

Review

Chemistry of the Genus *Plectranthus*

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Abstract

This review presents the phytochemical constituents of the genus *Plectranthus* up to 1999. Only a tetrameric derivative of caffeic acid was isolated from *P. japonicus*, but a group of long-chain alkylphenols, of possible taxonomic significance in the genus, was isolated. As a genus of the subfamily Nepetoideae, *Plectranthus* is free from iridoid glycosides and rich in essential oil (i.e. > 0.5% volatile oil on a dry weight basis).

Diterpenoids are the more common secondary metabolites in *Plectranthus*. The majority of them are highly modified abietanoids. It seems to be similar to the pattern of diterpenoids of *Salvia*, but no clerodane diterpenoids were found in *Plectranthus*.

Keywords: *Plectranthus*, *Coleus*, Labiatae, phytochemical constituents, abietane diterpenoids.

Introduction

Labiatae is a large family occurs worldwide and has species that are adapted to almost all habitats and altitudes. The genus *Plectranthus* L' He'r. belongs to subfamily Nepetoideae of tribe Ocimeae [1]. It comprizes about eighty species worldwide, as indicated in this review. *Coleus* Lour. is taxonomically the closest to *Plectranthus* [2]. *Coleus* species are now generally accepted as belonging to either *Plectranthus* or to *Solenostemon* Thonn. (eds.) [3]. Many combinations are made between *Plectranthus* and *Coleus* species [4,5].

In *Plectranthus*, the upper lip of the flower is unusually four-lobed and the large shoe-shaped lower lip is formed from a single lobe, while in Labiatae the upper lip often consisting of two lobes and the lower consisting of three [6].

Many *Plectranthus* species are economic and medicinal plants. Several species may be grown as ornamentals; like *P. tenuiflorus* in Saudi Arabia. The tubers of an unidentified *Plectranthus* species are eaten in Swaziland [7]. Livingstone potato tubers, *P. esculentus* is cultivated in tropical Africa for its edible tubers [8,9]. *P. floribundus* is cultivated in Nigeria for its edible tubers; that are also relished in Natal [10,11]. In Polynesia, the seed-oil of *P. amboinicus* is applied to the ear for acute edematous otitis acuta [12]. The leaf extract of *P. tenuiflorus* is used in Saudi Arabia to treat ear infections [13]. The leaves of *P. asirensis* are used as an antiseptic dressing for wounds in Saudi Arabia [13]. The leaves of *P. caninus* are chewed in Africa to relieve toothache [14]. In East Africa the leaves of *P. elegans* are used as a vermicide [14]. *P. vetiverioides* is prescribed in Indian ayurvedic medicine against vomiting and nausea [15]. The East African medicinal plant *P. barbatus* is used as a remedy for stomach-ache and as a purgative, and is also resistant to insect attack, from which an aphid antifeedant diterpene was isolated [16].

The chemistry of *Plectranthus* is still not well known. This is the first review of chemical constituents of *Plectranthus* species.

The main phytochemical constituents of the genus *Plectranthus* are diterpenoids, essential oils and phenolics.

Diterpenoids

About 140 diterpenoids were identified from the colored leaf-glands of *Plectranthus* species. The majority of them are highly modified abietanoids, in addition to some phyllocladanes (structures **D140-D146**), *ent*-kaurenes (structures **D147-D154**) and a *seco*-kaurene (structure **D155**). Abietanoids could be classified, according to structure variation, into royleanones (structures **D1-D37**), spirocoleons (structures **D38-D66**), vinylogous quinones (also named extended quinones) (structures **D67-D76**), quinone methides (structures **D77-D93**), acylhydroquinones (structures **D94-D117**), (4→3) *abeo*-acylhydroquinones (structures **D118, D119**), phenolic abietanoids (structures **D120-D122**), 1,4-phenanthraquinones (structures **D123-D127**), dimeric abietanoids (structures **D128-D136**) and *seco*-abietanoids (structures **D137-D139**). Names of these diterpenoids are listed in Table 2. Distribution of diterpenoids and other constituents in species of *Plectranthus* is shown by Table 1.

Essential oils

Plectranthus is one of the oil-rich genera belonging to the subfamily Nepetoideae [17]. Table 1 shows *Plectranthus* species that have been investigated for essential oils. The main constituents of essential oils of *Plectranthus* are mono- and sesquiterpenes. As instances, constituents of essential oil of *P. rugosus* [18], as eluted from fused silica capillary column, are α -pinene, camphene, β -pinene, sabinene, 3-carene, myrcene, α -phellandrene, α -terpinene, limonene, β -phellandrene, *cis*- β -ocimene, γ -terpinene, *trans*- β -ocimene, *p*-cymene, terpinolene, thujone, 1-nonen-3-ol, α -copane, β -bourbonene, β -cubebene, linalool, caryophyllene, terpinen-4-ol, humulene, γ -muurolene, germacrene D, piperitone epoxide, α -muurolene, bicyclogermacrene, δ -cadinene, γ -cadinene, α -curcumene, caryophyllene oxide, T-cadinol, torreyol and α -cadinol. On the same GC column (fused silica capillary), essential oil of *P. amboinicus* [19] was separated into α -pinene, camphene, 1-octen-3-ol, β -pinene, myrcene, α -phellandrene, Δ -3-carene, α -

terpinene, *p*-cymene, limonene, (Z)-β-ocimene, (E)-β-ocimene, α-phelandrène, γ-terpinene, α-terpinolene, linalool, camphor, 1-terpinen-4-ol, α-terpineol, thymol, carvacrol, α-cubebene, β-cubebene, β-elemene, β-caryophyllene, α-bergamotene, (Z)-β-farnesene, α-humulene, β-guaiene, (-)-α-selinene, β-bisabolene, δ-cadinene, caryophyllene oxide, δ-cadinol, α-cadinol, farnesol, calamenol and (-)-4β-7β-aromadendrandiol. Also on fused silica capillary column, essential oil of *P. fruticosus* [20] gave α-thuyene, sabinene, γ-terpinene, β-bourbonene, linalool, terpinen-4-ol, sabinyl acetate, α-humulene, aromadendrene, α-cubebene, β-bisabolene, γ-cadinene, α-elemene, *trans*-farnesol and *trans*-copaene.

Long-chain alkylphenols

A group of long-chain alkylphenols, of possible taxonomic significance in the genus, was isolated [28,29]. From *P. albidus* long-chain alkylphenols **L1-L8**, **L10-L12** were isolated and showed a significant in vitro antioxidant activity [28]. Antioxidant activity guided fractionation of extracts of *P. sylvestris* [29] and HPLC separation yielded the oxygenated long-chain alkylcatechols **L9**, **L13-L18**.

Miscellaneous constituents

Only one aristolane sesquiterpene, 1(10)-aristolen-13-al **M1**, was isolated from *P. hereroensis* [30].

Five triterpenoids, named plectranthoic acid, **M2**, acetylplectranthoic acid, **M3**, plectranthadiol, **M4**, plectranthoic acid A, **M5** and plectranthoic acid B, **M6**, in addition to β-sitosterol were isolated from *P. rugosus* [31, 32]. From the same species Misra *et al.* [85] isolated the triterpenoids oleanolic acid **M7**, ursolic acid **M8** and betulin **M9**, in addition to β-sitosterol and hexacosanol.

Flavonoids seem to be rare in *Plectranthus*. Only two flavonoids were identified, 4',7-dimethoxy-5,6-dihydroxyflavone, **M10** from *P. ambiguus* [33] and chryso-splenetin, **M11** from *P. marruboides* [34].

From *P. mollis* (= *P. incanus*), Mahmoud *et al.* Reported the isolation of vernolic and cyclopropenoid fatty acids [35].

From *P. japonicus* (= *Rabdosia japonica*), a tetrameric derivative of caffeic acid was isolated [36].

Conclusion

Although the genus *Plectranthus* comprises many medicinal and economic plants [80], its chemistry remains poorly known. Caffeic acid and its derivatives are of widespread occurrence in the Labiatae family and of particular attention as chemotaxonomic markers. Chlorogenic acid appears to be of almost universal occurrence within this family, whereas rosmarinic acid is restricted to the subfamily Nepetoideae [81]. Only a tetrameric derivative of caffeic acid was isolated from *P. japonicus* [36]. But a group of long-chain alkylphenols, of possible taxonomic significance in the genus, was isolated [28,29]. Generally, the subfamily Lamioideae is rich in iridoid glycosides, whereas they are absent from the Nepetoideae [82]. No iridoid glycosides were isolated from *Plectranthus*.

Generally, *Plectranthus* species are essential-oil-rich (i.e. > 0.5% volatile oil on a dry weight basis), in agreement with the general situation that the Nepetoideae are oil-rich, whilst the Lamioideae are oil-poor [83].

Diterpenoids are the more common secondary metabolites in *Plectranthus*. The majority of them are highly modified abietanoids, in addition to some phyllocladanes and *ent*-kaurenes. It seems to be similar to the pattern of diterpenoids of *Salvia* [84], but no clerodane diterpenoids were found in *Plectranthus*.

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Table 1: Alphabetical list of *Plectranthus* species and isolated compounds from them.

<i>Plectranthus</i> species	Isolated chemical constituents	References
Abyssinian <i>P.</i> sp.	D1, D5, D9, D10, D12-D14, D21, D30	37
<i>P. albidus</i>	L1-L8, L10-L12	28
<i>P. aliciae</i>	—	62
<i>P. allopectus</i>	—	63
<i>P. ambiguus</i>	D141-D146, flavonoid M10	33
<i>P. amboinicus</i>	Essential oil	19
<i>P. argentatus</i>	D4, D5, D8, D21, D25, D101, D102, D112	38
<i>P. asirensis</i>	—	13
<i>P. australis</i>	—	64
<i>P. barbatus</i>	D29, D65, D75, D76, D115, D117	39
	D65	16
<i>P. burorum</i>	—	65
<i>P. caninus</i>	D108, D109	40
	D59-D64	86
<i>P. ciliatus</i>	—	61
<i>P. coesta</i>	D148	41
	D147	42
<i>P. coetsa</i>	—	66
<i>P. coetsoides</i>	D147, D149-D154	43
<i>P. coleoides</i>	Essential oil	25
<i>P. cyrpiculoides</i>	—	67
<i>P. defoliatu</i>	Essential oil	26
<i>P. ecklonii</i>	D86, M12-M15	68
<i>P. edulis</i>	D17, D18, D21, D22, D23, D24, D38-D48, D50, D55, D56, D66, D67, D69, D70, D94-D100, D106, D107, D118, D119, D137, D138	44
	D118	45
<i>P. elegans</i>	D93, D120	46
<i>P. esculentus</i>	—	69
<i>P. fasciculatos</i>	—	70
<i>P. floribundus</i>	—	11
<i>P. fruticosus</i>	Essential oil	20
<i>P. gandicalyx</i>	—	65
<i>P. garckeianus</i>	—	65
<i>P. geradianus</i>	—	71
<i>P. glandulosus</i>	Essential oil	23
<i>P. glaucocalyx</i>	An antimicrobial diterpenoid	47
<i>P. grandidentatus</i>	D68, D101, D102, D128-D134	48
	D5, D11	49
<i>P. gratus</i>	—	63
<i>P. hadiensis</i>	—	67
<i>P. hereroensis</i>	D9, D35, D36	50
	D37	51
	D9, D16	52
	Sesquiterpene M1	30
<i>P. hilliardiae</i>	—	61
<i>P. incanus</i> (= <i>P. mollis</i>)	Essential oil	27, 79
	Fatty acids	35
<i>P. inflexus</i>	—	72

<i>P. japonicus</i>	D155	53
	Caffeic acid derivative	36
<i>P. japonicus</i> var. <i>glaucocalyx</i>	—	77
<i>P. kapatensis</i>	—	65
<i>P. lanuginosus</i>	D17, D30-D34, D45, D47, D52-D54, D57, D58, D67, D71, D74, D88-D90, D100, D103, D110, D111	54
<i>P. lucidus</i>	—	62
<i>P. madagascariensis</i>	Essential oil	24
<i>P. malvinus</i>	—	62
<i>P. marrubioides</i>	Flavonoid M11	34
<i>P. melissoides</i>	—	79
<i>P. mollis</i> (= <i>P. incanus</i>)	—	79
<i>P. mollis</i>	—	79
<i>P. myrianthus</i>	D128	48
	D2, D4, D96, D98, D101	87
<i>P. neochilus</i>	—	73
<i>P. nilgherricus</i>	D82, D83, D139, D140	88
<i>P. oribiensis</i>	—	61
<i>P. ornatus</i>	—	74
<i>P. parviflorus</i>	D77, D82-D86	55
<i>P. pentheri</i>	—	62
<i>P. porpeodon</i>	—	65
<i>P. pseudobarbatus</i>	—	65
<i>P. puberulentus</i>	—	65
<i>P. purpuratus</i>	D72, D73, D77, D79, D91, D92, D121, D122, D140	56
<i>P. purpuratus</i> subsp. <i>montanus</i>	—	62
<i>P. purpuratus</i> subsp. <i>tongaensis</i>	—	62
<i>P. reflexus</i>	—	61
<i>P. rugosus</i>	Essential oil	18
	Triterpenoids M2-M6 & β -sitosterol	31, 32
	Triterpenoids M7-M9 , β -sitosterol & hexacosanol	85
<i>P. saccatus</i> subsp. <i>pondoensis</i>	—	62
<i>P. saccatus</i> var. <i>longitubus</i>	—	61
<i>P. sanguineus</i>	D3, D4-D7, D9, D15, D21, D25, D26, D68, D99, D102, D128-D131, D139	57
<i>P. schimperi</i>	—	65
<i>P. sp.</i> from the borders of Lake Kiwu, Rwanda	D19-D21, D27-D29, D49, D51, D75, D76, D104, D105, D113-D116, D123-D127	58
	D123-D126	59
<i>P. spectabilis</i>	—	63
<i>P. stenophyllus</i>	—	75
<i>P. stocksii</i>	—	79
<i>P. strigosus</i>	D77, D78, D82-D87	60
<i>P. sylvestris</i>	L9, L13-L18	29
<i>P. tenuiflorus</i>	Essential oil	21,22
<i>P. vestitus</i>	Essential oil	76
<i>P. vettiveroides</i>	—	78

<i>P. zatarhendi</i>	—	67
<i>P. zatarhendi</i> var. <i>tomentosus</i>	—	67
<i>P. zuluensis</i>	—	61

Table 2: Names of diterpenoids encountered in *Plectranthus* species.

diterp.	Name of diterpenoid	Diterp.	Name of diterpenoid
D1	Royleanone	D79	(11-Hydroxy-19-isovaleroyloxy-5,7,9(11),13-abietatetraen-12-one)
D2	6 β , 7 α -Dihydroxy-royleanone	D80	Fuerstione
D3	7-O-Formylhorminone	D81	3 β -Acetoxyfuerstione
D4	6 β -Hydroxy-7 α -formyloxyroyleanone	D82	Parviflorone C
D5	6 β -Hydroxy-7 α -acetoxyroyleanone	D83	Parviflorone E
D6	6 β -Hydroxyroyleanone	D84	Parviflorone B
D7	5,6-Dihydrocoleone U	D85	Parviflorone D
D8	6 β -Formyloxy-7 α -hydroxyroyleanone	D86	Parviflorone F
D9	Horminone	D87	Parviflorone G
D10	7 α -Acetoxyroyleanone	D88	Lanugone M
D11	6 β -Hydroxy-7 α -acyloxyroyleanone	D89	Lanugone L
D12	Taxoquinone (= 7 β -Hydroxyroyleanone)	D90	Lanugone N
D13	7-Oxoroyleanone	D91	6 α ,11-Dihydroxy-19-isovaleroyloxy-7,9(11),13-abietatrien-12-one
D14	8 α ,9 α -Epoxy-7-Oxoroyleanone	D92	6 α ,11-Dihydroxy-19-seneciolyloxy-7,9(11),13-abietatrien-12-one
D15	6 β ,7 α -Dihydroxy(allyl)royleanone	D93	11-Hydroxy-12-oxo-7,9(11),13-abietatriene
D16	7 α ,12-Dihydroxy-17(15 \rightarrow 16)-abeo-abieta-8,12,16-trien-11,14-dione	D94	(2' ξ ,3aR,10bR)-8-(2'-Acetoxy-1'-methylethyl)-3,3a-dihydro-7,9,10-trihydroxy-3a,10b-dimethyl-1H-phenanthro[10,1-bc]furan-4(2H),6(10bH)-dione
D17	Lanugone A	D95	16-O-Acetylcoleon C
D18	(4bS,7R,8aR)-7-Formyloxy-4b,5,6,7,8,8a-hexahydro-3-hydroxy-4b,8,8-trimethyl-2-(2-propenyl)phenanthren-1,4-dione	D96	Coleon U
D19	Plectranthone F	D97	Coleon C
D20	Plectranthone G	D98	
D21	6 β ,7 α -Dihydroxyroyleanone	D99	16-O-Acetylcoleon D
D22	(4bS,7R,8aR,9S,10S)-7-Formyloxy-	D100	(15S)-Coleon D

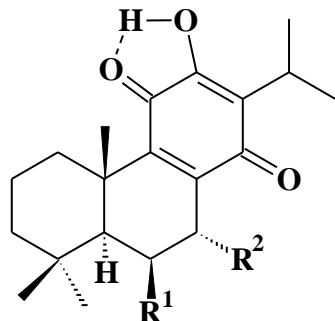
	4b,5,6,7,8,8a,9,10-octahydro-3,9,10-trihydroxy-4b,8,8-trimethyl-2-(2-propenyl)phenanthren-1,4-dione		
D23	(4bS,7R,8aS,9S,10S)-4b,5,6,7,8,8a,9,10-Octahydro-3,9,10-trihydroxy-4b,7-dimethyl-8-methyliden-2-(2-propenyl)phenanthren-1,4-dione	D101	Coleon V
D24	(2'ξ,4bS,7R,8aS,9S,10S)-4b,5,6,7,8,8a,9,10-Octahydro-3,9,10-trihydroxy-2-(2'-hydroxypropyl)-4b,7-dimethyl-8-methylidenphenanthren-1,4-dione	D102	Coleon U
D25	Coleon-U-quinone	D103	(15S)-Coleon C
D26	8α,9α-Epoxy-8,9-dihydrocoleon-U-quinone	D104	(15S)-2α-Acetoxycoleon C
D27	Plectranthone H	D105	(15S)-Coleon H
D28	Plectranthone I	D106	(2'ξ,4aS,10aS)-1,2,3,4,4a,10a-Hexahydro-5,6,8-trihydroxy-7-(2'-hydroxypropyl)-1,1,4a-trimethylphenanthren-9,10-dione
D29	Plectranthone J	D107	(2'ξ,4aR)-2,3,4,4a-Tetrahydro-5,6,8,10-tetrahydroxy-7-(2'-hydroxypropyl)-1,1,4a-trimethylphenanthren-9(1H)-one
D30	6,7-Didehydroroleanone	D108	Coleon T
D31	Lanugone B	D109	Coleon S
D32	Lanugone C	D110	Lanugone R
D33	Lanugone D	D111	Lanugone S
D34	Lanugone E	D112	5,6-Dihydrocoleon U
D35	3β-Acetoxy-6β,7α,12-trihydroxy-17-(15→16);18(4→3)-bisabeo-abieta-4(19),8,12,16-tetraen-11,14-dione	D113	(15S)-2α-Acetoxycoleon D
D36	16-Acetoxyhorminone	D114	(15S)-Coleon I
D37	16-Acetoxy-7α,12-dihydroxy-8,12-abietadien-11,14-dione	D115	Plectrinone B
D38	(2R,2'S,3'R,4'bS,7'R,8'aS,9'S,10'S)-3',10'	D116	(16S)-Plectrinone A

	Diacetoxy-4'b,5',6',7',8',8'a,9',10'-octahydro-9'-hydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione		
D39	(2R,2'S,3'R,4'bS,7'R,8'aS,9'S,10'S)-3'-Acetoxy,10'-formyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-9'-hydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D117	(16R)-Plectrinone A
D40	(2R,2'S,3'R,4'bS,7'R,8'aS,9'S,10'S)-10'-Acetoxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-dihydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D118	Edulone A
D41	(2R,2'S,3'R,4'bS,7'R,8'aS,9'S,10'S)-3'-Acetoxy-4'b,5',6',7',8',8'a,9',10'-octahydro-9',10'-dihydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D119	(1'S,10bS)-7,9,10-Trihydroxy-8-(2'-hydroxy-1'-methylethyl)-3,10b-dimethyl-1H-benzo[g]cyclopenta[de][1]benzopyran-4(2H),6(10bH)-dione
D42	(2R,2'S,3'R,4'bS,7'R,8'aS,9'S,10'S)-10'-Formyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-dihydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D120	7 α ,11-Dihydroxy-12-methoxy-8,11,13-abietatriene
D43	(2R,2'S,3'R,4'bS,7'R,8'aS,9'S,10'S)-4'b,5',6',7',8',8'a,9',10'-Octahydro-3',9',10'-trihydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D121	11,12-Dihydroxy-19-isovaleroyloxy-8,11,13-abietatrien-7-one
D44	(2R,2'S,3'R,4'bS,7'R,8'aR,9'S,10'S)-9'-Acetoxy-7'-formyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',10'-dihydroxy-2,4'b,8',8'-tetramethylspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D122	11,12-Dihydroxy-19-seneciolyloxy-8,11,13-abietatrien-7-one
D45	Lanugon G	D123	Plectranthone B

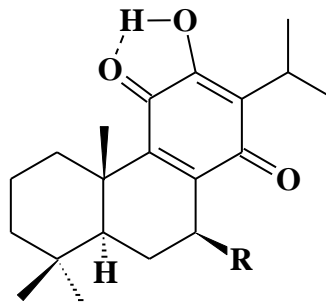
D46	(2R,2'S,3'R,4'bS,7'R,8'aR,9'S)-7'-Formyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-dihydroxy-2,4'b,8',8'-tetramethylspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D124	Plectranthone A
D47	Lanugone F	D125	Plectranthone C
D48	(2R,2'S,3'R,4'bS,7'R,8'aR,9'S,10'S)-7',10'-Bisformyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-dihydroxy-2,4'b,8',8'-tetramethylspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D126	Plectranthone D
D49	Plectranthone K	D127	Plectranthone E
D50	(2R,2'S,3'R,4'bS,7'ξ,8'aR,9'S,10'S)-7',10'-Diacetoxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-dihydroxy-2,4'b,7'-trimethyl-8'-methylidenspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D128	Grandidone A
D51	Plectranthone L	D129	7-Epigrandidone A
D52	Lanugone H	D130	Grandidone B
D53	Lanugone I	D131	7-Epigrandidone B
D54	Lanugone J	D132	Grandidone D
D55	(2S,2'S,3'R,4'bS,7'R,8'aR,9'S,10'S)-7'-Formyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-diacetoxy-10'-hydroxy-2,4'b,8',8'-tetramethylspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D133	7-Epigrandidone D
D56	(2S,2'S,3'R,4'bS,7'R,8'aR,9'S,10'S)-7',10'-Bisformyloxy-4'b,5',6',7',8',8'a,9',10'-octahydro-3',9'-dihydroxy-2,4'b,8',8'-tetramethylspiro[cyclopropan-1,2'(1'H)-phenanthren]-1',4'(3'H)-dione	D134	Grandidone C
D57	Lanugone K	D135	Nilgherron A
D58	Lanugone K'	D136	Nilgherron B
D59	Coleon R	D137	(3R)-6,9-Dihydroxy-3,4-dimethyl-7-(1-methylethyl)-3-(2-propenyl)naphtho[2,3-b]furan-2-(3H),5,8-trione

D60	Coleon M	D138	(2'ξ,3R)-7-(2'-Acetoxy-1'-methylethyl)-6,9-dihydroxy-3,4-dimethyl-3-(2"-propenyl)naphtho[2,3-b]furan-2-(3H),5,8-trione
D61	7,12-Diacetylcoleon J	D139	Sanguinon A
D62	Coleon N	D140	(16R)-17,19-Diacetoxy-16-hydroxy-13β-kauran-3-one
D63	Coleon Q	D141	(16R)-2α-Seneciolyoxy-3α-acetoxyphyllocladan-16,17-diol
D64	Coleon P	D142	(16R)-2α-Seneciolyoxy-3α,17-diacetoxy-16-hydroxyphyllocladane
D65	Plectrin	D143	(16R)-2α-Isovaleroyloxy-3α-acetoxyphyllocladan-16,17-diol
D66	Coleon Z	D144	(16R)-2α-Isovaleroyloxy-3α,17-diacetoxy-16-hydroxyphyllocladane
D67	(15S)-Lanugone O	D145	(16R)-3α-Acetoxyphyllocladan-16,17-diol
D68	14-Hydroxytaxodione	D146	(16R)-2α-Seneciolyoxy-16,17-dihydroxyphyllocladan-3-one
D69	(4bS,8aS)-2-(2-Acetoxypropyl)-4b,5,6,7,8,8a-hexahydro-1,4-dihydroxy-4b,8,8-trimethylphenanthren-3,9-dione	D147	Plecostonol (= coetsidin A)
D70	(2'ξ,4bS,8aS)-4b,5,6,7,8,8a-Hexahydro-1,4-dihydroxy-2-(2'-hydroxypropyl)-4b,8,8-trimethylphenanthren-3,9-dione	D148	Coestinol
D71	Lanugone P	D149	Coetsidin B
D72	19-Isovaleroyloxytaxodione	D150	Coetsidin C
D73	19-Seneciolyoxytaxodione	D151	Coetsidin D
D74	Lanugone Q	D152	Coetsidin E
D75	Coleon F	D153	Coetsidin F
D76	(16S)-Coleon E	D154	Coetsidin G
D77	Parviflorone A (= 11-hydroxy-19-seneciolyoxy-5,7,9(11),13-abietatetraen-12-one)	D155	Rabdosin B
D78	Parviflorone H		

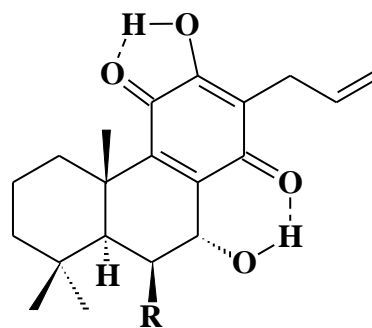
**Diterpenoids isolated from *Plectranthus*
Royleanones**



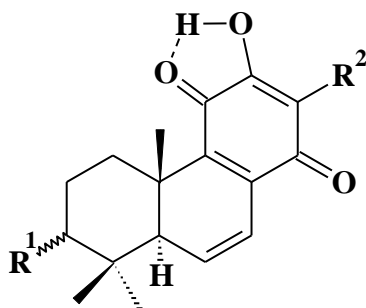
- D1;** $R^1 = R^2 = H$
D2; $R^1 = R^2 = OH$
D3; $R^1 = H, R^2 = OCHO$
D4; $R^1 = OH, R^2 = OCHO$
D5; $R^1 = OH, R^2 = OAc$
D6; $R^1 = OH, R^2 = H$
D7; $R^1 = OH, R^2 = =O$
D8; $R^1 = OCHO, R^2 = OH$
D9; $R^1 = H, R^2 = OH$
D10; $R^1 = H, R^2 = OAc$
D11; $R^1 = OH, R^2 = \text{fatty acid carboxylate}$



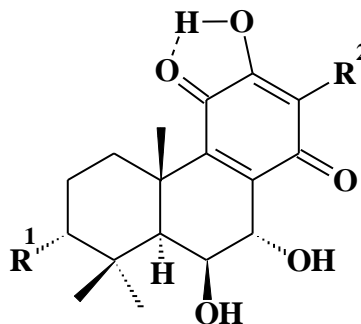
- D12;** $R = OH$
D13; $R = =O$
D14; $R = =O, 8\alpha, 9\alpha\text{-epoxide}$



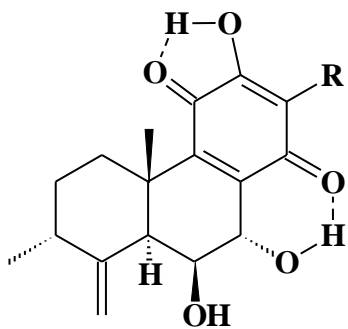
- D15;** $R = OH$
D16; $R = H$



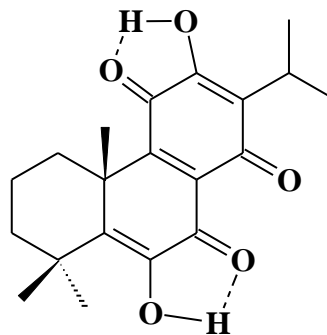
- D17;** $R^1 = H, R^2 = CH_2CH=CH_2$
D18; $R^1 = \alpha OCHO, R^2 = CH_2CH=CH_2$
D19; $R^1 = \beta OH, R^2 = CH_2CH=CH_2$
D20; $R^1 = \beta OH, R^2 = CH_2CH(OAc)CH_3$



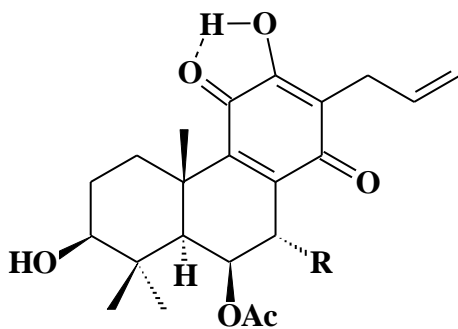
- D21;** $R^1 = H, R^2 = CH(CH_3)_2$
D22; $R^1 = OCHO, R^2 = \text{allyl}$



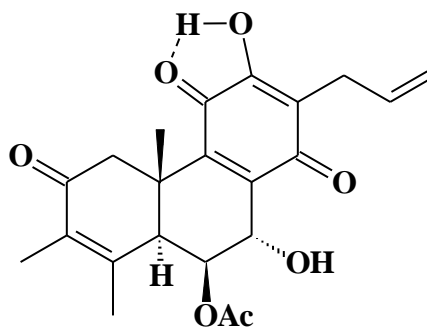
D23; R= allyl
D24; R= CH₂-CH(OH)CH₃



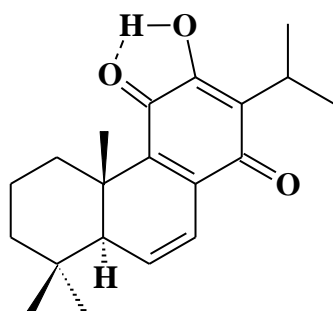
D25
D26; 8 α , 9 α -epoxide



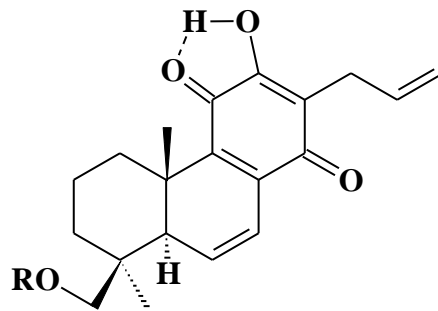
D27; R= H
D28; R= OH



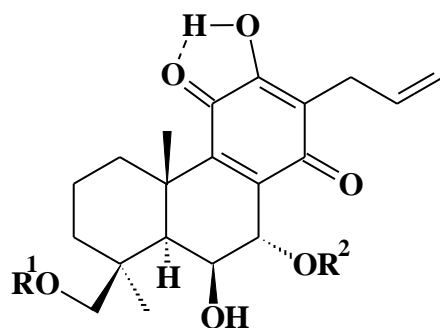
D29



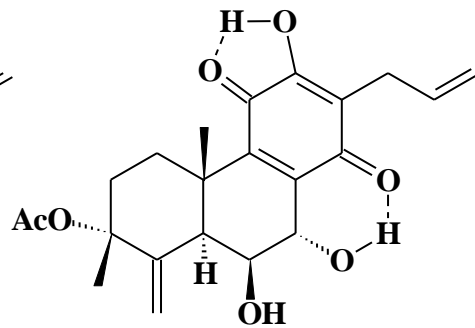
D30



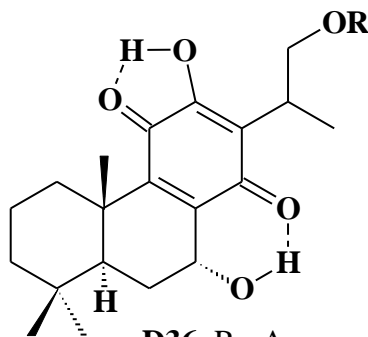
D31; R= H
D32; R= CHO



D33; $R^1 = \text{CHO}$, $R^2 = \text{H}$
D34; $R^1 = \text{H}$, $R^2 = \text{C}_2\text{H}_5$

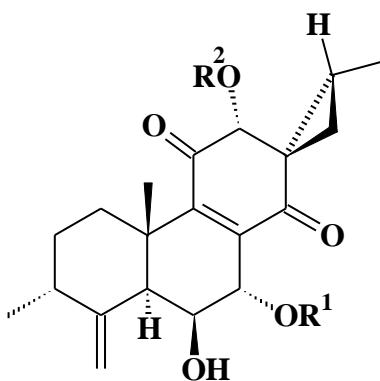


D35

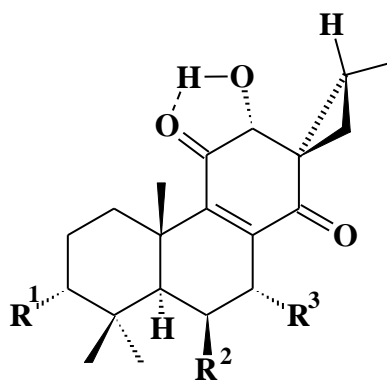


D36; $R = \text{Ac}$
D37; $R = \text{CH}_3$

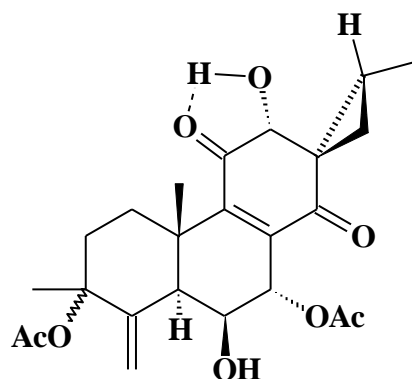
Spirocoleons



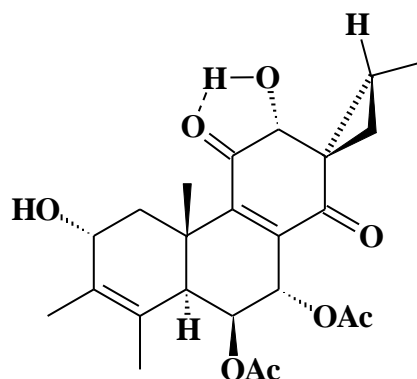
D38; $R^1 = R^2 = \text{Ac}$
D39; $R^1 = \text{CHO}$, $R^2 = \text{Ac}$
D40; $R^1 = \text{Ac}$, $R^2 = \text{H}$
D41; $R^1 = \text{H}$, $R^2 = \text{Ac}$
D42; $R^1 = \text{CHO}$, $R^2 = \text{H}$
D43; $R^1 = R^2 = \text{H}$



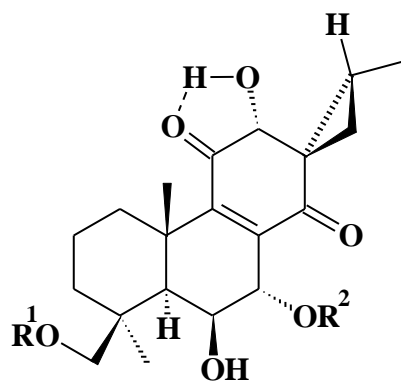
D44; $R^1 = \text{OCHO}$, $R^2 = \text{OAc}$, $R^3 = \text{OH}$
D45; $R^1 = \text{H}$, $R^2 = \text{OH}$, $R^3 = \text{OCHO}$
D46; $R^1 = \text{OCHO}$, $R^2 = \text{OH}$, $R^3 = \text{H}$
D47; $R^1 = \text{H}$, $R^2 = R^3 = \text{OH}$
D48; $R^1 = R^3 = \text{OCHO}$, $R^2 = \text{OH}$
D49; $R^1 = \text{H}$, $R^2 = \text{OH}$, $R^3 = \text{OAc}$



D50



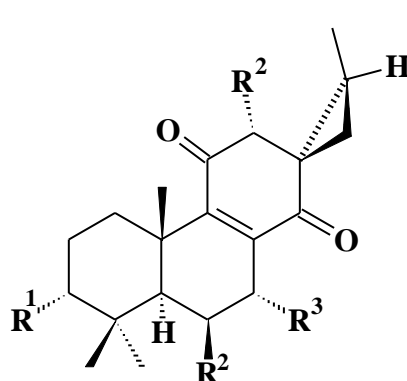
D51



D52; R¹ = H, R² = CHO

D53; R¹ = CHO, R² = H

D54; R¹ = R² = CHO



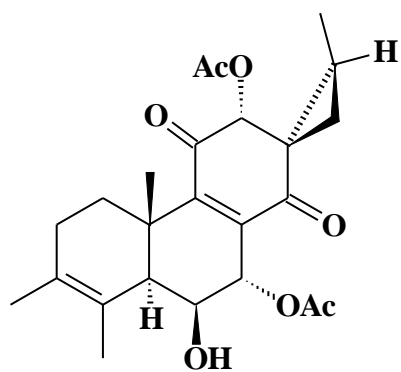
D55; R¹ = OCHO, R² = OAc, R³ = OH

D56; R¹ = R³ = OCOH, R² = OH

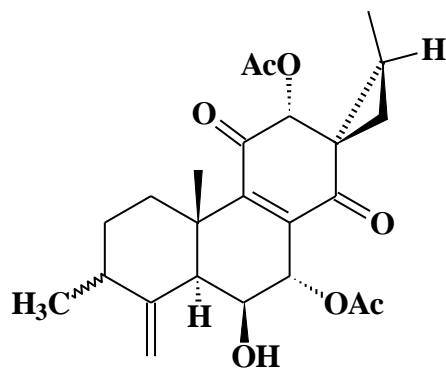
D57; R¹ = H, R² = OH, R³ = OAc

D58; R¹ = H, R² = OH, R³ = OCHO

D59; R¹ = R² = R³ = OAc

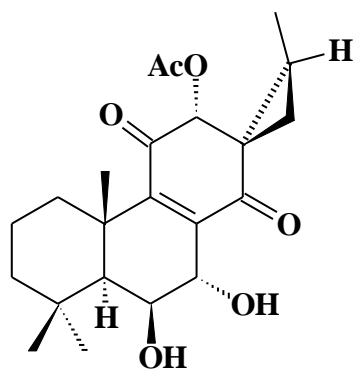


D60

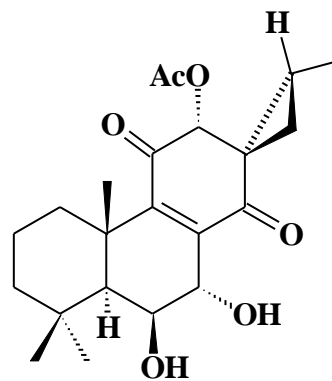


D61; α CH₃

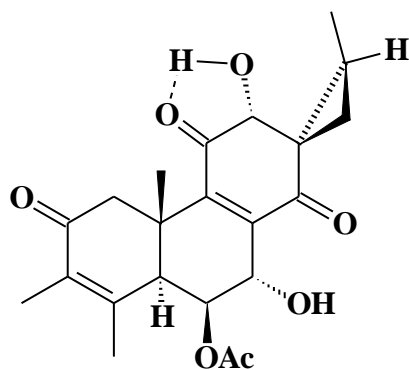
D62; β CH₃



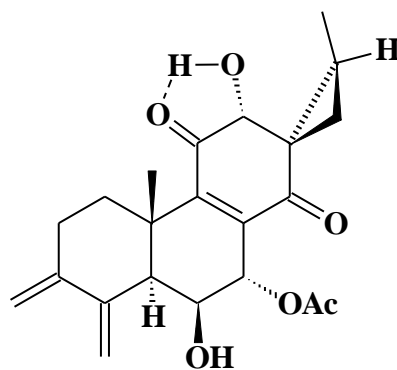
D63



D64

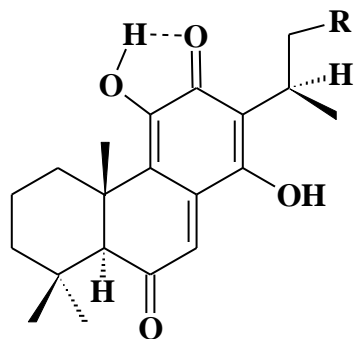


D65



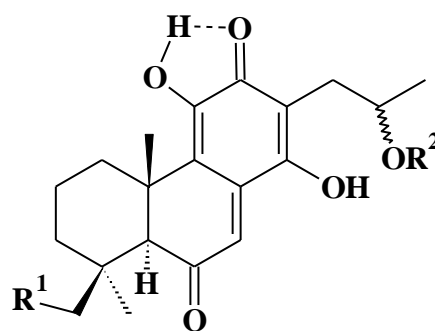
D66

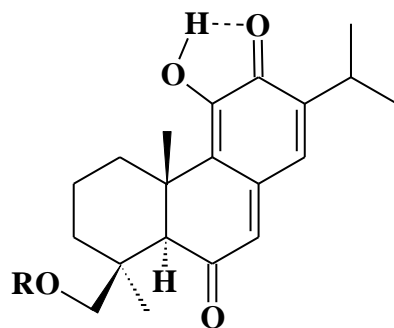
Vinylogous quinones



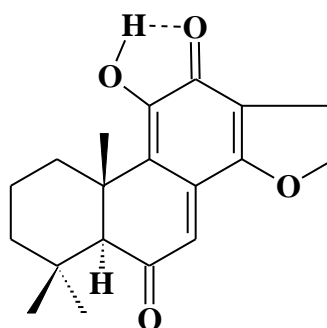
D67; R= OH

D68; R= H

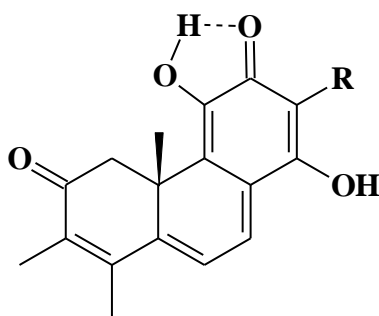
D69; R¹= H, R²= AcD70; R¹= R²= HD71; R¹= OCHO, R²= H



D72; R= COCH₂CH(CH₃)₂
D73; R= COCH=C(CH₃)₂

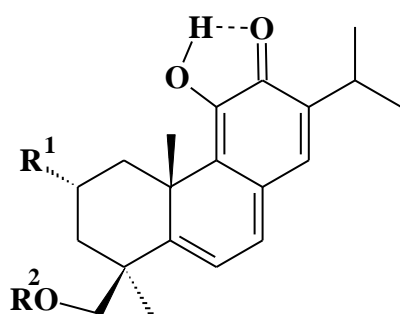


D74

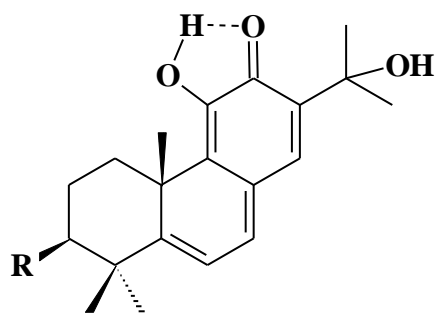


D75; R= CH₂CH=CH₂
D76; R= (S)-CH₂CH(OH)CH₃

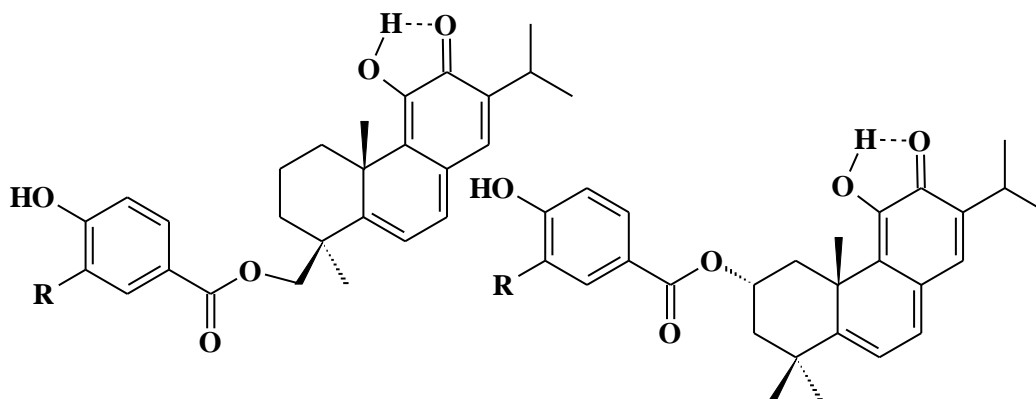
Quinone methides



D77; R¹= H, R²= COCH=C(CH₃)₂
D78; R¹= OH, R²= COCH=C(CH₃)₂
D79; R¹= H, R²= COCH₂CH(CH₃)₂

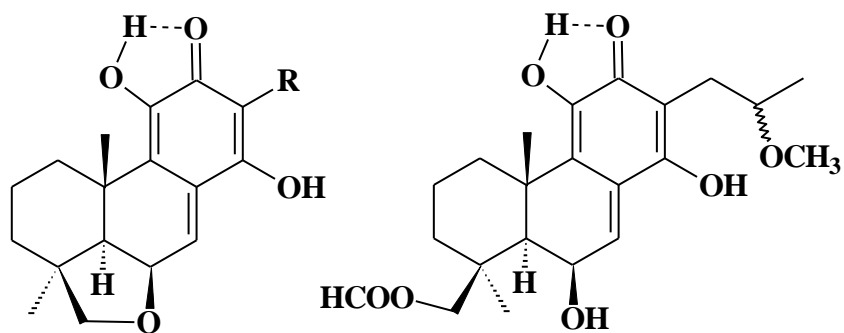


D80; R= H
D81; R= OAc



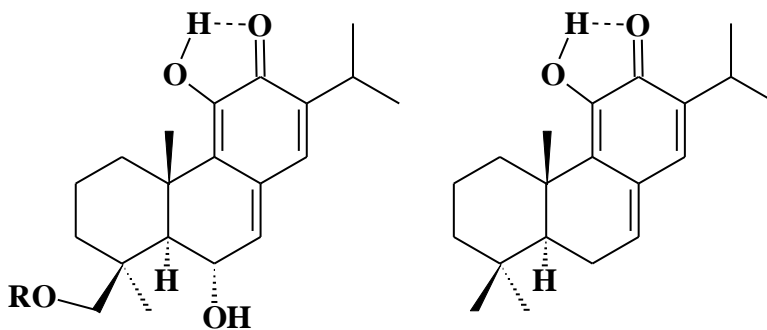
D82; R= H
D83; R= OH
D84; R= OCH₃

D85; R= H
D86; R= OH
D87; R= OCH₃



D88; R= CH₂CH=CH₂
D89; R= (S)-CH₂CH(OH)CH₃

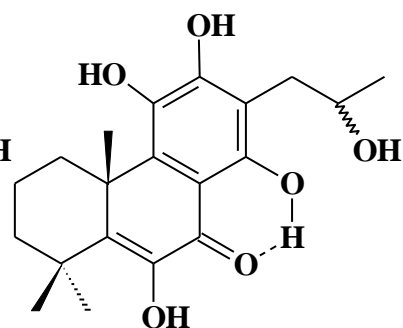
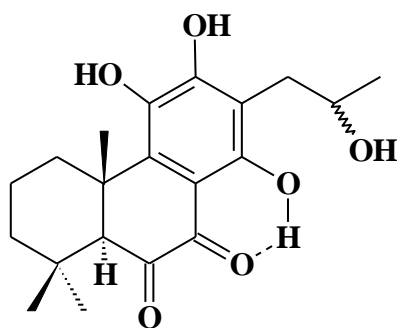
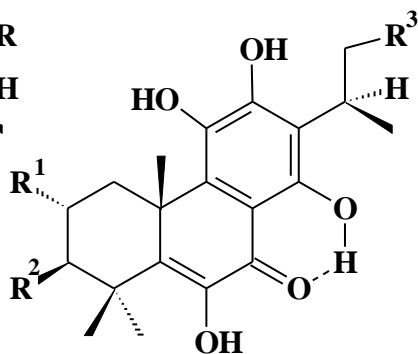
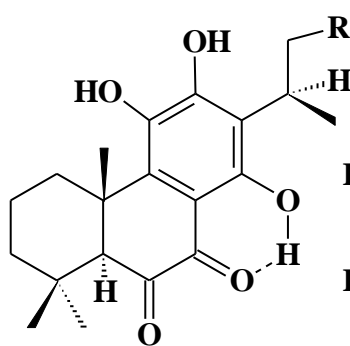
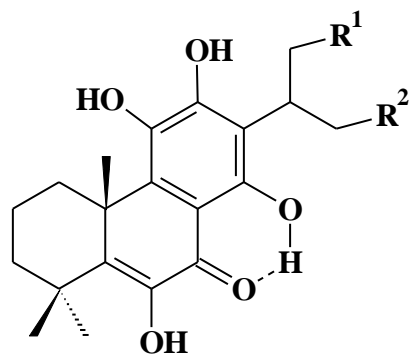
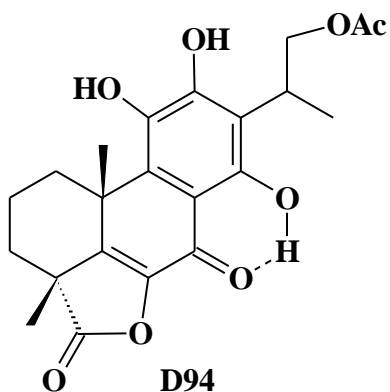
D90

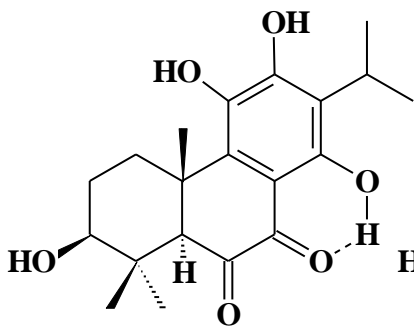


D91; R= COCH₂CH(CH₃)₂
D92; R= COCH=C(CH₃)₂

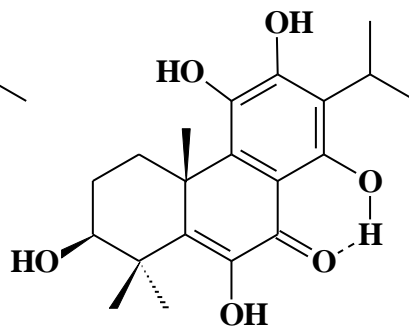
D93

Acylhydroquinones

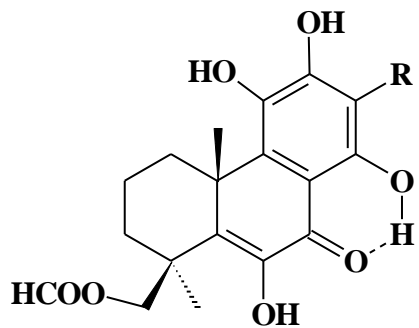




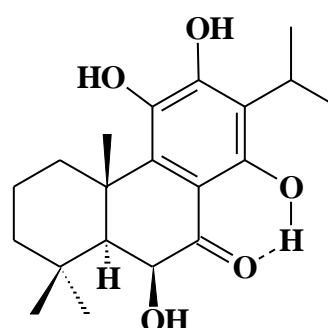
D108



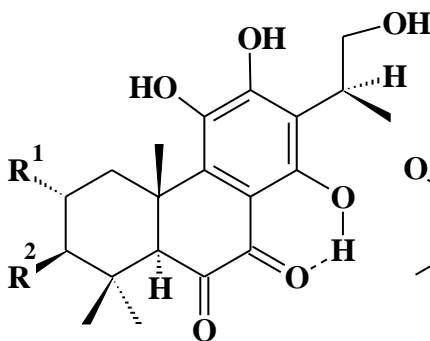
D109



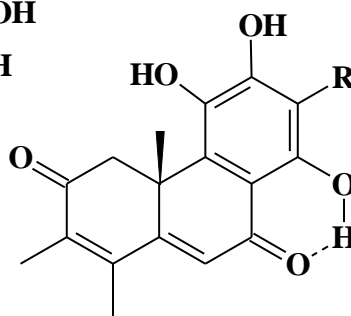
D110; R = CH₂CH=CH₂
D111; R = CH₂CH(OH)CH₃



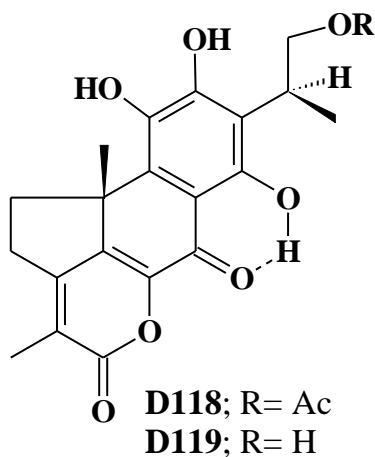
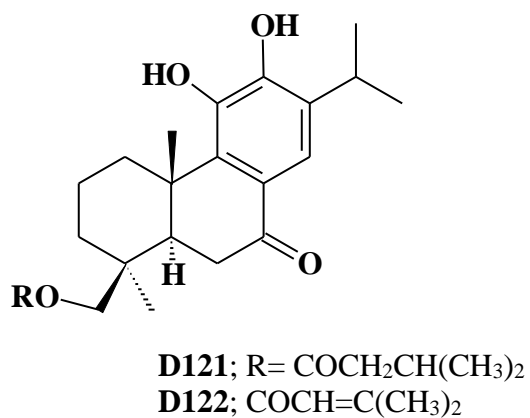
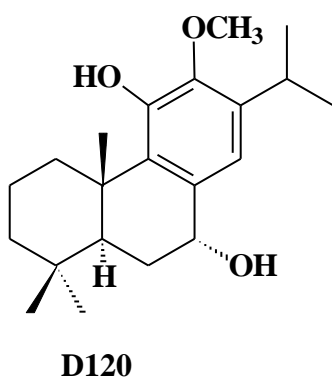
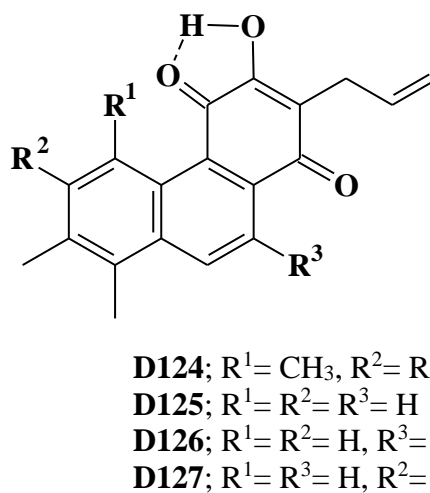
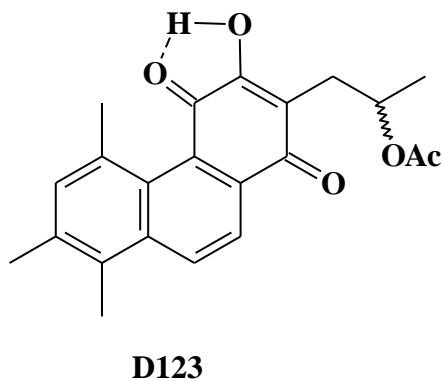
D112



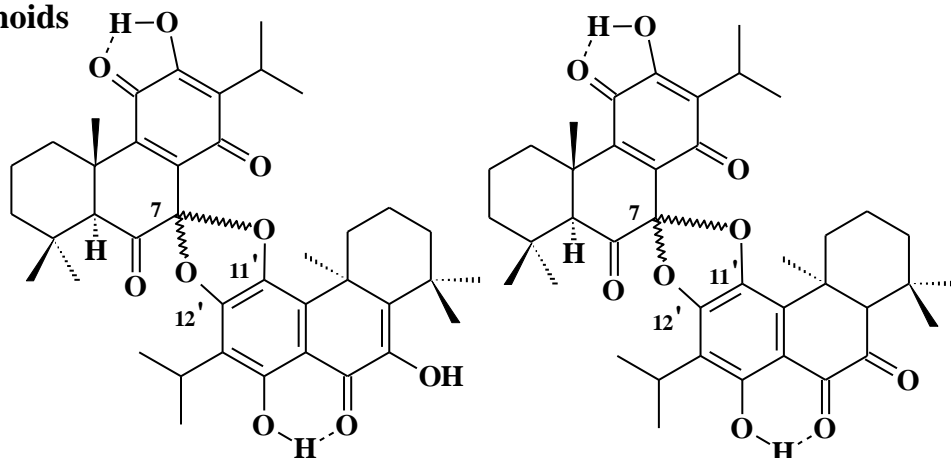
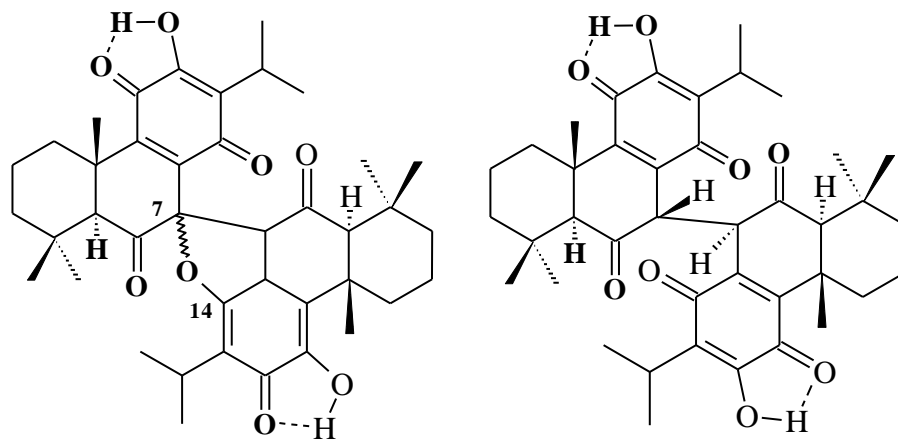
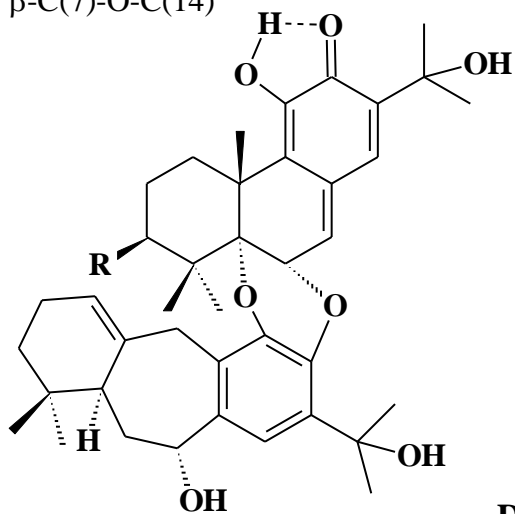
D113; R¹ = OAc, R² = H
D114; R¹ = H, R² = OAc



D115; R = CH₂CH=CH₂
D116; R = (S)-CH₂CH(OH)CH₃
D117; R = (R)-CH₂CH(OH)CH₃

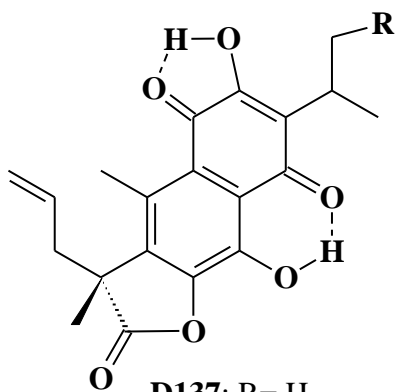
(4→3)abeo-Acylhydroquinones**Miscellaneous Phenolics****1,4-Phenanthraquinones**

Dimeric abietanoids

**D128**; β -C(7)-O-C(11')**D129**; β -C(7)-O-C(12')**D130**; β -C(7)-O-C(11')**D131**; β -C(7)-O-C(12')**D132**; α -C(7)-O-C(14)**D133**; β -C(7)-O-C(14)**D134****D135**; R= H**D136**; R= OAc

Seco-abietanoids

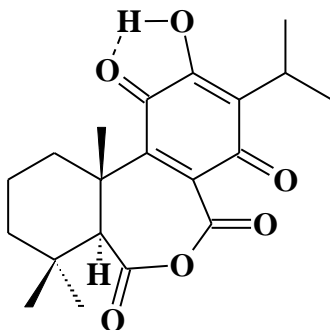
1,10-Seco-abietanoids



D137; R= H

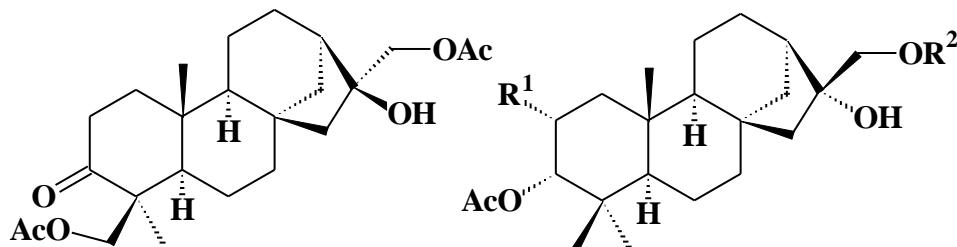
D138; R= OAc

6,7- Seco-abietanoids

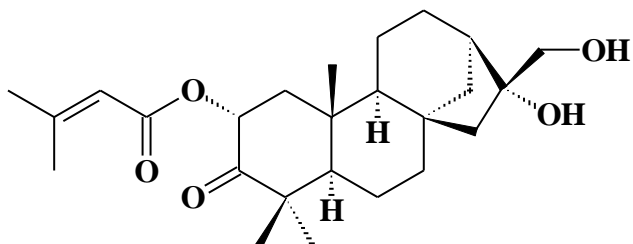


D139

Phyllocladanes

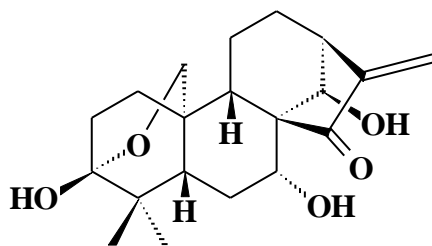


D140

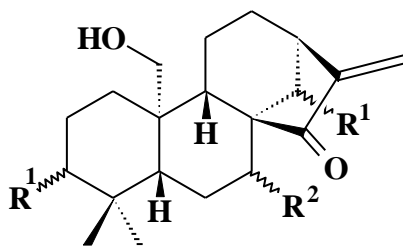
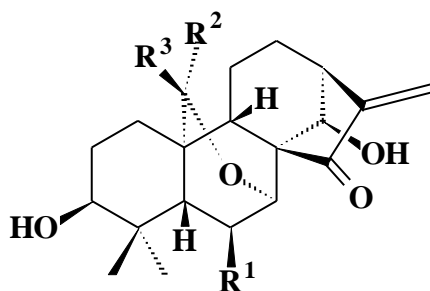
D141; R¹= OCOCH=C(CH₃)₂, R²= HD142; R¹= OCOCH=C(CH₃)₂, R²= AcD143; R¹= OCOCH₂CH(CH₃)₂, R²= HD144; R¹= OCOCH₂CH(CH₃)₂, R²= AcD145; R¹= R²= H

D146

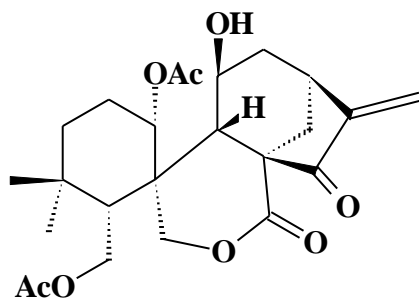
Ent-kaurenes



D147

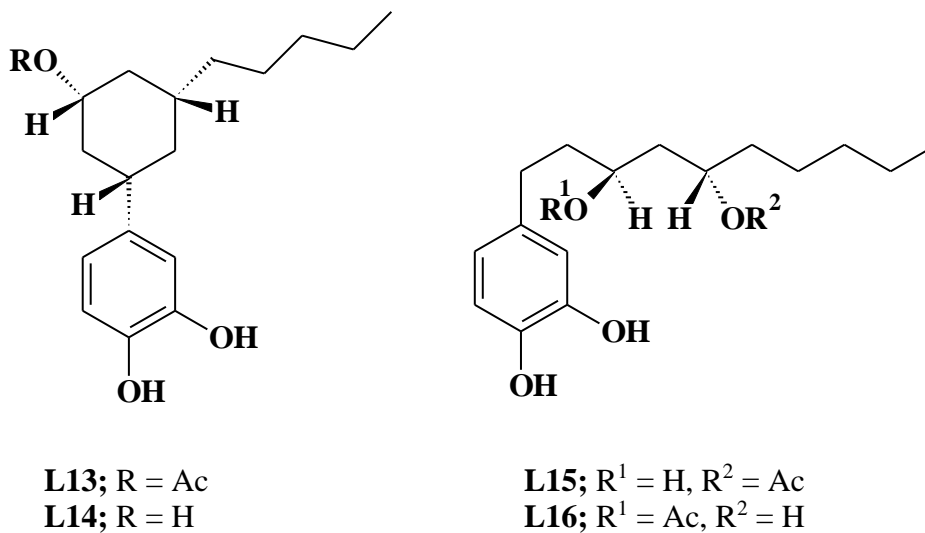
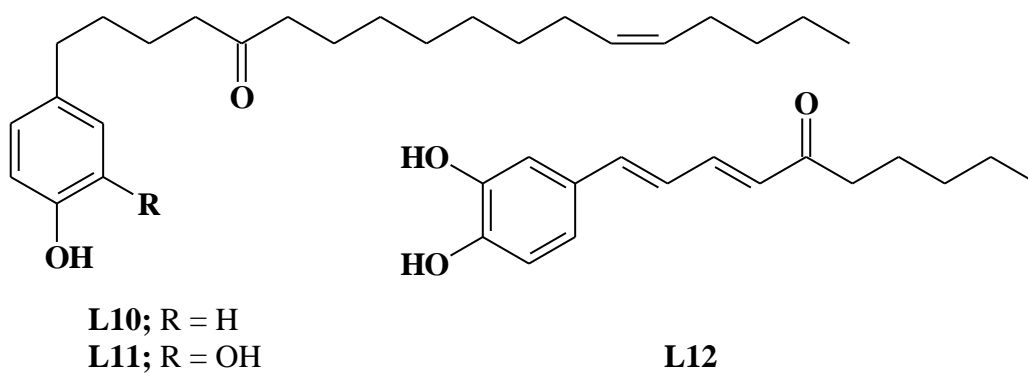
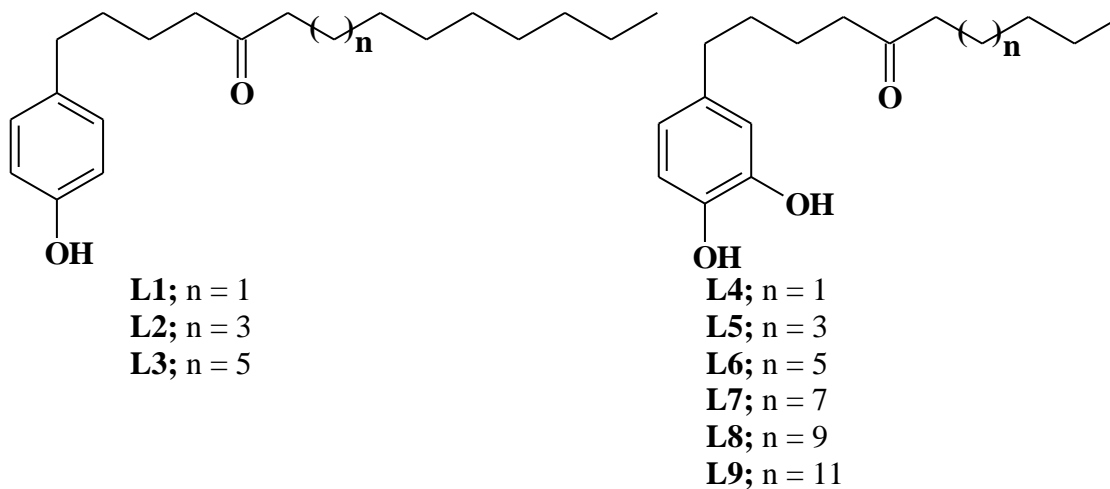
D148; R¹ = β OH, R² = α OHD149; R¹ = α OH, R² = β OHD150; R¹ = H, R² = OCH₃, R³ = HD151; R¹ = OH, R² = OCH₃, R³ = HD152; R¹ = H, R² = OC₂H₅, R³ = HD153; R¹ = R³ = H, R² = OHD154; R¹ = R² = H, R³ = OH

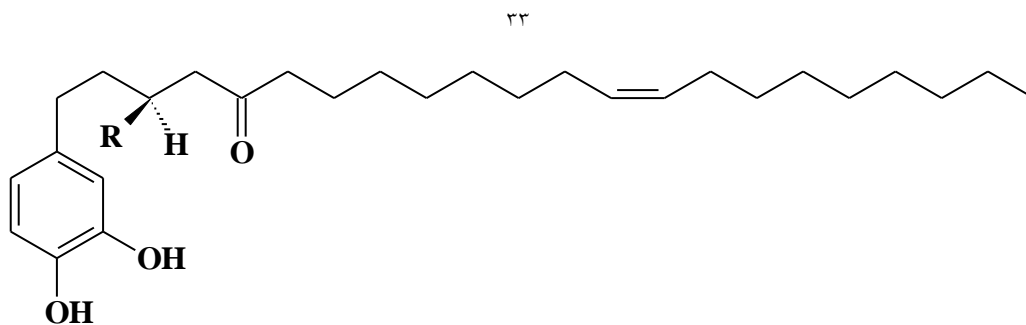
Seco-kaurenes



D155

Long-chain alkylphenols

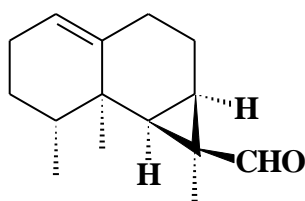




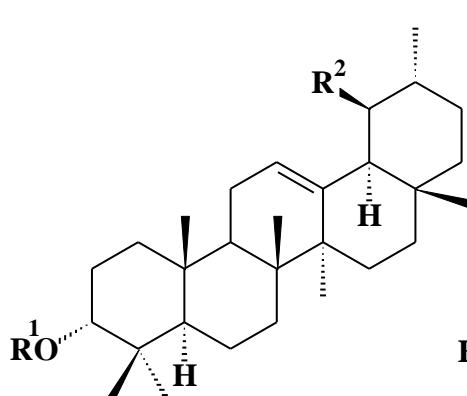
L17; R = OH

L18; R = H

Miscellaneous constituents



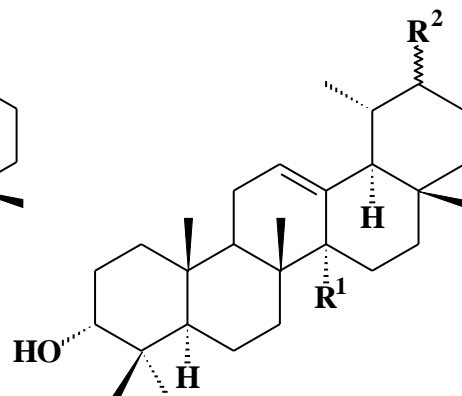
M1



M2 ;R¹ = H, R² = COOH

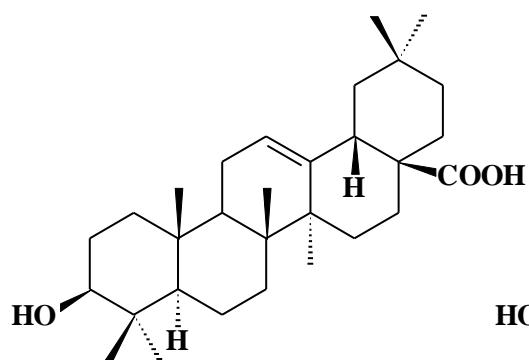
M3 ;R¹ = Ac, R² = COOH

M4 ;R¹ = H, R² = CH₂OH

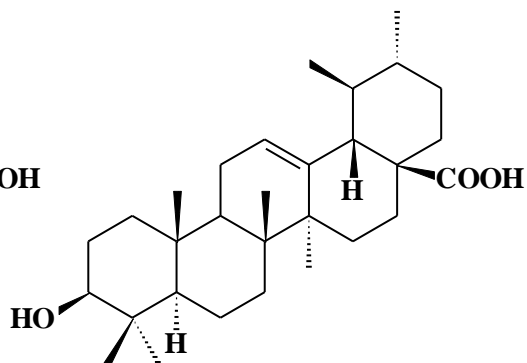


M5; R¹ = CH₃, R² = β COOH

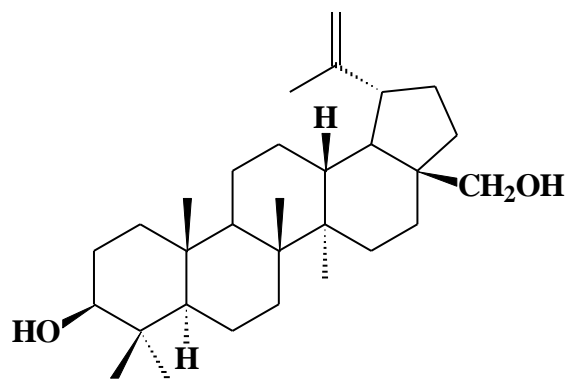
M6; R¹ = COOH, R² = α CH₃



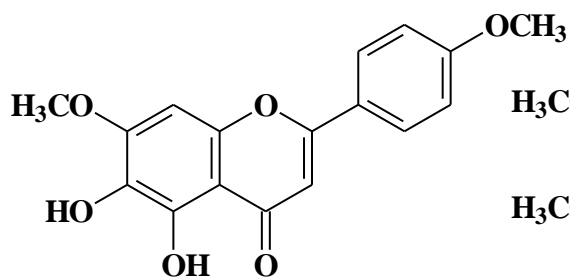
M7; oleanolic acid



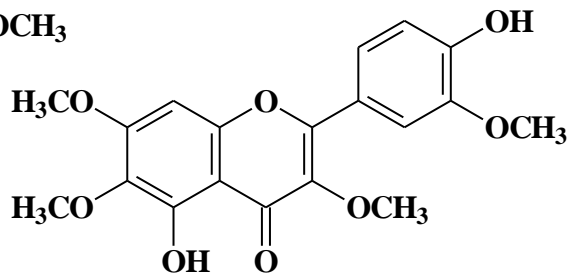
M8; ursolic acid



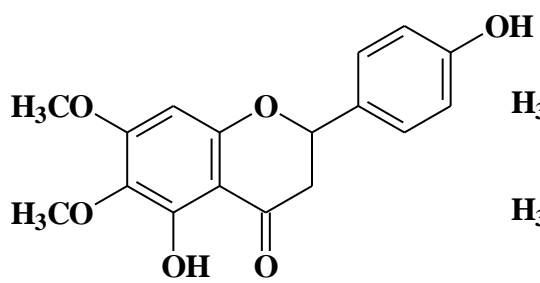
M9; betulin



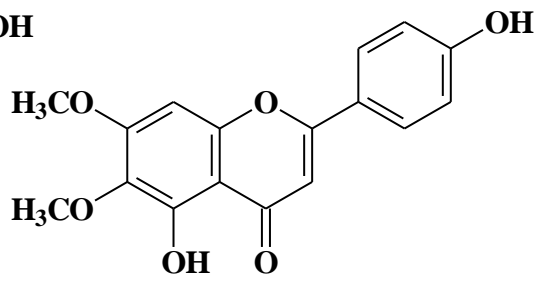
M10



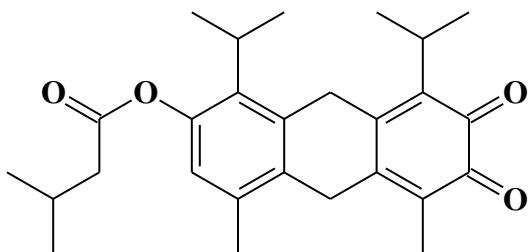
M11



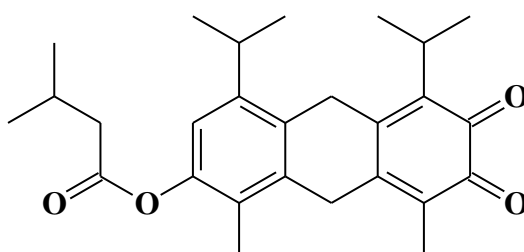
M12



M13



M14; ecklonoquinone A



M15; ecklonoquinone B