CHAPTER II

HISTORICAL

Taxa and Classification of *Chromolaena odorata* (L.) R. M. King & H. Rob.

Kingdom	: Plantae (Plants)
Subkingdom	: Tracheobionta (Vascular plants)
Superdivision	: Spermatophyta (Seed plants)
Division	: Magnoliophyta (Flowering plants)
Class	: Magnoliopsida (Dicotyledons)
Subclass	: Asteridae
Order	: Asterales
Family	: Asteraceae (Aster family)
Genus	: *Chromolaena* DC. (thoroughwort)
Species	: *Chromolaena odorata* (L.) R. M. King & H. Rob. (24)

Plant Synonyms : *Eupatorium odoratum* L. *Osmia odorata* (L.) Schultz-Bip. (24)

Common names : Siam weed, Christmas bush, Triffid weed, Devil weed, Bitter bush, Jack in the bush and Pesebrito (7-8, 24)

Chemistry of the Compounds from *Chromolaena* and *Eupatorium* spp.

1. *Chromolaena odorata* (L.) R. M. King & H. Rob.

Phytochemical studies of this plant have been investigated both on volatile and non-volatile components. The phytochemical differences of components in the exudate of the affected leaves and in the normal leaves have also been determined (25-26). Previous chemical analyses of non-volatile extracts have revealed

several classes of compounds including pyrrolizidine alkaloids (22), saturated alcohol, sterols (27), anisic acid (28), triterpenes (29), fatty acids (30) and flavonoids (25-26, 31-39). In addition, the volatile oils from this plant have been found to contain mostly monoterpenes and sesquiterpenes (12, 40-47). Among the various compounds isolated from this plant, flavonoids were found to be the most abundant class of chemical component and these are summarized in Table 2.1.

1.1 Flavonoids

Table 2.1 The flavonoids isolated from *C. odorata*

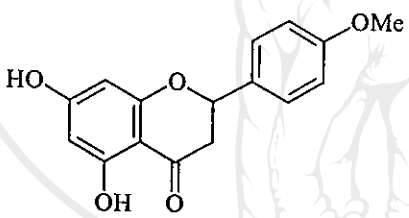
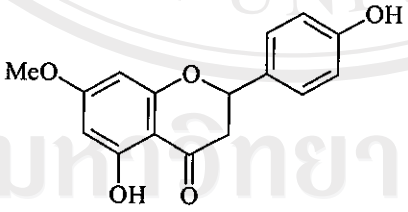
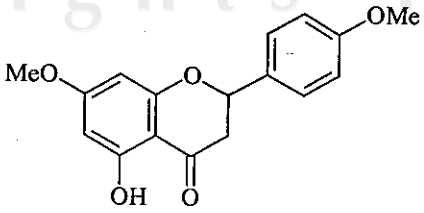
Groups	Compounds	Ref.
Flavanones	[1] isosakuranetin or naringenin-4′-OMe or 5,7-dihydroxy-4′-methoxyflavanone 	(11, 25, 31, 32, 36, 37, 39)
	[2] sakuranetin or naringenin-7-OMe or 5,4′-dihydroxy-7-methoxyflavanone 	(11, 25, 36)
	[3] naringenin-7,4′-dimethyl ether or 5-hydroxy-7,4′-dimethoxyflavanone 	(25, 35)

Table 2.1 (continued)

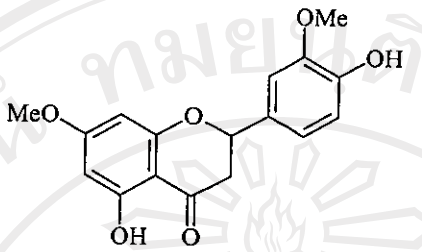
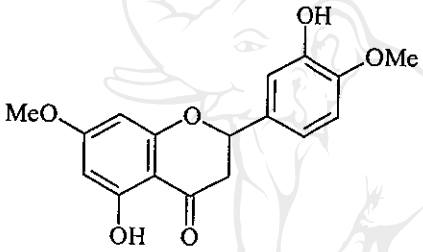
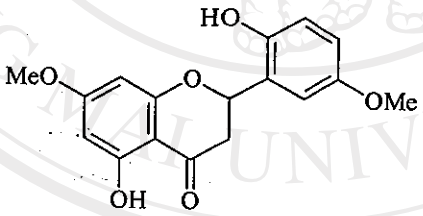
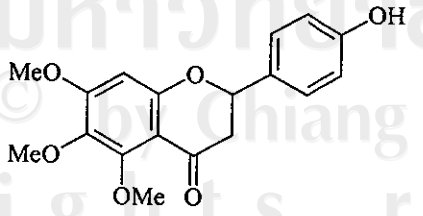
Groups	Compounds	Ref.
Flavanones	[4] 5,4′-dihydroxy-7,3′-dimethoxyflavanone 	(35)
	[5] persicogenin or eriodictyol-7,4′-diOMe or 5,3′-dihydroxy-7,4′-dimethoxyflavanone 	(25, 39)
	[6] 5,2′-dihydroxy-7,5′-dimethoxyflavanone 	(38)
	[7] 4′-hydroxy-5,6,7-trimethoxyflavanone 	(34, 37, 39)

Table 2.1 (continued)

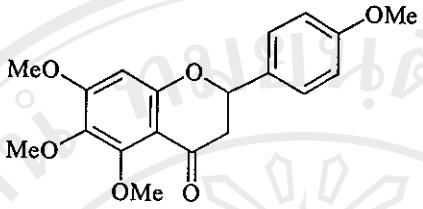
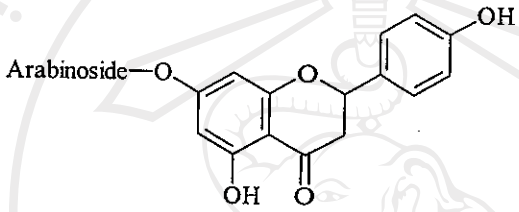
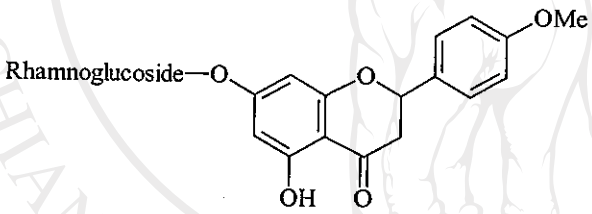
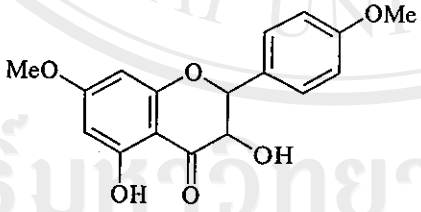
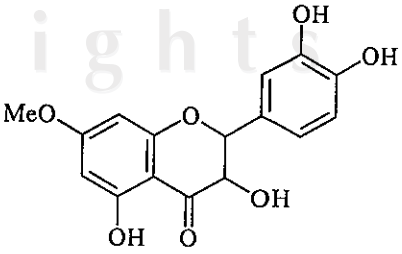
Groups	Compounds	Ref.
Flavanones	[8] 5,6,7,4′-tetramethoxyflavanone 	(37, 39)
	[9] sakuranetin-7-O-arabinoside 	(11)
	[10] isosakuranetin-rhamnoglucoside 	1.11
Flavanonols	[11] aromadendrin-7,4′-dimethyl ether or 5-hydroxy-7,4′-dimethoxyflavanonol 	2.2 (mixtures)
	[12] taxifolin-7-methyl ether or padmatin or 5,3′,4′-trihydroxy-7-methoxyflavanonol 	2.2

Table 2.1 (continued)

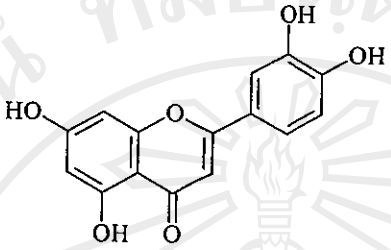
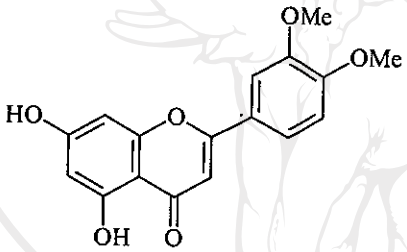
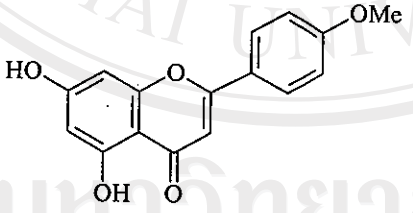
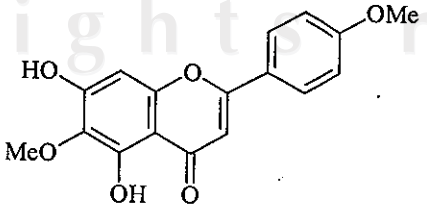
Groups	Compounds	Ref.
Flavones	[13] luteolin or 5,7, 3′,4′-tetrahydroxyflavone 	(39)
	[14] luteolin-3′,4′-dimethyl ether or 5,7-dihydroxy-3′,4′-dimethoxyflavone 	(25)
	[15] acacetin, apigenin-4′-OMe, linarigenin or 5,7-dihydroxy-4′-methoxyflavone 	(25, 32, 39)
	[16] scutellarein-6,4′-dimthyl ether or 5,7-dihydroxy-6,4′-dimethoxyflavone 	(25)

Table 2.1 (continued)

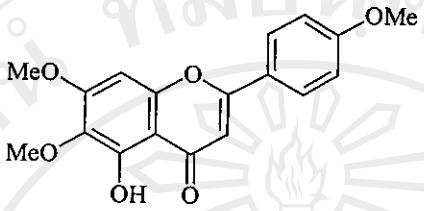
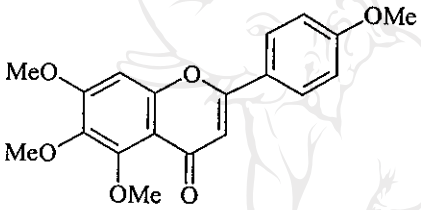
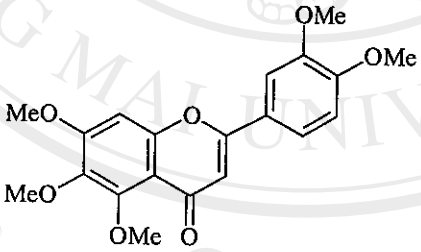
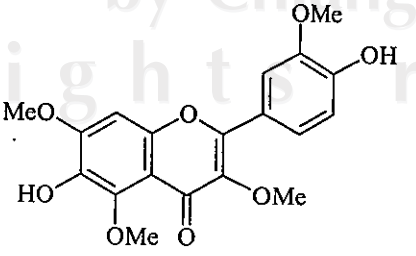
Groups	Compounds	Ref.
Flavones	[17] salvigenin or scutellarein-6,7,4′-triOMe or 5-hydroxy-6,7,4′-trimethoxyflavone 	(33)
	[18] scutellarein-5,6,7,4′-tetramethyl ether or 5,6,7,4′-tetramethoxyflavone 	(25, 34)
	[19] sinensetin or 5,6,7,3′,4′-pentamethoxyflavone 	(25, 34)
	[20] quercetagetin-3,5,7,3′-tetramethyl ether or 6,4′-dihydroxy-3,5,7,3′-tetramethoxyflavone 	(11)

Table 2.1 (continued)

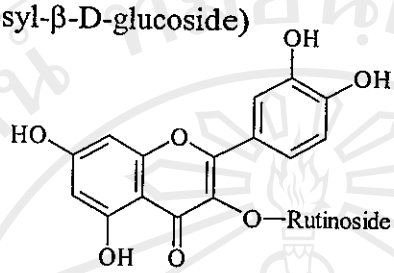
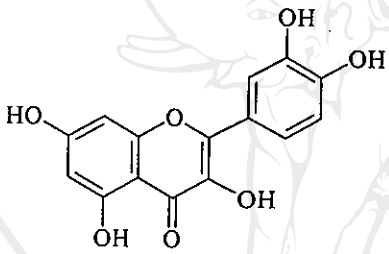
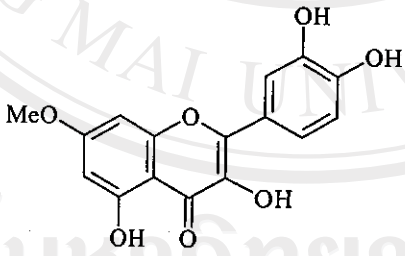
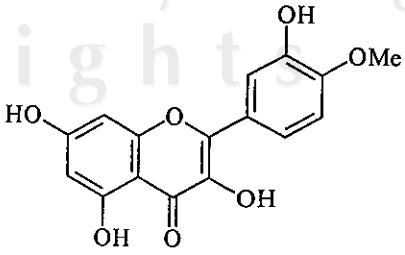
Groups	Compounds	Ref.
Flavones	[21] rutin or quercetin 3-O-β-rutinoside or 5,7,3′,4′-tetrahydroxyflavone-3-(6-O-α-L-rhamnosyl-β-D-glucoside) 	(25)
Flavonols	[22] quercetin or 5,7,3′,4′-tetrahydroxyflavonol 	(11, 25)
	[23] rhamnetin or quercetin-7-OMe or 5,3′,4′-trihydroxy-7-methoxyflavonol 	(25)
	[24] tamarixetin or quercetin-4′-OMe or 5,7,3′-trihydroxy-4′-methoxyflavonol 	(25, 36)

Table 2.1 (continued)

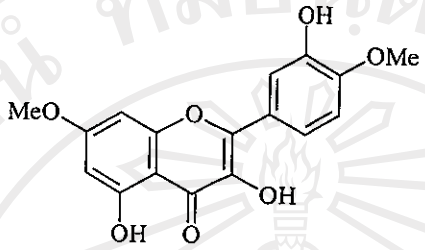
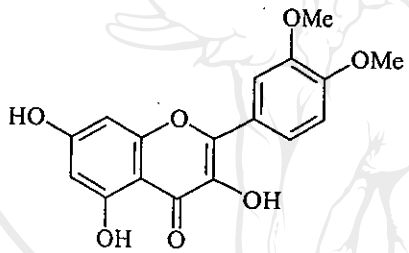
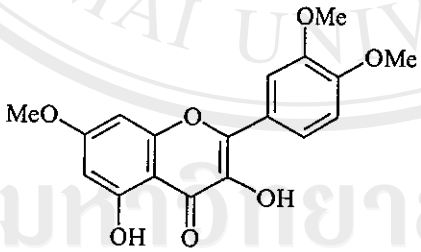
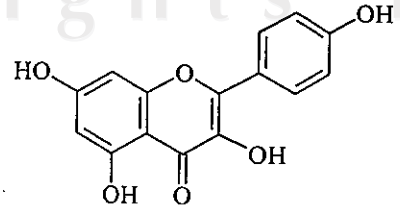
Groups	Compounds	Ref.
Flavonols	[25] ombuin or quercetin-7,4′-diOMe or 5,3′-dihydroxy-7,4′-dimethoxyflavonol 	(25)
	[26] quercetin-3′,4′-dimethyl ether or 5,7-dihydroxy-3′,4′-dimethoxyflavonol 	(25)
	[27] quercetin-7,3′,4′-trimethyl ether or 5-hydroxy-7,3′,4′-trimethoxyflavonol 	(25)
	[28] kaempferol or 5,7,4′-trihydroxyflavonol 	(25)

Table 2.1 (continued)

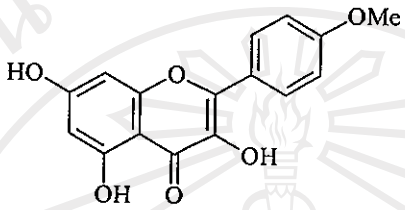
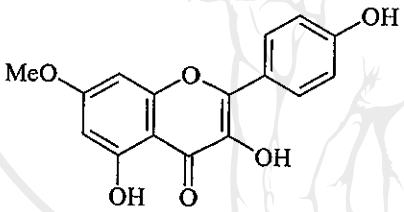
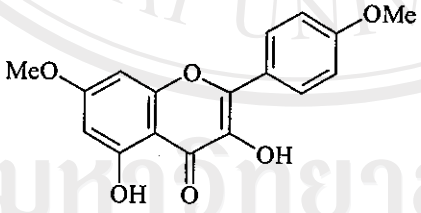
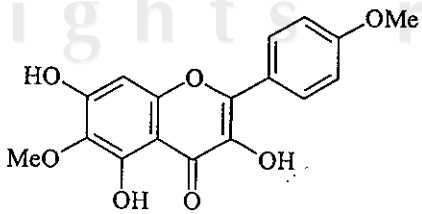
Groups	Compounds	Ref.
Flavonols	[29] kaempferide or kaempferol-4′-methyl ether or 5,7-dihydroxy-4′-methoxyflavonol 	(11, 25, 36)
	[30] rhamnocitrin or kaempferol-7-methyl ether or 5,4′-dihydroxy-7-methoxyflavonol 	(25)
	[31] kaempferol-7,4′-dimethyl ether or 5-hydroxy-7,4′-dimethoxyflavonol 	(25)
	[32] betuletol or 5,7-dihydroxy-6,4′-dimethoxyflavonol 	(11)

Table 2.1 (continued)

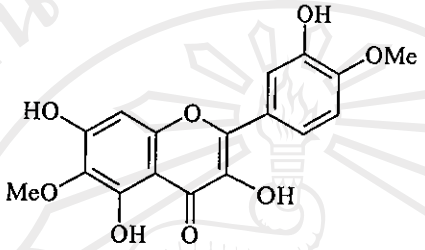
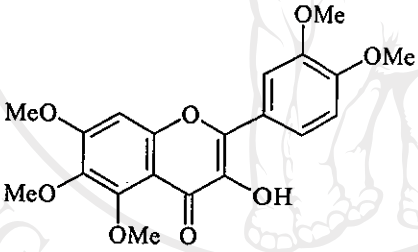
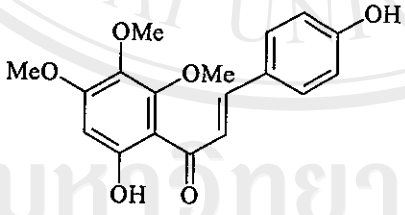
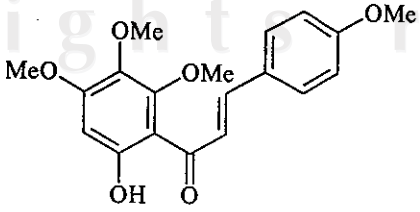
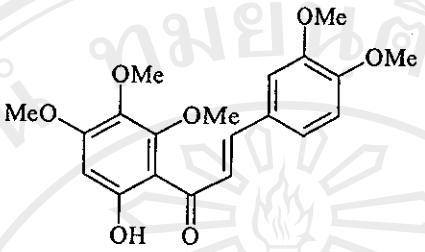
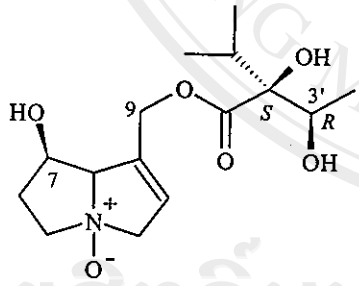
Groups	Compounds	Ref.
Flavonols	[33] laciniatin or quercetagetin-6,4′-dimethyl ether or 5,7,3′-trihydroxy-6,4′-dimethoxyflavonol 	(25)
	[34] marionol or quercetagetin-5,6,7,3′,4′-pentamethyl ether or 5,6,7,3′,4′-pentamethoxyflavonol 	(26)
Chalcones	[35] 2′,4-dihydroxy-4′,5′,6′-trimethoxychalcone 	(25, 34, 37, 39)
	[36] odoratin or 2′-hydroxy-4,4′,5′,6′-tetramethoxychalcone 	(25, 31-32, 34-35, 37, 39)

Table 2.1 (continued)

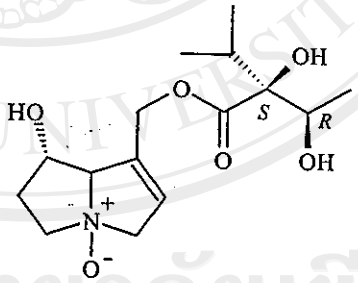
Groups	Compounds	Ref.
Chalcones	[37] 2′-hydroxy-3,4,4′,5′,6′-pentamethoxy chalcone 	(25, 34)

1.2 Pyrrolizidine alkaloids

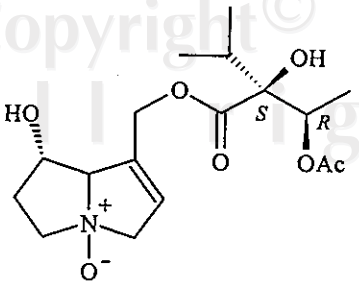
C. odorata contained the *N*-oxides of five pyrrolizidine alkaloids including intermedine [38], rinderine [39], 3′-acetylrinderine [40], 7-angeloyl retronecine [41] and 9-angeloylretronecine [42]. Highest concentrations occurred in roots and mature flower heads, while leaves and stems were almost devoid of alkaloids, and no alkaloid was present in nectar (22).



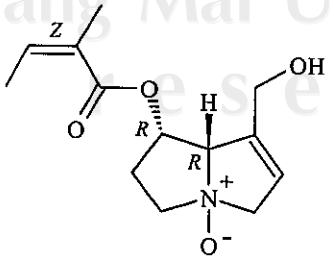
[38] Intermedine



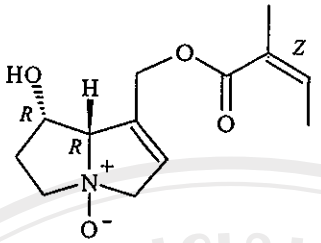
[39] Rinderine



[40] 3′-Acetylrinderine



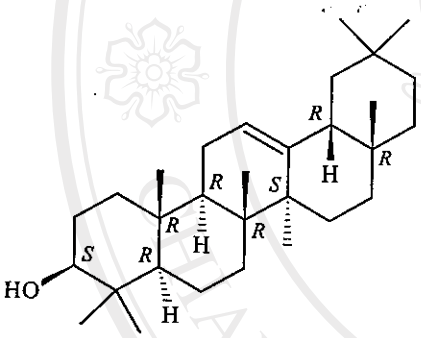
[41] 7-Angeloylretronecine



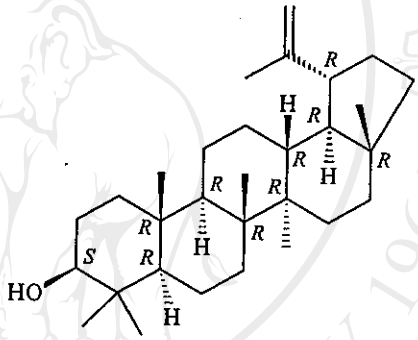
[42] 9-Angeloylretronecine

1.3 Triterpenoids

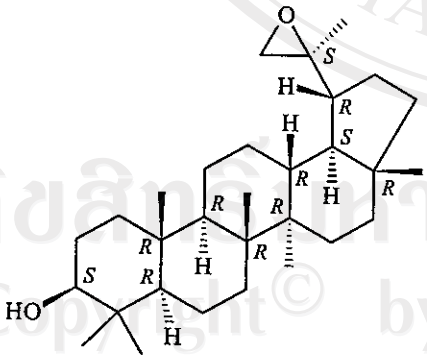
Only three triterpenoids have been reported as chemical constituents of *C. odorata* including β-amyrin [43], lupeol [44] (11, 33) and epoxylupeol [45] (29).



[43] β-Amyrin



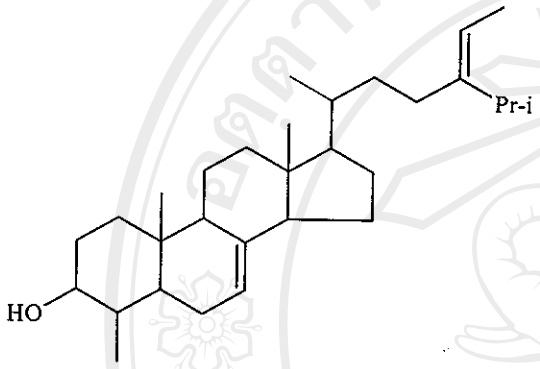
[44] Lupeol



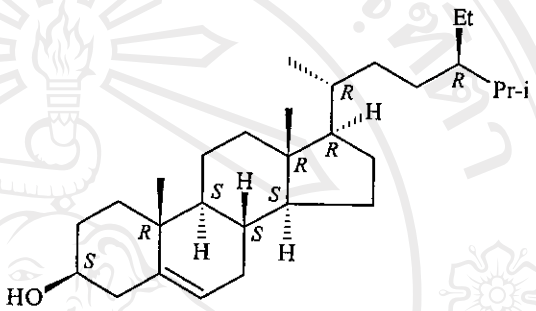
[45] Epoxylupeol

1.4 Sterols

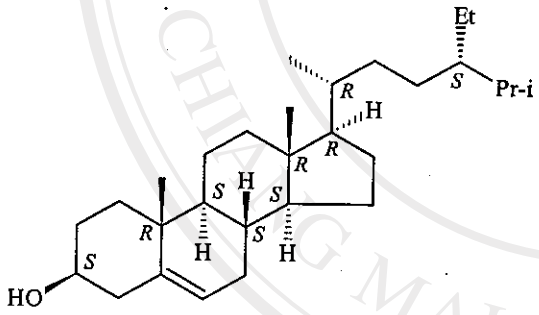
Exhaustive percolation of the green mature leaves of *C. odorata* with rectified spirit gave a light green extract. After concentration, the deep green gummy mass was triturated with petroleum ether, benzene and chloroform. The benzene fraction gave a coloured crystalline mass which contained α-sitosterol [46] (mp 160-163 °C), β-sitosterol [47] (mp 135-137 °C) and γ-sitosterol [48] (mp 146-148 °C) (27).



[46] α-Sitosterol



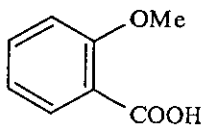
[47] β-Sitosterol



[49] γ-Sitosterol

1.5 Miscellaneous compounds

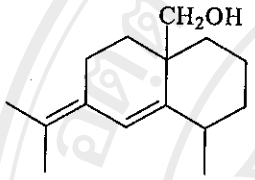
Ceryl alcohol (mp 80 °C) and anisic acid [50] (mp 182-183 °C) were obtained from the rectified spirit extract of *C. odorata* leaves (27-28). The chemical investigation of *C. odorata* flowers revealed the presence of fatty acids mainly myristic, palmitic, linoleic and linolenic acids (30).



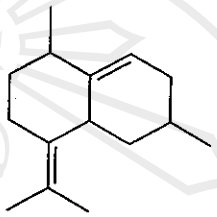
[50] Anisic acid

1.6 The volatile components

The volatile oil of *C. odorata* was investigated in 1956 by Dhingra, Dhingra, and Bhattacharyya and three sesquitepenes were isolated from the oils obtained by steam distillation including eupatol [51], *d*-eupatene and *l*-eupatene [52] (40-41). The studies of other volatile oil constituents of *C. odorata* are summarized in Table 2.2.



[51] Eupatol



[52] *d* and *l*-eupatene

Table 2.2 The chemical compositions of the essential oils of *C. odorata*.

Compound name	Percentage of components from listed literature (references)									
	(12)	(40)	(41)	(42)	(43)[A]	(43)[B]	(44)	(45)	(46)[C]	(47)
(+)-camphor	15.46									
(*E*)-β-ocimene					5.2		0.5	3.7		3.39
Σ-muurolene								0.9		
(*Z*)-β-ocimene					0.8		0.5		1.3	0.95
1-hexenol								2.5		0.1
2-hexenol (*E*)								4.5		
3-hexenol (*Z*)								2.3		
4-terpineol					0.3	0.1	0.2	0.5	0.4	0.39
5-phenylpentan-2-one										0.1
5-phenylpentan-3-one										0.18
bicyclogermacrene					1.1	0.3				0.93
Bornyl acetate							3.5			
Cadinene	19.09									
Cadinol isomer	6.36								4.7	0.22
Calamenene									0.8	
Carvacryl acetate						1.3				
Caryophyllene oxide					0.1	0.9				0.06
Carvacrol						0.2				
Citronellal	0.40									

Table 2.2 (continued)

Compound name	Percentage of components from listed literature (references)									
	(12)	(40)	(41)	(42)	(43)[A]	(43)[B]	(44)	(45)	(46)[C]	(47)
Cubenol										0.15
d-eupatene			/	/						
Elemol							2.0	1.0		0.42
Epicubenol										0.20
epi-geijerene (*cis*)										0.95
Eupatol		/		/						
Geijerene					9.0	4.2	42.5	4.7	7.8	11.68
Geijerene isomer							4.9		1.3	
Geranial					0.3	0.8				
Geraniol	0.40									
Germacrene B							1.3		1.8	
Germacrene D								8.2		9.50
Globulol									0.3	
Hexenal								2.7		
Isogeijerene C										0.10
l-eupatene			/	/						
Limonene	10.22			/	1.4	1.7	0.5	1.4	1.0	1.14
Linalol										0.3
Muurol-5-en-4-β-ol										0.14
Muurol-5-en-4-α-ol										0.13
Myrcene					2.4	0.2	0.9	2.3	0.8	2.36
Neral						0.7				
p-cymene	1.59					22.2				0.10
Pregeijerene					25.1	14.8		14.3		19.61
Sabinene					1.2	1.4	0.6			1.76
Spathulenol									1.8	
Terpinolene					0.1					0.10
Thymol						0.9				
Thymyl acetate						15.8				
Unknown	1.14						5.7		5.8	
Unknown	0.68								2.7	
Unknown									4.0	
Unknown									1.9	
Unknown									0.9	
Viridiflorol							0.2			
α-cadinol							0.6	0.6	2.6	0.28
α-copaene					1.4	1.1	1.0	2.3	2.1	0.90
α-elemene								0.5		

Table 2.2 (continued)

Compound name	Percentage of components from listed literature (references)									
	(12)	(40)	(41)	(42)	(43)[A]	(43)[B]	(44)	(45)	(46)[C]	(47)
α-eudesmol										0.10
α-humulene					1.2	1.6	1.9	1.6	2.6	1.04
α-ionone							0.9			
α-pinene	19.32			/	14.3	8.5	2.6	18.8	18.8	21.15
α-terpinene										0.13
α-terpineol					0.1					
β-bourbonene							0.2			
β-caryophyllene	7.05				4.3	9.8	7.4	6.5	10.2	3.45
β-cubebene							12.5		13.0	
β-elemene							1.4			
β-eudesmol								0.6		0.10
β-phellandrene								0.7		0.13
β-pinene					8.0	5.9	2.6	10.5	7.2	10.12
δ-cadinene					1.6	0.5	2.1	3.8	3.4	1.68
δ-cadinol (torreyol)							0.2		2.1	0.22
δ-elemene							0.4		0.7	0.35
γ-cadinene					0.1	0.8		0.3	0.7	
γ-elemene								1.3		
γ-eudesmol								0.3		0.12
γ-muurolene					9.8	1.7			1.9	0.31
γ-terpinene					0.2		0.1			0.15

A –the sample was collected in Cameroon
B –the sample was collected in the Congo
C –the essential oil was obtained from the flowers, others were obtained from the leaf

2. Other *Chromolaena* or *Eupatorium* spp.

Because several species in the genus *Eupatorium* have been placed with the genus *Chromolaena*, this review also includes the literature on phytochemical work on the genus *Eupatorium*. According to the literature, several types of compounds were isolated and these are arranged by the year of publication as follows in Table 2.3.

Table 2.3 Chemical constituents of plants of the genera *Chromolaena* and *Eupatorium*

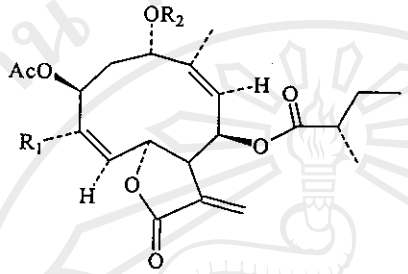
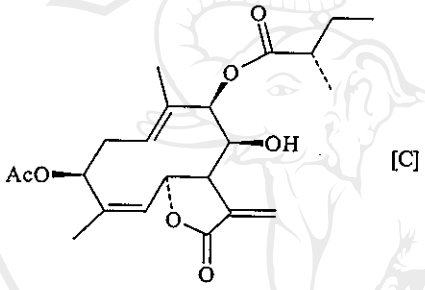
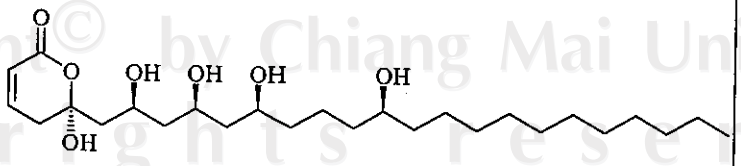
Year	Species	Compound name	Ref.
1978	*E. recurvans*	*Eurecurvin [A] *Heliangolides [B-C]  [A] : $R_1 = CH_2OH$; $R_2 = H$ [B] : $R_1 = CH_3$; $R_2 = H$  [C]	(48)
1978	*E. pilosum*	*δ-lactones of *Z*-5(*R*),7,9,11-tetrahydroxy hexacos-2-enoic acid  *δ-lactones of *Z*-5(*R*),7,9,11,15-pentahydroxy hexacos-2-enoic acid  *salvigenin *cirsimaritin	(49)

Table 2.3 (continued)

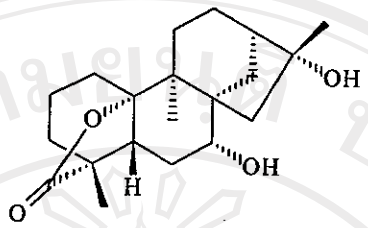
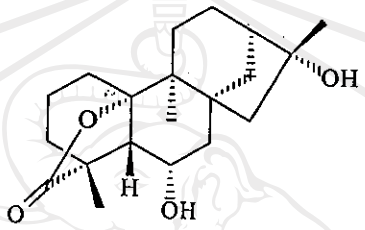
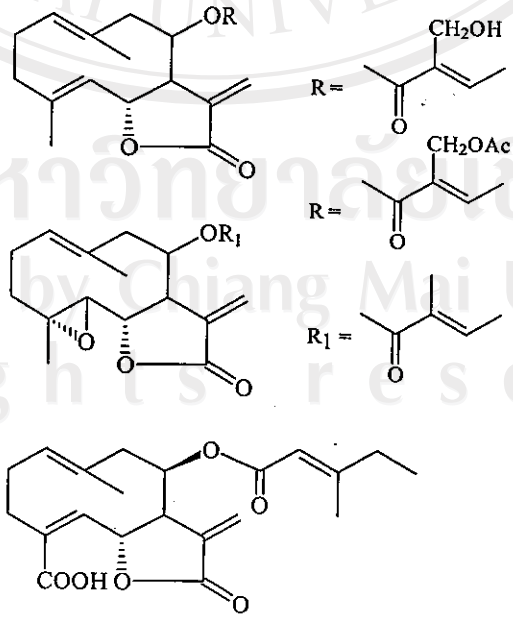
Year	Species	Compound name	Ref.
1979	*E. album*	Tetracyclic diterpenoids *Eupatalbin or *ent*-7β-hydroxy-9,10-friedokauran-19,10β-olide  *Eupatoralbin or *ent*-6β-hydroxy-9,10-friedokauran-19,10β-olide 	(50)
1979	*E. coelestinum*	*Coumarin *Nobiletin *Lucidin dimethyl ether *5,6,7,3′,4′-pentamethoxyflavone *5,6,7,8,3′,4′,5′-heptamethoxyflavone *5,6,7,8,5′-pentamethoxy-3′,4′-methylenedioxyflavone	(51)
1979	*E. serotinum*	*germacranolides [A-D] 	(52)

Table 2.3 (continued)

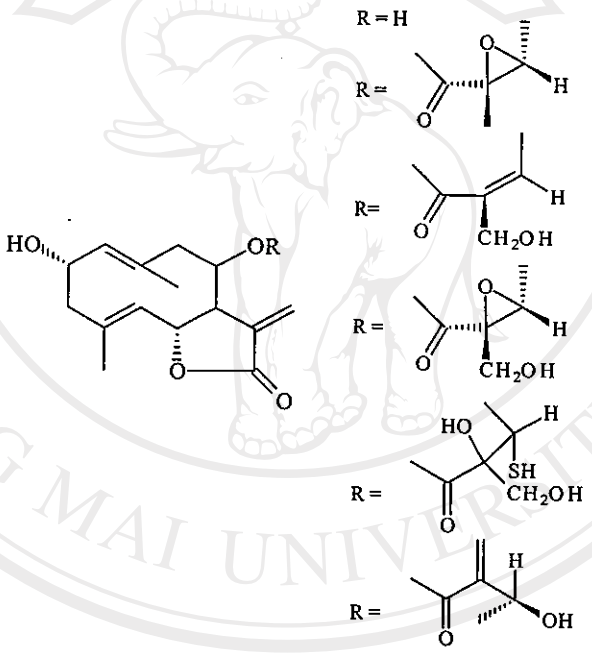
Year	Species	Compound name	Ref.
1979	*E. serotinum*	*Pectolinarigenin or 5,7-dihydroxy-6,4′-dimethoxyflavone *Hispidulin or 5,7,4′-trihydroxy-6-methoxyflavone	(52)
1979	*E. sessilifolium*	*new germacranolide, new guaianolides	(53)
1979	*E. villosum*	*Evillosin (Labdane diterpenoid lactone)	(54)
1979	*E. anomalum* *E. mohrii*	*Eurecurvin and other new guaianolides and germacradienolide	(55)
1980	*E. deltoideum*	*Deltoidin A, B (germacrolide sesquiterpene lactones) *Ligustrin (guaianolide), Diterpenes and Triterpenes	(56)
1980	*E. mikanioides*	*2-hydroxy-8-(acyloxy)-*trans,trans*-1-(10),4-germacradienolides [A-F] 	(57)
1980	*E. rotundifolium*	*new guaianolides	(58)
1981	*C. collina*	*7α-acetoxy-*trans*-communic acid (labdane diterpene)	(59)
1981	*C. morii*	Chromomoric acid (cyclopentenolone, cyclic fatty acid derivative, prostaglandin-like fatty acid)	(60)
1981	*E. capillifolium*	*Astragalin or kaempferol-3-β-glucoside *Hyperoside or quercetin-3-β-galactoside *(*2R,3R*)-3,4′-dihydroxy-5,7-dimethoxyflavanone *(*2R,3R*)-7-methoxy-3,5,4′-trihydroxyflavanone *Thymohydroquinone *Taraxasterol and its esters	(61)

Table 2.3 (continued)

Year	Species	Compound name	Ref.
1981	*E. inulaefolium*	*Pedalitin or 6-hydroxyluteolin-7-methyl ether	(62)
1981	*E. lancifolium* *E. semiserratum*	Heliangolides *Eupacunolin *Eupacunin *Desacetyleupacunin Germacradienolide Coumarin	(63)
1982	*C. chasleae*	Cyclic octadecanoids (Prostaglandin-like acid)	(64)
1982	*C. pseudoinsignis*	Three novel cadinene derivatives	(64)
1982	*C. morii*	Cyclic octadecanoids (Prostaglandin-like acid)	(65)
1982	*E. aschembornianum*	*Eupatoriochromene B *Eupatoriochromene B *Benzofuran derivative	(66)
1982	*E. chinense*	Allyl hydroxyl guaianolide sesquiterpene lactones *Peroxyeupahakonin A * Peroxyeupahakonin B Guaianolides *Eupahakonin A and B *Eupahakonenin A and B *Eupahakonesin	(67)
1982	*E. leucolepis*	*3′,4′-methylenedioxy-5,6,7,8-tetramethoxyflavone *3′,4′-methylenedioxy-5,6,7,8,5′-pentamethoxyflavone *Nobiletin *3′-hydroxy-5,6,7,8,4′,5′-hexamethoxyflavone *4′-hydroxy-5,6,7,8,3′,5′-hexamethoxyflavone *4′-hydroxy-5,6,7,8,3′-pentamethoxyflavone	(68)
1982	*E. scabridum*	Guaianolides and germacradienolides	(69)
1982	*E. serotinum*	*11-hydroxy-α-cubebene *11-hydroxy-β-cubebene	(70)

Table 2.3 (continued)

Year	Species	Compound name	Ref.
1982	*E. sternbergianum*	*Eupatarone (benzofuran) *2-hydroxy-4,5-dimethoxybenzaldehyde *12-hydroxy-2,3-dihydroeuparine *Spathulenol *Precocene II *Dammaradienol and Dammaradielnol acetate *5,3′-dihydroxy-7,4′-dimethoxyflavanone *5,7-dihydroxy-4′-methoxyflavanone	(71)
1983	*E. petiolare*	*2α-*iso*-valeroyloxyeperuic acid (diterpene acid)	(72)
1984	*E. glechonophyllum*	*10-acetoxy-8,9-epoxythymolisobutyrate *10-acetoxy-8,9-dihydroxythymolisobutyrate *8,9,10-trihydroxythymol	(73)
1984	*E. serotinum*	Germacranolides	(74)
1985	*C. glaberrima*	Heliangolide *Chromolaenide *4-dehydrochromolaenide	(75)
1985	*C. laevigata*	Compounds derived from chromolaenin Clerodane derivatives Norsesquiterpenes Sesquiterpenes	(76)
1985	*E. quadrangularae*	Sesquiterpene lactones	(77)
1985	*E. quadrangularae*	*Quadrangulin A (eudesmanolides)	(78)
1986	*C. glaberrima*	*Guaianolide 8β-(4′-hydroxytigloyl)-oxypreeupatundin	(79)
1986	*E. angustifolium*	*Umbelliferone	(80)
1986	*E. altissimum*	Guaianolides Heliangolides *Costunolide	(81)
1986	*E. areolare* var. *leiocarpum*	*flavonols and flavonol glycosides (15 compounds)	(82)
1986	*E. cannabinum* *E. perfoliatum*	*4-*O*-methylglucuronoxylans (polysaccharide)	(83)
1986	*E. deltoideum*	*Bornyl *p*-coumarate	(84)

Table 2.3 (continued)

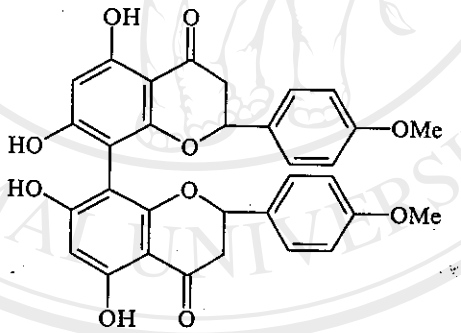
Year	Species	Compound name	Ref.
1986	*E. turbinatum*	*Clerodane derivative (diterpenes) *Abietane derivative (diterpenes) *Friedolabdane (diterpenes) *Liliolide *β-farnesene *Pachypodol (flavonol)	(85)
1987	*E. quadrangularae*	*Quadrangolide (heliangolide)	(86)
1987	*E. subhastatum*	*Eupatorin *Acacetin *Hispidulin *5,7,3′,4′-tetrahydroxy-6-methoxyflavanone *Protocatechuic acid	(87)
1988	*C. opadoclinia*	Germacranolide-type sesquiterpene lactones	(88)
1988	*E. subhastatum*	*I-5, II-5, I-7, II-7-tetrahydroxy-I-4′, II-4′-dimethoxy I-8, II-8-biflavanone (biflavanone) 	(89)
1989	*C. connivens*	*ent*-Clerodane derivatives (diterpenes) Prostagladin-like acids	(90)
1989	*C. turnariensis*	(widespread compounds)	(90)
1989	*E. cannabinum*	Benzofuran derivatives	(91)
1989	*E. cannabinum*	*Eupatoriopicrin (sesquiterpene lactone)	(92)

Table 2.3 (continued)

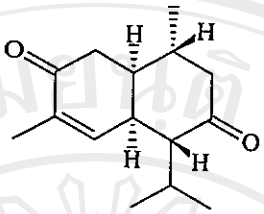
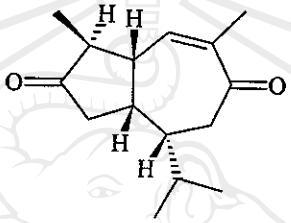
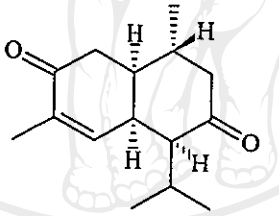
Year	Species	Compound name	Ref.
1989	*E. trapezoideum*	*epimer of 9-oxoageraphorone (cadinane-type sesquiterpene) 	(93)
1989	*E. adenophorum*	*Eupatorenone (new bicyclic sesquitepene skeleton)  *9-oxoageraphorone (cadinane-type sesquiterpene) 	(93)
1990	*E. glandulosum*	*Betuletol or 3,5,7-trihydroxy-6,4′-dimethoxyflavone or 6-hydroxykaempferol 6,4′-dimethylether *Betuletol-3-galactoside	(94)
1990	*E. salvia*	Labdane diterpenes Sesquiterpene Flavonoids	(95)
1990	*E. tinifolium*	Flavonol glycosides *3′-methylquercetagetin-3-*O*-galactoside *3′-methylquercetagetin-3-*O*-glucoside	(96)
1990	*E. tinifolium*	*6-*O*-β-D-glucopyranosyloxy-3-hydroxy-*p*-menth-1-ene (monoterpene glycoside) **O*-coumaroylglucose *5-*O*-feruloylquinic acid	(97)

Table 2.3 (continued)

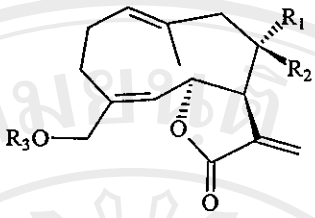
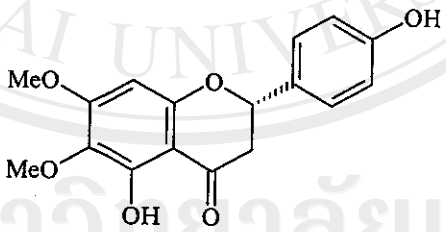
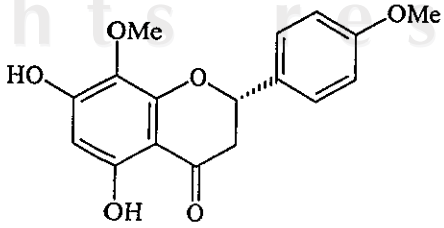
Year	Species	Compound name	Ref.
1991	*E. mohrii* [A] *E. hyssopifolium* [B]	*heliangolide derivatives (sesquiterpene lactone)  [A] $R_1 = R_3 = H$, $R_2 = OOCC(Me)=CHCH_2OH$ [B] $R_1 = H$, $R_2 = OOCC(Me)=CHCH_2OH$, $R_3 = Ac$	(98)
1991	*E. salvia*	Diterpenes	(99)
1992	*E. fortunei*	Pyrrolizidine alkaloids *Supinine *Rinderine *O-7-acetylrinderine	(100)
1992	*E. riparium*	*Methylripariochromene A or 6-acetyl-7,8-dimethoxy-2,2-dimethylchromene (chromene)	(101)
1993	*C. subscandens*	*β-sitosterol *p-methoxybenzoic acid *Umbelliferone *Kaempferol-7-α-(L)-rhamnoside *Kaempferitrin *Sakuranetin *5,4′-dihydroxy-6,7-dimethoxyflavanone  * Subscandenin or 5,7-dihydroxy-8,4′-dimethoxyflavanone 	(102)

Table 2.3 (continued)

Year	Species	Compound name	Ref.
1993	*E. glandulosum*	*6-hydroxykaempferol-7-(6''-caffeoylglucoside)	(103)
1994	*E. buniifolium*	*5,7,5′-trihydroxy-3,6,2′,4′-tetramethoxyflavone *Brickellin	(104)
1995	*C. arnottiana*	*5,3′-dihydroxy-6,7,4′-trimethoxyflavone *5-hydroxy-6,7,3′,4′-tetramethoxyflavone *5-hydroxy-6,7,3′,4′,5′-pentamethoxyflavone *derivative of 3,4-dihydroxyacetophenone	(105)
1995	*C. farinose*	*Acacetin, *5,7-dihydroxy-3′,4′-dimethoxyflavone *Pilloin or 5,3′-dihydroxy-7,4′-dimethoxyflavone *Diosmetin or 5,7,3′-trihydroxy-4′-methoxyflavone *Ombuin *Persicogenin *5,3′,4′-trihydroxy-7-methoxyflavanone	(106)
1995	*E. cannabinum*	*Hispidulin or scutellarein-6-methylether *Pectolinarigenin or scutellarein-6,4′-dimethylether *Eupafolin or 6-hydroxyluteolin-6-methylether *Jaceosidin or 6-hydroxyluteolin-6,3′-dimethylether *Santin or 6-hydroxykaempferol-3,6,4′-trimethylether *Centaureidin or Quercetagetin-3,6,4′-trimethylether	(107)
1995	*E. glandulosum*	*4′-methylquercetagetin 7-*O*-(6''-*E*-caffeoyl-β-D-glucoside) *Quercetagetin 7-*O*-(6-acetyl-β-D-glucoside) *7-*O*-glucosides of 6-hydroxykaempferol *Quercetin *Quercetagetin	(108)
1995	*E. morii* *E. chaslae*	*Clopentenolone and cyclic octadecanoids *Cylic octadecanoids	(109)
1998	*C. moritziana*	*Kaempferol *Kaempferol-3-*O*-rutinoside *Rutin *Isoquercitrin	(110)

Table 2.3 (continued)

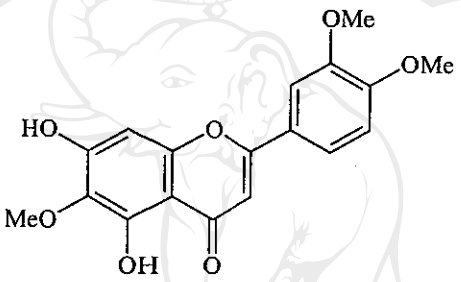
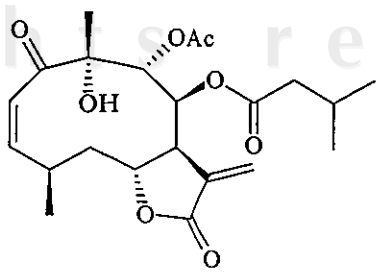
Year	Species	Compound name	Ref.
1998	*E. buniifolium*	Labdane-type diterpenes *Methyl-*ent*-labd-8(17)-en-18-oic acid-15-oate *15-hydroxy-*ent*-labd-8(17)-en-18-oic acid *15,16-epoxy-15-methoxy-*ent*-labd-8(17)-en-18-oic acid *15-methoxy-*ent*-labd-8(17)-13-dien-18-oic acid methyl ester-16,15-olide *Polyalthic acid *Nivenolide acid	(111)
1998	*E. salvia*	*7-hydroxy-8(17)-labden-15-oic acid or salvic acid *7-acetoxy-8(17)-labden-15-oic acid or salvic acid acetate	(112)
2000	*Eupatorium* spp.	*Eupatillin or 5,7-dihydroxy-6,3′,4′-trimethoxyflavone 	(113)
2001	*E. fortunei*	*Thymol derivatives (16 compounds)	(114)
2001	*E. buniifolium*	*5,7,5′-trihydroxy-3,6,2′,4′-tetramethoxyflavone *Scopoletin *Centaureidin	(115)
2001	*E. semialatum*	Pyrrolizidine alkaloids *Tussilagin *Isotussilagin *Neo-tussilagin *Neo-isotussilagin *Pyrrolidine-2-acetic acid methyl ester	(116)
2002	*E. inulaefolium*	*Neurolenin B 	(117)

Table 2.3 (continued)

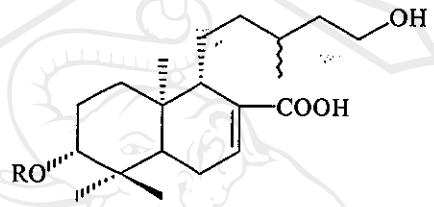
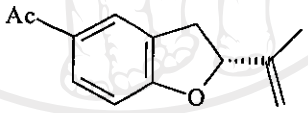
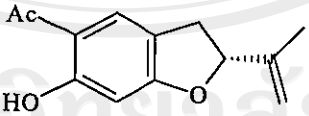
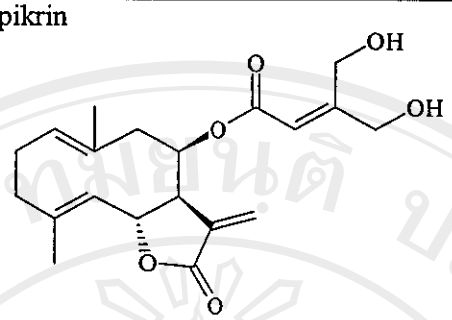
Year	Species	Compound name	Ref.
2002	*E. glutinisum*	*15-hydroxy-7-labden-17-oic acid *15-acetoxy-7-labden-17-oic acid *Dammara-20,24-dien-3-acetate **Epi*-friedelanone *Nepehinol palmitate ester (lupane triterpenes) *Stigmasterol	(118)
2002	*E. glutinosum*	*3,15-dihydroxy-*ent*-labd-7-en-17-oic 3-*O*-β-D-glucoside and its aglycone  R = Glucosyl R = H	(119)
2003	*E. urticaefolium*	(*R*)-(-)-tremetone  (*R*)-(-)-hydroxy-tremetone  	(120)
2004	*E. betonicaeforme*	Volatile oil *β-caryophyllene *α-humulene *γ-muurolene *bicyclogermacrene *2,2-dimethyl-6-vinylchroman-4-one *2-senecioyl-4-vinylphenol	(121)

Table 2.3 (continued)

Year	Species	Compound name	Ref.
2004	*E. cannabinum*	*Eupatoriopikrin 	(122)
2004	*E. chinense*	*Eupachinilide A-J *Eupachifolin D *Budlein B *8β-(4′-hydroxytiglyloxy)-2β-hydroxy-1α*H*,5α*H*,6β*H*,7α*H*-guai-3,10(14),11(13)-trien-6,12-olide *1,10-hydrobahia *2α-hydroxyeupatolide *Eupaserrin *Mollisorin B	(123)
2004	*E. lindleyanum*	*Eupalinilide A-J *Eupachinilide C *Eupachinilide E *Eupachifolin D *2α-hydroxyeupatolide *8β-tigloyloxy-3β,14-dihydroxy-6β*H*,7α*H*-germacra-1(10)*Z*, 4*E*,11(13)-trien-6,12-olide *3-deacetyleupalinin A *Heliangine *8β-(4′-hydroxytigloyloxy)-3β,14-dihydroxy-6β*H*,7α*H*-germacra-1(10)*Z*,4*Z*,11(13)-trien-6,12-olide *8β-tigloyloxy-2,3-seco-6β*H*,7α*H*-helianga-4*Z*,11(13)-diene-3,10β;6,12-diolid-2-oic acid	(124)