	*Cinnamomum wilsonii*	Leaves	[42]
57	Wilsonol L	*Cinnamomum wilsonii*	Leaves	[42]
58	Apocynol A	*Cinnamomum wilsonii*	Leaves	[42]
59	(+)-(6*S*,7*E*,9*Z*)-Abscisic ester	*Cinnamomum wilsonii*	Leaves	[42]
60	Asicariside B_1	*Cinnamomum subavenium*	Leaves	[44]
61	Staphylionoside D	*Litsea cubeba*	Twigs	[46]
62	Vomifoliol 9-*O*-*β*-D-glucopyranoside	*Litsea cubeba*	Twigs	[46]
63	Dihydrovomifoliol-9-*O*-*β*-D-glucopyranoside	*Litsea cubeba*	Twigs	[46]
	Bisabolane-type sesquiterpenoids			
64	3,4-Dihydroxy-*β*-bisabolol	*Machilus zuihoensis*	Stem woods	[47]
65	*rel*-(5*R*,7*R*)-l0-Desmethyl-1-methyl-1,10-dioxo-1,10-*seco*-11-eudesmene	*Ocotea corymbosa*	Unripe fruits	[48]
66	Azoridione	*Laurus azorica*	Aerial parts	[49]
67	(+)-*β*-Sesquiphellandren-12-oic acid	*Ocotea minarum*	Leaves	[34]
68	(+)-2-Methyl-6 [4-*oxo*-2-cyclohexen-1-yl]-2-(*E*)-heptenoic acid	*Ocotea minarum*	Leaves	[34]
69	(-)-Lanceolic acid	*Ocotea minarum*	Leaves	[34]
70	4-*oxo*-Lanceolic acid	*Ocotea minarum*	Leaves	[34]
71	4-Hydroxy-1,10-*seco*-muurol-5-*ene*-1,10-dione	*Cinnamomum cassia*	Barks	[50]
72	6-(2-Hydroxy-6-methylhept-5-en-2-yl)-3-(hydroxymethyl)-4-oxocyclohex-2-en-1-yl acetate	*Lindera benzoin*	Leaves	[51]
73a/b	3-(Hydroxymethyl)-6-(5-(2-hydroxypropan-2-yl)-2-methyltetrahydrofuran-2-yl)-4-oxocyclohex-2-en-1-yl acetate	*Lindera benzoin*	Leaves	[51]
74	(-)-Curcumen-12-oic acid	*Ocotea minarum*	Leaves	[34]
75	2-Methyl-6-(*p*-tolyl)heptane-2,3-diol	*Cinnamomum chartophyllum*	Aerial part	[52]
76	Litseachromolaevane A	*Litsea verticillata, Cinnamomum cassia*	Twigs, Barks, Leaves	[39, 50]
77	Cinnacasside A	*Cinnamomum cassia*	Barks	[45]
78	Bisabolene oxide	*Phoebe porosa*	Oil extract	[53]
79	(1*S*,3*S*,5*R*,6*S*)-11-*O*-*β*-D-Glucopyranosyl-14-*oxo*-dihydrophaseate	*Litsea cubeba*	Twigs	[54]
80	– [a] (CAS: 1300726-66-2)	*Lindera strychnifolia*	Roots	[55]
81	– [a] (CAS: 1300726-67-3)	*Lindera strychnifolia*	Roots	[55]
82	– [a,b]	*Lindera strychnifolia*	Roots	[55]
	Elemane-type sesquiterpenoids			
83	Hiiranlactone C	*Neolitsea hiiranensis*	Leaves	[56]
84	Isofuranogermacrene	*Lindera strychnifolia*	Roots	[57]
85	Sericealactone	*Neolitsea hiiranensis*	Roots	[58]
86	Hiiranlactone A	*Neolitsea hiiranensis*	Leaves	[56]
87	*de-O*-Methylsericealactone	*Neolitsea hiiranensis*	Leaves	[56]
88	Linderolide F	*Lindera strychnifolia*	Roots	[59]
89	8-Hydroxyisogermafurenolide	*Lindera strychnifolia*	Roots	[28]
90	Hiiranlactone B	*Neolitsea hiiranensis*	Leaves	[56]
91	Hiiranlactone D	*Neolitsea hiiranensis*	Leaves	[56]
92	Isosericenine	*Neolitsea sericea*	Leaves	[60]
93	Lauroxepine	*Laurus nobilis*	Fruits	[61]
94	Spirafolide	*Laurus nobilis*	Fruits	[61]
	Germacrane-type sesquiterpenoids			
95	Litseagermacrane	*Litsea verticillata*	Leaves, Twigs	[39]
96	Shiromodiol-diacetate	*Parabenzoin trilobum = Lindera triloba*	Leaves	[62]
97	Shiromodiol-monoacetate	*Parabenzoin trilobum = Lindera triloba*	Leaves	[62]
98	Shiromool	*Parabenzoin trilobum = Lindera triloba*	Leaves	[62]
99	Costunolide	*Laurus nobilis*	Leaves	[63]
100	Anhydroperoxycostunolide	*Laurus nobilis*	Leaves	[64]
101	Lucentolide	*Laurus nobilis*	Leaves	[64]
102	Deacetyl laurenobiolide	*Laurus nobilis*	Leaves	[65]
103	Cyclodeca [*b*]furan,4,7,8,11-tetrahydro-3,6,10-trimethyl	*Lindera strychnifolia*	Roots	[57]
104	Sericenine	*Neolitsea sericea*	Leaves	[66]
105	Sericenic acid	*Neolitsea sericea*	Leaves	[66]
106	Deacetylzeylanine	*Neolitsea parvigemma*	Stems	[67]
107	Parvigemonol	*Neolitsea parvigemma*	Stem	[67]

(*continued on next page*)

Table 2 (*continued*)

No.	Name	Species	Botanical parts	Ref.
108	Linderalactone	*Neolitsea hiiranensis, Neolitsea zeylanica, Lindera strychnifolia, Neolitsea parvigemma*	Roots, Stems	[58, 68, 69, 70]
109	Litsealactone	*Lindera strychnifolia*	Roots	[71]
110	Zeylanane	*Lindera strychnifolia*	Roots	[71]
111	Parvigemone	*Lindera strychnifolia, Neolitsea parvigemma*	Roots, Stems	[72, 73]
112	Linderanlide C	*Lindera aggregata*	Root tubers	[74]
113	Zeylaninone	*Neolitsea acutotrinervia = N. aciculata*	Roots	[75]
114	Acutotrinol	*Neolitsea acutotrinervia = N. aciculata*	Roots	[75]
115	Pseudoneoliacine	Neolitsea hiiranensis Neolitsea villosa	Leaves, Roots	[56, 76]
116	Neoliacinolide A	*Neolitsea hiiranensis, Neolitsea aciculuta*	Leaves	[56, 77]
117	Neoliacine	*Neolitsea aciculuta*	Leaves	[77]
118	Linderoline	*Lindera strychnifolia*	Roots	[59]
119	Neoliacinolide B	*Neolitsea aciculuta*	Leaves	[77]
120	Neoliacinolide C	*Neolitsea aciculuta*	Leaves	[77]
121	Neoliacinic acid	*Neolitsea aciculuta*	Leaves	[77]
122	Linderanine B	*Lindera aggregata*	Root tubers	[74]
123	Linderanine A	*Lindera aggregata*	Root tubers	[74]
124	Linderanlide A	*Lindera aggregata*	Root tubers	[74]
125	Litseacassifolide	*Litsea cassiaefolia*	Barks	[78]
126	Pseudovillosine	*Neolitsea kedahensis*	Stems	[79]
127	Linderanlide B	*Lindera aggregata*	Root tubers	[74]
128	Acutotrinone	*Neolitsea acutotrinervia = N. aciculata*	Roots	[75]
129	(+)-Villosine	*Neolitsea hiiranensis, Neolitsea villosa*	Leaves, Roots	[56, 76]
130	Acutotrine	*Neolitsea acutotrinervia = N. aciculata*	Roots	[75]
131	Linderane	*Neolitsea zeylanica, Lindera strychnifolia, Cryptocarya densiflora*	Barks, Roots	[68, 71, 80]
132	Litseaculane	*Lindera strychnifolia*	Roots	[71]
133	Linderanlide D	*Lindera aggregata*	Root tubers	[74]
134	Linderanlide E	*Lindera aggregata*	Root tubers	[74]
135	Zeylanane	*Lindera strychnifolia*	Roots	[71]
136	Linderadine	*Lindera strychnifolia*	Roots	[71]
137	Pseudolinderadin	*Cryptocarya densiflora*	Barks	[80]
138	Zeylanidine	*Neolitsea zeylanica, Neolitsea parvigemma,*	Roots, Stems, Leaves,	[68, 70, 81]
139	Deacetylzeylanidine	*Neolitsea parvigemma*	Stems	[70]
140	(+)-Linderadine	*Neolitsea Hiiranensis, Neolitsea villosa*	Roots	[58, 76]
141	Neolitrane	*Neolitsea parvigemma*	Stems	[73]
142	Neolinderane	*Neolitsea zeylanica, Lindera strychnifolia*	Roots	[68, 71]
143	Pseudoneolinderane	*Neolitsea parvigemma, Neolitsea villosa*	Stems, Roots	[70, 76]
144	Zeylanicine	*Neolitsea zeylanica, Neolitsea parvigemma,*	Roots, Stems, Leaves	[68, 70, 81]
145	Neolindenenonelactone	*Lindera aggregata*	Roots	[82]
	Humulane-type sesquiterpenoids			
146	Litseahumulane B	*Litsea verticillata*	Leaves, Twigs	[39]
147	Litseahumulane A	*Litsea verticillata*	Leaves, Twigs	[39]
148	Humulene Epoxide III	*Phoebe porosa*	Oil extract	[53]
149	(2*E*,9*E*)-6,7-*cis*-Dihydroxyhumulan-2,9-diene	*Cinnamomum cassia*	Barks	[45]
	Other monocyclic sesquiterpenoids			
150	Isolinderalactone	*Lindera aggregata*	Roots	[83]
151	Zeylanine	*Neolitsea zeylanica*	Roots	[68]
Bicyclic sesquiterpenoids				
	Oplopanane-type sesquiterpenoids			
152	Oplopanone	*Neolitsea acuminatissima*	Roots	[7]
	Oppositane-type sesquiterpenoids			
153	Octahydro-4-hydroxy-3*R*-methyl-7-methylene-*R*-(1-methylethyl)-1H-indene-1-methanol	*Litsea verticillata*	Leaves, Twigs	[39]
154	1β,7-Dihydroxyl opposit-4(15)-ene	*Cinnamomum cassia*	Buds	[41]
155	1β,11-Dihydroxyl opposit-4(15)-ene	*Cinnamomum cassia*	Buds	[41]
	Cyperane-type sesquiterpenoids			
156	(+)-Faurinone	*Lindera glauca*	Twigs	[84]

(*continued on next page*)

Table 2 (*continued*)

No.	Name	Species	Botanical parts	Ref.
157	Cinnamosim A	*Cinnamomum cassia*	Buds	[41]
158	3α-Hydroxyisoiphion-11 (13)-en-12-oic acid 5β-Hydroxy-4-*oxo*-11 (13)-dehydroiphionan-12-oic acid	*Nectandra cissiflora*	Barks	[85]
159	5β-Hydroxy-4-*oxo*-11 (13)-dehydroiphionan-12-oic acid	*Nectandra cissiflora*	Barks	[85]
160	Eudeglaucone	*Lindera glauca*	Twigs	[84]
	Eremophilane-type sesquiterpenoids			
161	4β,5β,7β- Eremophil-11-en-10α-ol	*Ocotea lancifolia*	Leaves	[86]
162	10,11-Dihydroxyeremophilan-3-one 11-*O*-β-D-glucopyranoside	*Lindera strychnifolia*	Roots	[55]
163	(*rel*)-4β,5β,7β-Eremophil-9-en-12-oic acid	*Ocotea lancifolia*	Leaves	[86]
164	(*rel*)-4β,5β,7β-Eremophil-1 (10)-en-12-oic acid	*Ocotea lancifolia*	Leaves	[86]
165	(*rel*)-4β,5β,7β-Eremophil-1 (10)-en-2-*oxo*-12-oic acid	*Ocotea lancifolia*	Leaves	[86]
166	(*rel*)-4β,5β,7β-Eremophil-9-en-12,8α-olide	*Ocotea lancifolia*	Leaves	[86]
167	(*rel*)-4β,5β,7β-Eremophil-9-en-12,8β-olide	*Ocotea lancifolia*	Leaves	[86]
168	(*rel*)-4β,5β,7β-Eremophil-9α,10α-*epoxy*-12-oic acid	*Ocotea lancifolia*	Leaves	[86]
169	Valenc-l (l0)-ene-8,ll-diol	*Litsea excelsa*	Barks	[78]
	Cadinane-type sesquiterpenoids			
170	1β,4β,11-Trihydroxyl-6β-gorgonane	*Cinnamomum cassia*	Buds	[41]
171	*rel*-(4*S*,6*S*)-Cadina-1(10),7(11)-diene	*Nectandra amazonum*	Leaves	[87]
172	*rel*-(1*R*,4*S*,6*S*,10*S*)-Cadin-7 (11)-en-10-ol	*Nectandra amazonum*	Leaves	[87]
173	15-Hydroxy-α-cadinol	*Cinnamomum cassia*	Barks	[45]
174	(-)-15-Hydroxy-T-muurolol	*Cinnamomum cassia*	Barks	[45]
175	10-Hydroxyl-15-*oxo*-α-cadinol	*Litsea verticillata*	Leaves, Twigs	[39]
176	Cinnamoid B	*Cinnamomum cassia*	Barks	[45]
174	Cinnamoid C	*Cinnamomum cassia*	Barks	[45]
178	(*4α,10β*)-4,10-Dihydroxy cadin-1 (6)-en-5-one	*Cinnamomum cassia*	Barks	[45]
179	Oxyphyllenodiol B	*Litsea verticillata*	Leaves, Twigs	[40]
180	1,2,3,4-Tetrahydro-2,5-dimethyl-8-(1-methylethyl)-1,2-naphthalenediol	*Litsea verticillata*	Leaves, Twigs	[40]
181	*rel*-(1*R*,4*S*)-7-Hydroxycalamenene	*Ocotea elegans*	Leaves	[88]
	Eudesmane-type sesquiterpenoids			
182	Cryptomeridol	*Neolitsea hiiranensis*	Roots	[58]
183	Ilicic acid	*Lindera glauca*	Twigs	[84]
184	(1*S*,2*S*,4*αR*,5*R*,8*R*,8*αS*)-Decahydro-1,5,8-trihydroxy-4α,8-dimethyl-methylene-2-naphthaleneacetic acid methylester	*Laurus nobilis*	Leaves	[64]
185	*rel*-(1*S*,4*S*,5*R*,7*R*,10*R*)-10-Desmethyl-1-methyl-11-eudesmene	*Ocotea corymbosa*	Unripe fruits	[48]
186	(3*αS*,5*αR*,6*R*,9*S*,9*αS*,9*βS*)-6,9-Dihydroxy-5α,9-dimethyl-3-methylidene-6. 3α,4,5,6,7,8,9α,9b-octahydrobenzo [g] [1]benzofuran-2-one	*Laurus nobilis*	Leaves	[64]
187	(3*αS*,5*αR*,6*R*,9*R*,9*αS*,9*βS*)-6-Hydroxy-9-methoxy-5α,9-dimethyl-3-methylidene-3α,4,5,6,7,8,9α,9β-octahydrobenzo [g] [1]benzofuran-2-one	*Laurus nobilis*	Leaves	[64]
188	*rel*-(1*S*,4*R*,5*R*,7*R*,l0*R*)-l0-Desmethyl-l0-hydroxy-1-methyl-3-*oxo*-ll-eudesmene	*Ocotea corymbosa*	Unripe fruits	[48]
189	Lauradiol	*Laurus azorica*	Aerial parts	[49]
190	Linderolide B	*Lindera strychnifolia*	Roots	[59]
191	Linderolide D	*Lindera strychnifolia*	Roots	[59]
192	(1*S*,2*S*,4*αR*,5*R*,6*R*,7*R*,8*S*,8*αS*)-Decahydro-1-hydroxy-5,6,7,8-diepoxy-4α,8-dimethyl-methylene-2-naphthaleneacetic acid methylester	*Laurus nobilis*	Leaves	[64]
193	(3*αS*,5*αR*,6*R*,7*R*,8*R*,9*S*,9*αS*,9*βS*)-6,7,8,9-Diepoxy-5α,9-dimethyl-3-methylidene-5. 3α,4,5,6,7,8,9α,9β-octahydrobenzo [g][1]benzofuran-2-one	*Laurus nobilis*	Leaves	[64]
194	γ-Selinene	*Persea japonica*	Stems	[89]
195	4(15)-Eudesmene-1β,7,11-triol	*Cinnamomum cassia*	Buds	[41]
196	1β,6α-Dihydroxyeudesm-4(15)-ene	*Cinnamomum cassia*	Buds	[41]
197	Polydactin B	*Lindera communis*	Fruits	[90]
198	Eudesm-4(15)-ene-1β,6α-diol	*Litsea verticillata*	Leaves, Twigs	[39]
199	7-*epi*-Eudesm-4(15)-ene-1α,6α-diol	*Litsea verticillata*	Leaves, Twigs	[39]
200	7-*epi*-Eudesm-4(15)-ene-1β,6β-diol	*Litsea verticillata*	Leaves, Twigs	[39]
201	5-*epi*-Eudesm-4(15)-ene-1β,6β-diol	*Litsea verticillata*	Leaves, Twigs	[39]
202	Costic acid	*Nectandra cissiflora*	Barks	[85]
203	Viscic acid	*Nectandra cissiflora*	Barks	[85]
204	Baynol C	*Laurus nobilis*	Leaves	[64]
205	Methyl-1β,2β,6α-trihydroxy-5α,7αH-eudesma-4(15),11(13)-dien-12-oate	*Laurus nobilis*	Leaves	[64]
206	Costic acid methyl ester	*Ocotea caudata*	Leaves	[91]
207	Reynosin	*Laurus nobilis*	Leaves	[64]
208	Hydroperoxide-magnolialide	*Laurus nobilis*	Leaves	[64]

(*continued on next page*)

Table 2 (*continued*)

No.	Name	Species	Botanical parts	Ref.
209	1β,2β-Dihydroxy-5α,6β,7αH-eudesma-4(15),11(13)-dien-12,6-olide	*Laurus nobilis*	Leaves	[64]
210	(3αS,5αR,6S,7R,9αR,9βS)-6-Hydroxy-7-acetoxy-5α-methyl-3,9-dimethylidene-3α,4,5,6,7,8,9α,9β-octahydrobenzo[g] [1]benzofuran-2-one	*Laurus nobilis*	Leaves	[64]
211	Linderolide G	*Lindera strychnifolia*	Roots	[28]
212	Linderolide H	*Lindera strychnifolia*	Roots	[28]
213	Methylneolitacumone A	*Neolitsea acuminatissima*	Roots	[7]
214	Neolitacumone A	*Neolitsea acuminatissima*	Roots	[7]
215	Neolitacumone B	*Neolitsea acuminatissima*	Roots	[7]
216	Neolitacumone E	*Neolitsea acuminatissima*	Roots	[7]
217	12-Carboxyeudesman-3,11(13)-diene	*Nectandra cissiflora*	Barks	[85]
218	Linerenone	*Lindera communis*	Fruits	[90]
219	Santamarine	*Laurus nobilis*	Leaves	[64]
220	(3αS,5αR,6R,7R,9αS,9βS)-6,7-Dihydroxy-5α,9-dimethyl-3-methylidene-4,5,6,7,9α,9β-hexahydro-3αH-benzo[g] [1]benzofuran-2-one	*Laurus nobilis*	Leaves	[64]
221	Linderagalactone E	*Lindera aggregata*	Root tubers	[92]
222	3-*oxo*-*g*-Costic acid	*Nectandra cissiflora*	Barks	[85]
223	Machikusanol	*Persea japonica*	Stems	[89]
224	γ-Eudesmol	*Persea japonica*	Stems	[89]
225	Carissone	*Persea japonica*	Stems	[89]
226	γ-Costic acid	*Lindera glauca*	Twigs	[84]
227	Magnolialide	*Laurus nobilis*	Leaves	[64]
228	3α-Peroxyarmefolin	*Laurus nobilis*	Leaves	[64]
229	Tubiferin	*Laurus nobilis*	Leaves	[64]
230	(1S,2S,4αS,7R,8αR)-Decahydro-1,7-dihydroxy-4α-methyl-,8-*bis*(methylene)-2-naphthaleneacetic acid methylester	*Laurus nobilis*	Leaves	[64]
231	(1S,2S,4αS,7R,8αR)-Decahydro-1-hydroxy-7-acetoxy-4α-methyl-,8-*bis*(methylene)-2-naphthaleneacetic acid methylester	*Laurus nobilis*	Leaves	[64]
232	Linderolide E	*Lindera strychnifolia*	Roots	[59]
233	Lindestrenolide	*Lindera strychnifolia*	Roots	[28]
234	Hydroxylindestrenolide	*Lindera strychnifolia*	Roots	[28]
235	Linderolide A	*Lindera strychnifolia*	Roots	[59]
236	Linderolide C	*Lindera strychnifolia*	Roots	[59]
237	Linderolide J	*Lindera strychnifolia*	Roots	[28]
238	Linderolide I	*Lindera strychnifolia*	Roots	[28]
239	3-*oxo*-4,5αH,8βH-Eudesma-1,7 (11)-dien-8,12-olide	*Lindera strychnifolia*	Roots	[93]
240	3-*oxo*-5αH,8βH-Eudesma-1,4(15),7(11)-trien-8,12-olide	*Lindera strychnifolia*	Roots	[93]
241	Lindestrene	*Lindera strychnifolia*	Roots	[94]
242	Cinnamosim B	*Cinnamomum cassia*	Buds	[41]
243	Neolitacumone C	*Neolitsea acuminatissima*	Roots	[7]
244	1β-Acetoxyeudesman-4(15),7(11),8(9)-trien-8,12-olide	*Neolitsea acuminatissima*	Stem barks	[95]
245	(1S,2S,4αS)-Decahydro-1-hydroxy-7-*oxo*-4α,8-dimethyl-methylene-2-naphthaleneacetic acid methylester	*Laurus nobilis*	Leaves	[64]
246	11,13-Dehydrosantonin	*Laurus nobilis*	Leaves	[64]
247	Gazaniolide	*Laurus nobilis*	Fruits	[61]
248	7αH-10βMe-eudesma-3,5-dien-11-ol	*Litsea lancilimba*	Fruits	[96]
249	Linderagalactone D	*Lindera aggregata*	Root tubers	[92]
250	8-Hydroxylindestenolide	*Lindera aggregata*	Root	[82]
251	1α,6β-Dihydroxy-5,10-*bis*-*epi*-eudesm-15-carboxaldehyde-6-*O*-β-D-glucopyranoside	*Cinnamomum subavenium*	Leaves	[44]
252	Verticillatol	*Litsea verticillata*	Leaves, Twigs	[97]
253	(-)-*ent*-6α-Methoxyeudesm-4(15)-en-1β-ol	*Neolitsea hiiranensis*	Leaves	[56]
254	Eudesm-4(15)-*ene*-1β,6α-diol	*Litsea verticillata*	Leaves, Twigs	[33]
255	α-Agarofuran	*Phoebe porosa*	Oil extract	[53]
256	(-)-Hydroxylindestrenolide	*Lindera strychnifolia*	Roots	[72]
257	3-*oxo*-Eudesma-l,4(15),ll (13)triene12,6α-olide	*Laurus nobilis*	Leaves	[98]
258	Bilindestenolide	*Lindera strychnifolia*	Roots	[99]
	Isodaucane-type sesquiterpenoids			
259	Aphanamol II	*Litsea verticillata*	Leaves, Twigs	[39]
260	Salvialenone	*Phoebe porosa*	Oil extract	[53]
	Guaiane-type sesquiterpenoids			
261	4α-10α-Dihydroxy-5β-H-guaja-6-*ene*	*Cinnamomum cassia*	Buds	[41]

(*continued on next page*)

Table 2 (*continued*)

No.	Name	Species	Botanical parts	Ref.
262	Isocurcumol	*Litsea cassiaefolia*	Barks	[78]
263	Pseudoguaianelactone C	*Lindera glauca*	Roots	[100]
264	Alismol	*Phoebe poilanei*	Leaves	[101]
265	Pseudoguaianelactone A	*Lindera glauca*	Roots	[100]
266	Zaluzanin D	*Laurus nobilis*	Leaves	[63]
267	Dehydrocostuslactone	*Lindera aggregata*	Root tubers	[74]
268	Pseudoguaianelactone B	*Lindera glauca*	Roots	[100]
269	Lancilimbnoid C	*Litsea lancilimba*	Fruits	[96]
270	Pancherione	*Litsea lancilimba*	Fruits	[96]
271	Lancilimbnoid D	*Litsea lancilimba*	Fruits	[96]
272	Lancilimbnoid E	*Litsea lancilimba*	Fruits	[96]
273	Shiluone B	*Litsea lancilimba*	Fruits	[96]
274	Shiluone C	*Litsea lancilimba*	Fruits	[96]
275	(-)-(4*S*,7*S*,10*S*)-2-*oxo*-Guaia-1(5),11(13)-dien-12-oic acid	*Machilus wangchiana*	Barks	[29]
	Caryophyllane-type sesquiterpenoids			
276	(+)-Caryophyllenol II	*Laurus azorica*	Aerial parts	[49]
277	(4*R*,5*R*)-4,5-Dihydroxycaryophyll-8 (13)-ene	*Beilschmiedia tsangii*	Roots	[102]
278	β-Caryophyllene oxide	*Neolitsea hiiranensis*	Leaves	[56]
279	Kobusone	*Neolitsea hiiranensis*	Leaves	[56]
	Spiroaxane-type sesquiterpenoids			
280	Linderagalactone B	*Lindera aggregata*	Root tubers	[92]
281	Linderagalactone C	*Lindera aggregata*	Root tubers	[92]
282	Lindenanolide G	*Lindera chunii*	Roots	[103]
283	Linderolide M	*Lindera strychnifolia*	Roots	[28]
	Other bicyclic sesquiterpenoids			
284	Chromolaevanedione	*Litsea verticillata*	Leaves, Twigs	[40]
285	Lindenanolide E	*Lindera chunii*	Roots	[103]
286	Linderagalactone A	*Lindera aggregata*	Root tubers	[92]
287	Porosadienone	*Phoebe porosa*	Oil extract	[53]
Tricyclic sesquiterpenoids				
	Bergamotene-type sesquiterpenoids			
288	(+)-(*E*)-*exo*-α-Bergamoten-12-oic acid	*Ocotea minarum*	Leaves	[34]
	Campherenane-type sesquiterpenoids			
289	Campherenol	*Cinnamomum camphora*	Woods	[104]
290	Campherenone	*Cinnamomum camphora*	Woods	[104]
	Aristolane-type sesquiterpenoids			
291	Aristofone	*Lindera communis*	Fruits	[90]
	Rearranged cadinane-type sesquiterpenoids			
292	Cinnamoid D	*Cinnamomum cassia*	Barks	[45]
293	Cinnamoid E	*Cinnamomum cassia*	Barks	[45]
294	Mustakone	*Cinnamomum cassia*	Barks	[45]
	Gymnomitrane-type sesquiterpenoids			
295	(+)-5-Hydroxybarbatenal	*Beilschmiedia tsangii*	Roots	[102]
	Clovane-type sesquiterpenoids			
296	Clovane -2β,9α-diol	*Cinnamomum cassia*	Barks	[45]
	Aromadendrane-type sesquiterpenoids			
297	(6α,7α)-4β-Hydroxy-10α-methoxyaromadendrane	*Neolitsea hiiranensis*	Leaves	[56]
298	Espatulenol	*Ocotea lancifolia*	Leaves	[86]
299	(-)-ent-4β-Hydroxy-10α-methoxyaromadendrane	*Neolitsea hiiranensis*	Leaves	[56]
300	4β,10α-Dihydroxyaromadendrane	*Neolitsea hiiranensis*	Leaves	[56]
301	Pipelol A	*Neolitsea hiiranensis*	Leaves	[56]
302	Spathulenol	*Neolitsea hiiranensis*	Leaves	[56]
303	Hiiranepoxide	*Neolitsea hiiranensis*	Leaves	[56]
304	Epiglobulol	*Lindera communis*	Fruits	[90]
305	Aromadendrane-4β,10α-diol	*Cinnamomum cassia*	Buds	[41]
306	Aromadendrane-4α,10α-diol	*Cinnamomum cassia*	Buds	[41]
307	1-Epimeraromadendrane-4β,10α-diol	*Cinnamomum cassia*	Buds	[41]
	Caryolane-type sesquiterpenoids			
308	Caryolane-1,9β-diol	*Cinnamomum cassia*	Barks	[45]

(*continued on next page*)

Table 2 (*continued*)

No.	Name	Species	Botanical parts	Ref.
	Lindenane-type sesquiterpenoids			
309	Linderolide K	*Lindera strychnifolia*	Roots	[28]
310	Linderolide N	*Lindera strychnifolia*	Roots	[72]
311	Linderolide O	*Lindera strychnifolia*	Roots	[72]
312	Linderolide P	*Lindera strychnifolia*	Roots	[72]
313	Linderolide Q	*Lindera strychnifolia*	Roots	[72]
314	Linderolide R	*Lindera strychnifolia*	Roots	[72]
315	Linderolide T	*Lindera strychnifolia*	Roots	[72]
316	Strychnilatone 2,6-dihydroxyxanthone	*Lindera strychnifolia*	Roots	[72]
317	Linderanlide F	*Lindera aggregata*	Root tubers	[74]
318	Lindenanolide A	*Lindera strychnifolia*	Roots	[28]
319	Lindenene	*Lindera strychnifolia*	Roots	[28]
320	Lindenenol	*Lindera strychnifolia*	Roots	[28]
321	Lindeneol	*Lindera chunii*	Roots	[103]
322	Lindeneyl acetate	*Lindera chunii*	Roots	[103]
323	Lindenanolide H	*Lindera chunii*	Roots	[103]
324	Strychinstenolide 6-*O*-acetate A	*Lindera chunii*	Roots	[103]
325	Strychinstenolide 6-*O*-acetate B	*Lindera chunii*	Roots	[103]
326	Strychnilactone	*Lindera strychnifolia*	Roots	[59]
327	Shizukanolide	*Lindera strychnifolia*	Roots	[28]
328	Chloranthalactone D	*Lindera strychnifolia*	Roots	[28]
329	Linderolide S	*Lindera strychnifolia*	Roots	[72]
330	Lindenanolide G	*Lindera strychnifolia*	Roots	[72]
331	Linderolide U	*Lindera aggregata*	Roots	[83]
332	Linderolide L	*Lindera strychnifolia*	Roots	[28]
333	Lindenenol	*Lindera aggregata*	Roots	[83]
334	Menelloide C	*Lindera strychnifolia*	Roots	[72]
335	Linderanoid A	*Lindera aggregata*	Roots	[27]
336	Linderanoid B	*Lindera aggregata*	Roots	[27]
337	Linderanoid C	*Lindera aggregata*	Roots	[27]
338	Linderanoid D	*Lindera aggregata*	Roots	[27]
339	Linderanoid E	*Lindera aggregata*	Roots	[27]
340	Linderanoid F	*Lindera aggregata*	Roots	[27]
341	Linderanoid G	*Lindera aggregata*	Roots	[27]
342	Linderanoid H	*Lindera aggregata*	Roots	[27]
343	Linderanoid I	*Lindera aggregata*	Roots	[27]
344	Linderanoid J	*Lindera aggregata*	Roots	[27]
345	Linderanoid K	*Lindera aggregata*	Roots	[27]
346	Linderanoid L	*Lindera aggregata*	Roots	[27]
347	Linderanoid M	*Lindera aggregata*	Roots	[27]
348	Linderanoid N	*Lindera aggregata*	Roots	[27]
349	Linderanoid O	*Lindera aggregata*	Roots	[27]
350	Lindenanolide I	*Lindera chunii*	Roots	[105]
351	Lindenanolide F	*Lindera chunii*	Roots	[103]
352	Aggreganoid A	*Lindera aggregata*	Roots	[106]
353	Aggreganoid B	*Lindera aggregata*	Roots	[106]
354	Aggreganoid C	*Lindera aggregata*	Roots	[106]
355	Aggreganoid D	*Lindera aggregata*	Roots	[106]
356	Aggreganoid E	*Lindera aggregata*	Roots	[106]
357	Aggreganoid F	*Lindera aggregata*	Roots	[106]
	Other tricyclic sesquiterpenoids			
358	Oreodaphnenol	*Phoebe porosa*	Woods	[107]
359	Cinnamoid A	*Cinnamomum cassia*	Bark	[45]
360	Subamol	*Cinnamomum subavenium*	Roots	[108]
361	Reticuol	*Cinnamomum reticulatum*	Leaves	[109]
362	Tenuifolin	*Cinnamomum reticulatum*, *Cinnamomum tenuifolium*	Leaves, Stems	[31, 32]

[a] The compound name was not given in the reference.
[b] . The CAS number was not given in the reference.

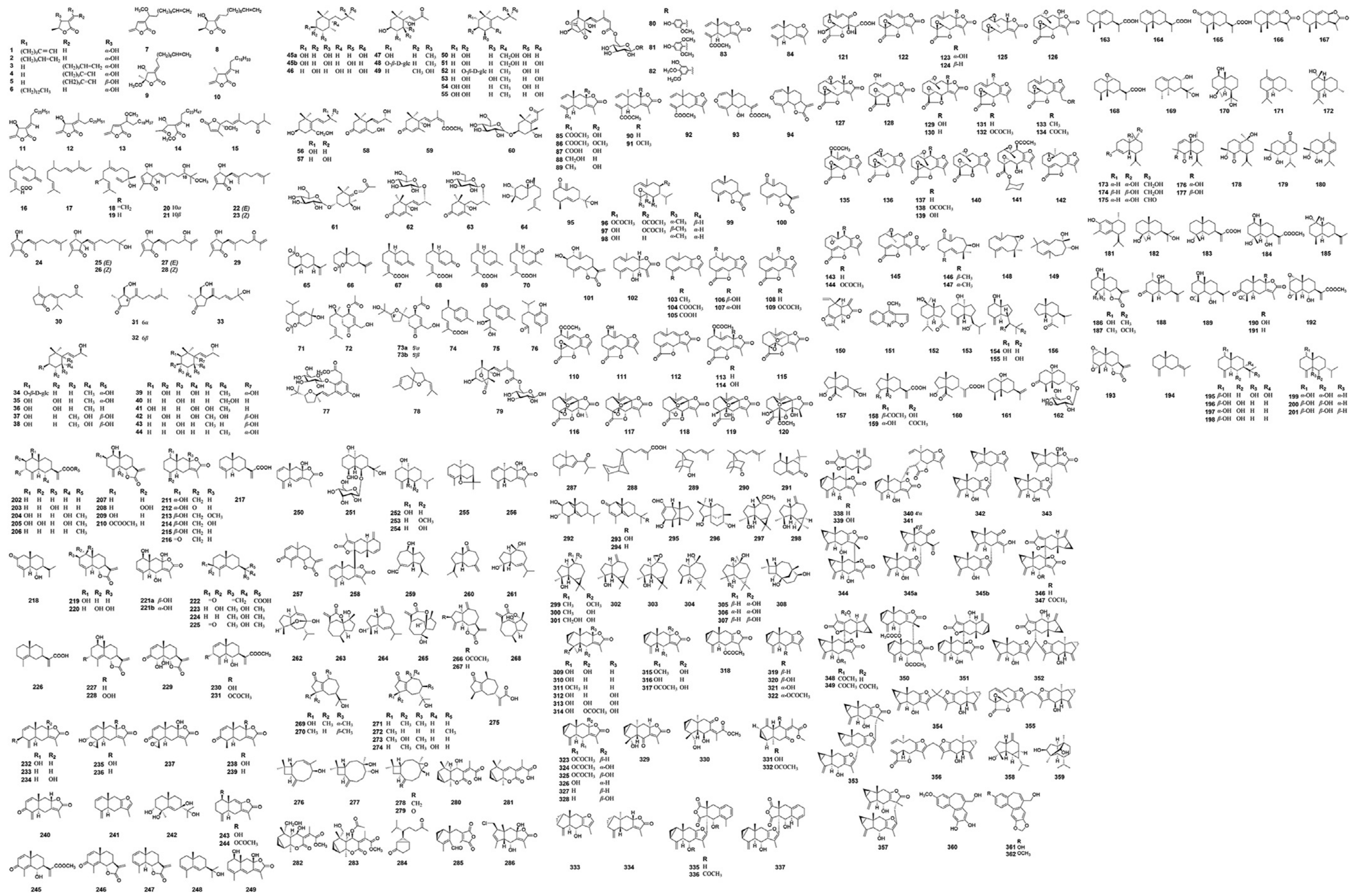

Figure 3. Chemical structures of the sesquiterpenes isolated from Lauraceae.

cassia or *C. verum* [5, 10, 11]; but no comprehensive review specially focuses on the characteristic sesquiterpenes and diterpenes covering the whole family, even though their quantity and variety are greatly enriched in recent years. Herein, we presented a compilation aimed to systematically classify the structural type of sesquiterpenes and diterpenes isolated from Lauraceae and figure out their potential beneficials to human health. Databases and primary sources including SciFinder, ScienceDirect, Web of Science, PubMed, CNKI, PhD and MSc dissertations were conducted with the query words “pharmacological”, “phytochemistry”, “sesquiterpenes”, “diterpenes”, “healthy”, “traditional usage”, “medicinal” and the names of each genera and species of Lauraceae, etc. We look forward to this article can provide some valuable scientific reference for the further studies and utilization of these functional components.

2. Traditional application

Lauraceae plants possess great economic value, extend beyond the nutritional, industrial and medicinal applications. Avocado or called as alligator pears, is a kind of green- to purple-skinned pulpy nutty fruit of *Persea americana* which is rich in healthy fats and oils and recognized as beneficial for all ages [12]. The stem woods of some high trees from *Ocotea*, *Nectandra*, *Persea* [13], *Beilschmiedia* [14], *Machilus* and *Phoebe* [15] are precious timbers for architecture, shipbuilding and home furnishing. Oil-rich barks, leaves and fruits of *Cinnamomum*, *Litsea*, *Lindera*, *Laurus*, *Neolitsea* and *Cryptocarya* species are applied widely as spices, perfume, natural preservatives, pesticides, agrochemicals, disinfectants, as well as the corrective agents in food, beverage and cosmetics [11, 16, 17, 18]. Moreover, as the important industrial raw materials, natural borneol can be acquired from *Cinnamomum camphora* [19] or *C. japonicum* [20] and camphor is found in *C. camphora* [19] and *C. osmophloeum* [21].

In terms of the officinal purpose, the barks and twigs of *Cinnamomum cassia*, the root tubers of *Lindera aggregata* and the fruits of *Litsea cubeba* have long been used in Traditional Chinese Medicine (TCM) for dispersing body cold, relieving stomach pain, treating of kidney disease, impotence, dysmenorrhea, diabetes and some inflammatory disorders [22, 23, 24, 25]. On the basis of folk usage, people further find out that the essential oil distilled from *C. cassia* is of significant antibacterial, spasmolytic and sedative activities [26]. Some representative classic TCM prescriptions and their functions with the above-mentioned herbs are listed in Table 1.

3. Phytochemistry

3.1. Sesquiterpenoids

To date, a total of 362 sesquiterpenes had been acquired from the plant materials of 12 genera and 44 species in Lauraceae family. Among them, *megastigmane*-, *germacrane*-, *eudesmane*- and *lindenane*-type sesquiterpenoids account for a fairly large proportion. Besides, a number of dimers and polymers discovered recently were further amplified the diversity of Lauraceae sesquiterpenoids [27, 28]. Hydroxyl, carbonyl, methyl, glycosyl and phenzyl substitutions with different configurations, as well as double bonds or epoxy groups are found to be the most common structural characteristics in sesquiterpenes. These compounds exhibit the extraordinary chemo-diversity and can be sketchily classified into acyclic, monocyclic, bicyclic and tricyclic system in the light of carbon rings, or assigned to sesquiterpene alcohols, aldehydes and

Table 3. Diterpenoids from the family Lauraceae.

No.	Name	Species	Botanical parts	Ref.
Hemiketal-type diterpenoids				
363	Cassiabudanol A	*Cinnamomum cassia*	Barks	[110]
364	Cassiabudanol B	*Cinnamomum cassia*	Barks	[110]
365	Secoperseanol	*Persea indica*	Aerial parts	[111]
366	Cinncassiol D_1	*Cinnamomum cassia*	Barks	[112]
367	Cinncassiol D_1 glucoside	*Cinnamomum cassia*	Barks	[112]
368	Cinncassiol D_2	*Cinnamomum cassia*	Barks	[112]
369	Cinncassiol D_2 glucoside	*Cinnamomum cassia*	Barks	[112]
370	Cinncassiol D_3	*Cinnamomum cassia*	Barks	[112]
371	Cinncassiol D_4	*Cinnamomum cassia*	Barks	[113]
372	Cinncassiol D_4 glucoside	*Cinnamomum cassia*	Barks	[113]
373	Indicol	*Persea indica*	Branches	[114]
374	Vignaticol	*Persea indica*	Branches	[114]
375	Perseanol	*Persea indica*	Branches	[114]
376	18-Hydroxyperseanol	*Cinnamomum cassia*	Stem barks	[115]
377	(*18S*)-3-Dehydroxycinncassiol D_3	*Cinnamomum cassia*	Leaves	[43]
378	(*18S*)-3-Dehydroxycinncassiol D_3 glucoside	*Cinnamomum cassia*	Leaves	[43]
379	(*18S*)-3,5-Didehydroxy-1,8-dihydroxycinncassiol D_3	*Cinnamomum cassia*	Leaves	[43]
380	(*18S*)-3-Dehydroxy-8-hydroxycinncassiol D_3	*Cinnamomum cassia*	Leaves	[43]
381	19-Dehydroxy-13-hydroxycinncassiol D_1	*Cinnamomum cassia*	Leaves	[43]
382	(*18S*)-1-Hydroxycinncassiol D_1	*Cinnamomum cassia*	Leaves	[43]
383	(*18R*)-1-Hydroxycinncassiol D_1	*Cinnamomum cassia*	Leaves	[43]
384	16-*O*-β-D-Glucopyranosyl-perseanol	*Cinnamomum cassia*	Leaves	[43]
385	(*18S*)-Cinncassiol D_1	*Cinnamomum cassia*	Leaves	[43]
386	(*18S*)-Cinncassiol D_3	*Cinnamomum cassia*	Leaves	[43]
387	(*E*)-3-Dehydroxy-13(18)-*ene*-19-*O*-β-D glucopyranyl-cinncassia D_3	*Cinnamomum cassia*	Leaves	[43]
388	Cinnacetal A	*Cinnamomum cassia*	Twigs and Leaves	[116]
389	Cinnacetal B	*Cinnamomum cassia*	Twigs and Leaves	[116]
390	Cinnzeylanine	*Cinnamomum cassia, Cinnamomum cassia*	Barks	[117, 118]
391	Cinnzeylanol	*Cinnamomum cassia, Cinnamomum cassia, Persea indica*	Barks, Terminal Twigs	[117, 118, 119]
392	Cinncassiol B	*Cinnamomum cassia*	Barks	[120]
393	Cinncassiol B 19-*O*-β-D-glucopyranoside	*Cinnamomum cassia*	Barks	[120]
394	*epi*-Cinnzeylanol	*Persea indica*	Branches	[121]
395	Cinnzeylanone	*Persea indica*	Branches	[121]
396	Ryanodol	*Persea indica*	Terminal twigs	[121]
397	Ryanodol 14-monoacetate	*Persea indica*	Branches	[121]
398	18-Hydroxycinnzeylanine	*Cinnamomum cassia*	Barks	[122]
399	Garajonone	*Persea indica*	Branches	[123]
400	2,3-Didehydrocinnzeylanone	*Persea indica*	Branches	[123]
Ketal-type diterpenoids				
401	Cinncassiol F	*Cinnamomum cassia*	Stem barks	[115]
402	Cinnamomol A	*Cinnamomum cassia*	Leaves	[124]
403	Cinnamomol B	*Cinnamomum cassia*	Leaves	[124]
404	Cinncassiol E	*Persea indica*	Aerial parts	[111]
Lactone-type diterpenoids				
405	Anhydrocinnzeylanine	*Cinnamomum cassia, Persea indica*	Barks, Branches	[118, 123]
406	Anhydrocinnzeylanol	*Cinnamomum cassia*	Barks	[118]
407	Cinncassiol A	*Cinnamomum cassia*	Barks	[118]
408	2,3-Dehydroanhydrocinnzeylanine	*Cinnamomum cassia*	Barks	[122]
409	1-Acetylcinnacassiol A	*Cinnamomum cassia*	Barks	[122]
410	*18S*-Cinncassiol A 19-*O*-β-D-glucopyranoside	*Cinnamomum cassia*	Barks	[122]

(*continued on next page*)

Table 3 (*continued*)

No.	Name	Species	Botanical parts	Ref.
411	*18R*-Cinncassiol A 19-*O*-*β*-D-glucopyranoside	*Cinnamomum cassia*	Barks	[122]
412	Anhydrocinnzeylanone	*Persea indica*	Branches	[123]
413	Epianhydrocinnzeylanol	*Cinnamomum cassia*	Barks	[125]
414	Cinnacasol	*Cinnamomum cassia*	Twigs	[126]
415	Cinnacaside	*Cinnamomum cassia*	Twigs	[126]
416	Cinnacasiol H	*Cinnamomum cassia*	Barks	[125]
417	Cinncassiol G	*Cinnamomum cassia*	Stem barks	[115]
418	16-O-*β*-D-Glucopyranosyl-19-deoxycinncassiol G	*Cinnamomum cassia*	Stem barks	[116]
419	Cinncassiol G_2	*Cinnamomum cassia*	Leaves	[127]
420	Cinnamomol C	*Cinnamomum cassia*	Leaves	[43]
421	Cinnamomol D	*Cinnamomum cassia*	Leaves	[43]
422	Cinnamomol E	*Cinnamomum cassia*	Leaves	[43]
423	Cinnamomol F	*Cinnamomum cassia*	Leaves	[43]
424	Cinnamomol F glucoside	*Cinnamomum cassia*	Leaves	[43]
Diketone-type diterpenoids				
425	Cinncassiol C_1	*Cinnamomum cassia*	Barks	[128]
426	Cinncassiol C_1 19-*O*-*β*-D-glucopyranoside	*Cinnamomum cassia*	Barks	[129]
427	Cinncassiol C_2	*Cinnamomum cassia*	Barks	[129]
428	Cinncassiol C_3	*Cinnamomum cassia, Persea indica*	Barks, Fruits	[129]
Other diterpenoids				
429	Kaurenoic acid	*Pleurothyrium cinereum*	Leaves	[130]
430	Cubelin	*Persea indica*	Fruits	[131]
431	Phytol	*Lindera glauca*	Aerial parts	[132]
432	*trans*-Phytol	*Neolitsea hiiranensis*	Leaves	[133]

lactones according their oxidation degree. Their detailed skeleton types, names, plant resources, applied botanical parts and chemical structures are listed in Table 2 and Figure 3, respectively.

3.2. Diterpenes

Based on the existed scientific research, 69 diterpenes were summed up in this review. Most diterpenes possess unprecedent, cage-like tricyclic or tetracyclic rigid carbon skeletons with multiple highly oxidized and modified functionalities. According to the different oxidation degree, these compounds can be divided into hemiketal-, ketal-, lactone- and diketone-type. Along with the deep-going research, eight sub-types of diterpene skeletons are categorized as: 11,12-*seco*-ryanodane (cinncassiol A type), ryanodane (cinncassiol B type), 7,8-*seco*-ryanodane (cinncassiol C type), isoryanodane (cinncassiol D type), 10,13-*cyclo*-12,13-*seco*-isoryanodane (cinncassiol E type), 12,13-*seco*-isoryanodane (cinncassiol F type), 11,12-*seco*-isoryanodane (cinncassiol G type) and 6,10-*cyclo*-12,13-*seco*-isoryanodane (cinnamomane). Among them, ryanodane diterpenes featured with a complex polyoxygenated 6/5/5/6/5 pentacyclic fused ring system prove to be the most characteristic chemical types. Notably, the distribution of ryanodane diterpenoid is so confined in *Cinnamomum cassia*, *Cinnamomum zeylanicum* and *Persea indica* that they can be regarded as the chemotaxonomic markers of the above species. All these compounds are summarized in Table 3 and their corresponding structures are detailed in Figure 4.

The key biosynthetic pathways of representative diterpenes were also summarized in this review. Both **388** and **389** have the same cinnamaldehyde structural fragment, their respective intermediates **a** and **b** are cascade oxidized by **373**. Then intermediates **a** and **b** with cinnamaldehyde, produce **388** and **389** through a step of acetalization at 5-OH, 16-OH and 4-OH, 5-OH, respectively. As for **401–403**, a ketone intermediate ii is formed by **375,** which the ether linkage between C-11 and C-6 of the hemiketal group is hydrolyzed under the catalysis of acid. **402** is produced by ii through aldol, retro-aldol, oxidation reaction and nucleophilic addition, while **403** is produced by an enzyme-mediated oxidation from **402**. Similarly, biosynthesis of **417** can be derived from **375** through oxidation, reduction and dehydration reaction. The proposed biosynthetic pathways of **388**, **389**, **401–403** and **417** are described as Figure 5.

4. Biological activities

At present, quite a few bioactivity studies on the isolated sesquiterpenes and diterpenes have been carried out. Notably, sesquiterpenes are the main class responsible for the anti-tumor effects, which exhibit the cytotoxic, anti-proliferative and/or apoptotic activities against a variety of human cancer cell lines. Besides, the sesquiterpenes inhibitory capacities on inflammation, oxidation, bacterium, HIV virus, diabetic nephropathy, platelet aggregation and *E. coli* *β*-Glucuronidase (anti-e*β*G) are also striking. As for the diterpenes, immunomodulation is their most prominent activity. Through the ConA/LPS-induced splenocyte proliferation assay, several ryanodines and isoryanodines with novel carbon skeletons exert the extraordinary T cells and Treg cells modulation abilities. Specific biological properties of the isolated sesquiterpenes and diterpenes are listed in Table 4.

5. Conclusion and prospects

The extensive application in medicinal and nutraceutical products of Lauraceae plants have inspired great attention of researchers on their scientific investigations and commercial development. Published works act as a jumping-off point for future research, however, the dispersive and broad conclusions from independent exploration are somewhat inability to precisely reflect the valuable points and highlights. This review summaries the sesquiterpenes and diterpenes obtained from Lauraceae plants and systematically examines their health-promoting benefits related to the plant traditional effectiveness and the modern

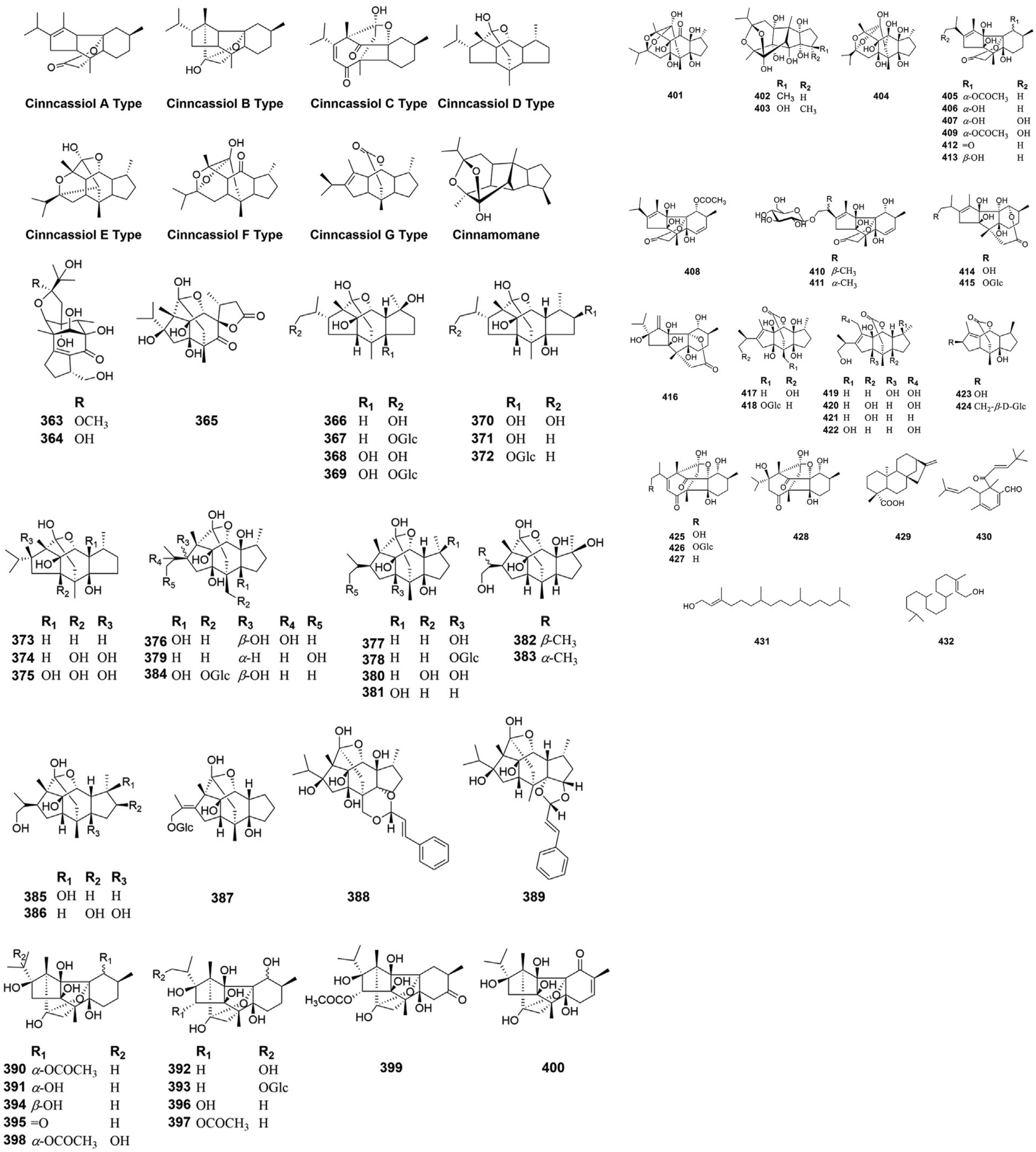

Figure 4. Eight known carbon skeletal types of diterpenoids from C. *cassia* and chemical structures of the diterpenes isolated from Lauraceae.

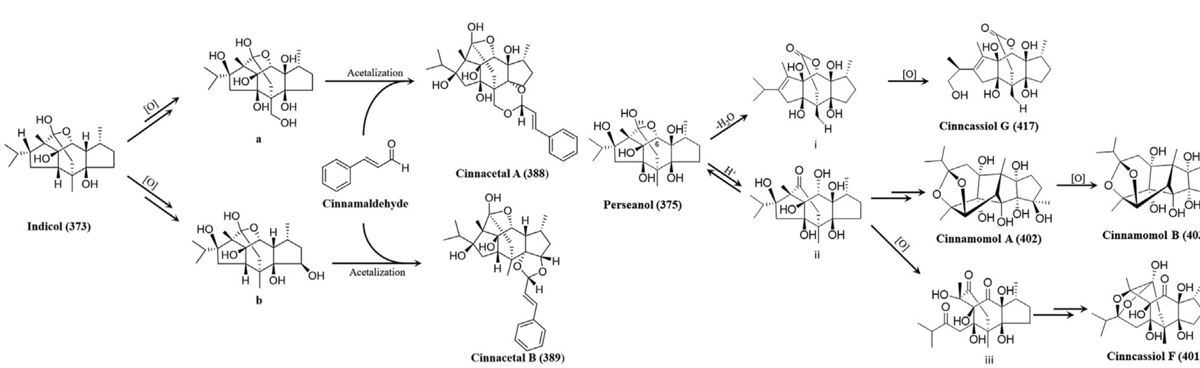

Figure 5. The proposed biosynthetic pathways of compounds (**388**, **389**, **401–403** and **417**).

Table 4. Biological properties of the isolated sesquiterpenes and diterpenoids.

Biological properties	Compound number	Effects	Ref.
Cytotoxic and anti-proliferative activity			
Cytotoxicity against myeloid leukemia cell (HL-60), hepatocellular carcinoma cell (SMMC-7721), lung cancer cell (A549), breast cancer cell (MCF-7) and colon cancer cell (SW-480)	52	IC_{50} values are 5.04, 3.13, 2.50, 3.14 and 12.28 μM, respectively	[42]
Cytotoxicity against human ovarian cancer cell (A2780)	99, 247, 93, 219, 246, 94, 207	IC_{50} values are 6.4, 4.2, 34.6, 9.4, 6.6, 4.0 and 13.5 μg/mL, respectively	[61]
Cytotoxicity against human CEM leukemia cell	17	IC_{50} value is 3.0 ± 0.5 μM	[35]
Cytotoxicity against A549 cell line, ovarian cancer cell (SK-OV-3), skin cancer cell (SK-MEL-2), CNS cancer cell (XF498) and colon cancer cell (HCT15)	7, 8, 9	EC_{50} values are 9.65, 4.73, 3.19, 3.88, 3.57 μg/mL for 7; EC_{50} values are 9.43, 6.71, 4.06, 7.14, 5.21 μg/mL for 8; EC_{50} values are 14.63, 12.92, 10.07, 12.80, 10.14 μg/mL for 9	[30]
Cytotoxicity against A549 cell line and colon cancer cell (HCT-8)	79	IC_{50} values are 8.9, 9.6 μM, respectively	[54]
Cytotoxicity against leukemia cell (K562)	207, 208, 210, 219, 220, 227, 228, 193, 186, 187, 246, 229, 100, 101, 230, 192, 184, 245	IC_{50} values are 126.61 ± 16.30, 24.19 ± 0.38, 243.41 ± 66.90, 22.47 ± 1.46, 222.09 ± 52.20, 27.83 ± 1.05, 4.57 ± 2.10, 136.73 ± 42.61, 193.31 ± 41.51, 58.71 ± 36.57, 46.95 ± 6.62, 90.90 ± 9.70, 39.46 ± 1.65, 116.00 ± 26.12, 111.27 ± 27.79, 182.66 ± 54.07, 233.28 ± 55.02, 246.03 ± 83.75 μM, respectively	[64]
Cytotoxicity against A549 cell line, mouse lymphocytic leukemia cell (P-388), oral epithelial carcinoma KB cell and colon cancer cell (HT-29)	150	EC_{50} values are 1.420, 0.816, 2.990, 1.528 ppm, respectively	[83]
Cytotoxicity against SK-MEL-2 and HCT15 cell lines	204, 202	IC_{50} values are 10.25 and 9.98 μM for 204; 12.20 and 11.60 μM for 202	[84]
Cytotoxicity against human lung cancer cell (H460), human mammary cancer cell (ES2) and human prostatic cancer cell (DU145)	218, 197, 291, 304	IC_{50} values are 2.1 ± 0.72, 2.8 ± 0.65, 3.0 ± 0.70 μM for 218; 56.1 ± 2.5, 57.0 ± 2.3, 45.8 ± 1.6 μM for 197; 51.3 ± 0.9, 61.5 ± 1.1, 58.0 ± 0.9 μM for 291; 33.0 ± 1.5, 29.9 ± 0.3, 27.3 ± 0.6 μM for 304	[90]
Cytotoxicity against human small lung cancer cell (SBC-3)	239	IC_{50} values are 7.2 and 32.2 μM, respectively	[93]
Cytotoxicity against human hepatoma cell (Hep G2) and Hep G2 cell transfected with HBV (Hep 2,2,15)	214, 215, 243	IC_{50} values are 8.4 ± 0.74, 8.4 ± 0.26 μM for 214; 7.6 ± 0.22, 0.24 ± 0.04 μM for 215; 8.5 ± 0.43, 0.08 ± 0.02 μM for 243	[95]
Growth inhibition and apoptotic induction to HL-60 cell line	99, 266	The proliferations of HL-60 cells are inhibited at 10μM of 99 and 15μM of 266, respectively. They exert antitumor activity by triggering apoptotic chromatin condensation	[63]
	100, 257	100 and 257 induced the apoptotic morphological changes of the nucleus and chromatin condensation in the HL-60 cells	[98]
Growth inhibition and apoptotic induction to HCT-116 cell line	150	IC_{50} value is 21.8 μM	[83]
Growth inhibition and apoptotic induction to human cervical cancer cell line (HeLa)	430	IC_{50} values are 34.43 μM at 24 h and 21.92 μM at 48 h. The cells exhibited changes in nuclear morphology and the cleaved caspase-3/-7, caspase-8 and caspase-9 of 430	[131]
Cytotoxicity against HSC-T6 hepatic stellate cells	211, 233, 241	211 and 233 showed inhibition of the viability of HSC-T6 cells, and 241 exhibits a weaker inhibition	[28]
Immunomodulatory activity			
ConA/LPS-induced splenocyte proliferation assay	35, 39, 50, 53, 43	35, 39, 50, 53 inhibited the proliferation of ConA-induced murine T cells, and 50, 53, 43 inhibited the proliferation of LPS induced murine B cells	[42]
	416, 414	416 and 414 inhibited the proliferation of ConA/LPS-induced splenocyte in a dose-dependent manner	[115]
	363, 364	363 and 364 promoted the proliferation of ConA/LPS-induced splenocyte with enhancement rates up to 39.99% and 92.36% at 0.0015 μM. 364 enhanced the immune function by upregulating $CD4^{+}$ and $CD8^{+}$ T cells and downregulating Tregs	[110]
ConA-induced splenocyte proliferation assay	402, 403	402 and 403 enhanced the proliferation of ConA-induced murine T cells with enhancement rates ranging from 29 to 64% at concentrations from 0.391 to 100 μM. 402 enhanced immunity by increasing $CD4^{+}$ T cell proliferation, while reducing Treg differentiation	[124]
Evaluation of the immunomodulatory effects on the splenocyte proliferation	280, 91, 432	280, 91 and 432 suppressed IFN-γ *in vitro*. 280 inhibits the expression of IFN-γ, T-bet, IL-12β2, T-cell differentiation and Th1-assocaited genes	[133]

(*continued on next page*)

Table 4 (*continued*)

Biological properties	Compound number	Effects	Ref.
Anti-inflammatory and anti-oxidative activity			
Evaluation of Nrf2 inducing effects	18	18 activates Nrf2 and its downstream genes, NAD(P)H quinone oxidoreductase 1 and γ-glutamyl cysteine synthetase, and enhances the nuclear translocation and stabilization of Nrf2 in human lung epithelial cells	[36, 37]
Inhibition of PGE2 formation in A549 cell line	72, 73a/b	72 and 73a/b reduce PGE2 formation at 10 μM and 100 μM, respectively	[51]
Inhibition of LPS-stimulated NO production in RAW 264.7 cells	18	18 inhibite LPS-stimulated NO production, blocked NF-κB, TNF-α, IL-6 and PGE2 activation	[36, 37]
	236, 191, 88	236, 191 and 88 are moderately inhibition to LPS-stimulated NO production	[59]
	311, 312, 111	311, 312 and 111 show inhibition against NO production with IC_{50} values of 6.3, 9.6 and 9.0 μM, respectively	[72]
	265, 268, 263	265, 268 and 263 inhibite NO production with IC_{50} values of 2.43 ± 0.27 μM, 4.00 ± 1.15 μM and 1.38 ± 0.30 μM, respectively, and suppress the production of TNF-α, IL-6, IL-1β and PGE2 and the enzyme expression of iNOS and COX-2 in protein levels	[100]
	269, 271, 272	IC_{50} values of 269, 272 and 272 are 35.5, 32.1, 46.7 μM, respectively	[96]
Inhibition of fMLP-induced superoxide production	90, 91	IC_{50} values are 21.86 ± 3.97 and 25.78 ± 4.77 μM, respectively	[56]
Inhibition of fMLP-induced neutrophils	143, 108	IC_{50} values are 21.86 ± 3.97 and 25.78 ± 4.77 μM, respectively	[70]
Inhibition of H_2O_2-induced oxidative damages on HepG2 cells	221, 131, 250, 108	221, 131, 250 and 108 show hepatoprotective activity against H_2O_2-induced oxidative damages on HepG2 cells with EC_{50} values of 67.5, 167.0, 42.4 and 98.0 μM, respectively	[92]
Inhibition of NO production in BV-2 cells	413, 416, 406, 405, 407, 391, 390	413, 416, 406, 405, 407, 391 and 390 show inhibition activities on NO production in LPS induced BV-2 microglial cells with IC_{50} values of 80.7, 76.1, 83.8, 73.8, 78.7, 72.3, 81.8, 68.6 and 71.5 μM, respectively	[125]
	160, 183, 226, 202	160, 183, 226, 202 significantly inhibite NO levels in LPS-stimulated BV-2 cells with IC_{50} values of 15.90, 3.67, 26.48, 14.92, 24.44 and 12.13 μM, respectively	[84]
Antimicrobial activity			
Evaluation for antimicrobial activities against *E. coli*, *C. albicans* and *S. aureus* using an agar-well diffusion method.	157, 242, 154,195, 196, 308, 261, 306, 307	157, 242, 154, 195, 196, 308, 261, 306 and 307 exhibit strong antimicrobial activities against *C. albicans* with inhibitory zones of 11, 10, 8, 9, 11, 10, 9, 10 and 10 mm at 300 μg/disk. 196, 308 and 306 show moderate antibacterial activities against *E. coli* and *S. aureus* with inhibitory zones of 8.5, 7, 7 and 11, 8.5, 10 mm, respectively	[41]
Evaluation for antifungal activities against *C. albicans*, *C. krusei*, and *Cryptococcus neoformans* using the broth microdilution method.	67, 69, 68, 288, 16	67, 69, 68, 288 and 16 exhibit MIC values in the 50–100 μg/mL	[34]
Evaluation for antimicrobial activities against periodontal pathogens	102	102 shows growth inhibitory effects with MICs at 375, 63, 500 and 125 μg/mL against *Actinomyces viscosus*, *A Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis* and *Prevotella intermedia*	[65]
Evaluation the *Mycobacterium tuberculosis* strain H37Rv by the microplate Alamar Blue assay	429	429 induces 91.3% growth inhibition at 50 μg/mL against *M. tuberculosis* H37Rv	[130]
Anti-HIV activity			
Inhibitory effects against HIV-1 replication in a reporter cell line HOG.R5	20 + 21	20 + 21 exhibit anti-HIV activity with an IC_{50} value of 49.6 μM	[33]
	32, 179, 180	32, 179 and 180 inhibit HIV-1 replication in HOG.R5 cell line with IC_{50} values of 38.1 ± 4.2, 54.6 ± 4.2, 91.0 ± 6.5 μM, respectively.	[40]
	95, 201, 30	95, 201 and 30 inhibit HIV-1 replication in HOG.R5 cell line with IC50 values of 6.5 (27.5), 17.4 (73.1) and 28.0 (119.7) μg/mL (μM), respectively	[38]
	252	252 demonstrates weak activity with an IC_{50} value of 34.5 μg/mL (144.7 μM) while being devoid of cytotoxicity at 20 mg/mL	[97]
Other bioactivities			
Antidiabetic nephropathy activity	293, 174, 300	293, 174 and 300 markedly decrease the expression of fibronectin, MCP-1 and interleukin-6 at the	[45]

(continued on next page)

Table 4 (*continued*)

Biological properties	Compound number	Effects	Ref.
		concentration of 50 μM in the high glucose-stimulated mesangial cells	
Inhibition of platelet aggregation	138, 144, 108, 106, 111, 107	At the concentration of 100 μg/mL, 138 and 144 inhibit the PAF induced platelet aggregation. 108 and 106 show inhibition of AA induced platelet aggregation. 111 and 107 inhibit the collagen-induced platelet aggregation	[134]
Anti-*E. coli* β-Glucuronidase (anti-eβG) activity	213	213 shows a moderate inhibitory effect and enzyme activity on bacterial-βG but not human-βG	[7]

pharmacology, which is intended to offer some preliminary information for follow-up studies on any bioactivities and components.

As reported, sesquiterpenes are a substantial oily composition and distribute so widely in the barks, leaves, twigs, roots and stem woods of all the Lauraceae plants studied so far. Coincide with the structure diversity, sesquiterpenes show a variety of physicochemical and biological properties. Notably, this composition is utilized primarily and coarsely in pharmacy, food and light industries until now. On the basis of this review, some clues for expanding their potential value are provided. Conversely, diterpenes appear only in a very limited species and ryanodane-type diterpenes are account for the overwhelming majority. As a kind of newfound compounds with unprecedent and diverse carbon skeletons, ryanodane-type diterpenes quickly become the focuses of organic chemistry, biosynthesis and pharmacology field. In the view of secondary metabolites biosynthesis, the structure type and species-genera distribution of sesquiterpenes and diterpenes in Lauraceae are indeed unique compared with other plants. Four types sesquiterpenes, megastigmane-, germacrane-, eudesmane- and lindenane-sesquiterpenes accounted for more than 60% of total sesquiterpenes. And almost all ryanodine-type diterpenes so concentrated in three Lauraceae plants *Cinnamomum cassia*, *Cinnamomum zeylanicum* and *Persea indica* that could be used as the chemical marker for plants identification. The highly concentration both chemicals and plants indicated some definite distribution and biosynthesis regularity deserved further research. Besides, research have indicated that ryanodane diterpenes are proposed as a potential new type agonist on ryanodine receptor, an important calcium channel in sarcoplasmic reticulum and one of the most important insecticide targets. The obvious antifeedant bioactivity of ryanodanes and the toxicity difference acting on the insects and mammalians prompts that ryanodanes are a category of promising pesticides and deserved a profound study.

This review points that 102 sesquiterpenes and 15 diterpenes possess the confirmed health promotive effects, but their applications in function improvements still face numerous challenges. Most of them need more in-depth studies, including *in vitro* and *in vivo* evaluation to prove the efficacy and safety of use. As the promising natural pesticide, ryanodanes are required more toxicological investigations to confirm the exact insecticidal activity. Once satisfactory results are obtained, engaged in the discovery of diverse ryanodanes and applied them in the medicine, fine chemistry and food industry is of broad prospects. Overall, the sesquiterpenes and diterpenes from Lauraceae plants are a large category of valuable natural resource that is worthy paying strengthened attention due to their extensive bioactivities and potential development.

Declarations

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

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Data availability statement

No data was used for the research described in the article.

Declaration of interests statement

The authors declare no competing interests.

Additional information

No additional information is available for this paper.

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