The family Burseraceae includes 17 genera and 540 species (Boulos, 2000).

Species belonging to the family Burseraceae, e.g. *Bursera* and *Protium*, are well known for producing fragrant oleoresins. Frankincense or olibanum, an oleo-gum-resin, is produced by trees of several *Bowsellia* species, which is characterized by resin bearing ducts in the cortex of the stems and throughout the leaves.

Proximate and Nutritional Composition

1. *Dacryodes* species: these plants are often reported to be high in lipids and proteins. The lipid content of *Dacryodes edulis* can account for as much as 72.6% of the entire edible fruit, 44% of the pulp and 27.3% of the seed. *Dacryodes edulis* was reported to be rich in proteins, particularly in its seeds (33.8%), pulp (25.9%) and resin (18.4%). The protein content of the plant is superior to that of maize (12.8%), soybean (14.0%) and peanut (6.9%). The dietary fiber content is comparable to that of pears (4.3%), apples (3.2%) and pomegranates (2.8%) and is higher than that of peaches (1.6%), oranges (1.1%) and grapes (1.2%) (Tee *et al.*, 2014).
2. *Dacryodes rostrata* (Blume) H. J. Lam.: The seeds and pulp were rich in fat, while peels had the highest ash contents. Potassium was the most prevalent mineral in peels (380.72–1112.00 mg/100 g) (Kong *et al.*, 2011).

Carbohydrates and Amino Acids

An acidic polysaccharide, containing appreciable quantity of 4-*O*-methyl-glucuronic acid, was extracted from the oleoresin of *Boswellia papyrifera* (Anderson *et al.*, 1965). The gum obtained from *Boswellia serrata* exudate contains xylose, rhamnose, arabinose, galactose, galacturonic acid and digitoxose (Bhuchar *et al.*, 1982). D-Glucose, D-glactose, D-fructose, D-lactose, L-sorbose and raffinose were detected in *Boswellia serrata* (Gangwal and Vardhan, 1995a).

The amino acid composition of *Dacryodes edulis* is shown in (Table **1**) (Tee *et al.* 2014).

Lipids and Related Comounds

1. *Boswellia serrata*: A lipid constituent, identified as 5(6)-ene,26-hydroxy-octacosanoic acid was isolated from the bark (Singh and Bhakuni, 2006). Unusual acids *viz.* saturated branched (14 Me 16:0) and diunsaturated (5.9 C:18:2) were detected in the seeds (Banerjee and Singh, 2000). A long chain compound, 5’,6’-epoxytridecanyl-1-[4’(5’),9’(10’)-ditetradecen],13-[12”(13”)-pentadecen]-dioate was isolated from the oleo gum resin (Singh and Bhakuni, 2006b).
2. *Bursera penicillata*: The major fatty acids of the seed oil (17-18%) are linoleic, 57.2; palmitic, 21.3 and oleic, 15.23% acids (Theagarajan, 1983).
3. *Canarium album* Raeusch: The acids identified in the seed oil were hexanoic, octanoic, decanoic, lauric, myristic, stearic, palmitic, oleic, linoleic, and 2 $C_{18:2}$ acids (Kameoka and Miyazawa, 1976).
4. *Canarium schweinfurthii* Engl.: The major fatty acids of the fruits (36.1%) were $C_{16:0}$, $C_{18:1}$, and $C_{18:2}$ (Kapseu *et al.*, 1999).

Table **1**. Essential and non-essential amino acids of *Dacryodes edulis* (Tee *et al*., 2014)

Source	Essential amino acids								
	Lysine (%)	Histidine (%)	Phenylalnine (%)	Leucine (%)	Isoleucine (%)	Threonine (%)	Methionine +cystine (%)	Valine (%)	Arginine (%)
Pulp	6.27	2.41	2.97	9.57	3.87	4.39	1.02	3.73	3.34
	3.60	2.28	3.85	7.49	3.39	2.80	0.81	3.43	4.73
Seeds	8.40	-	4.97	18.56	7.50	-	0.94	3.45	2.90

Source	Essential amino acids						
	Aspartic (%)	Serine (%)	Glutamic (%)	Proline (%)	Glycine (%)	Alanine (%)	Tyrosine (%)
Pulp	15.06	4.86	17.04	6.59	2.64	7.71	4.97
	10.52	2.64	14.23	2.93	3.90	4.04	2.90
Seeds	13.08	4.49	12.02	5.72	2.29	4.52	4.52

5. *Dacryodes* species: The oils extracted from *Dacryodes* species yield different types of fatty acids, such as palmitic acid (16:0), stearic acid (18:0), oleic acid (18:1) and linoleic acid (18:2). Palmitic acid is the most prevalent in the oil extracted from *Dacryodes edulis* fruit pulp, ranging from 17.2% to 45.0%, followed by oleic acid (22.0–40.5%), linoleic acid (16.0–25.0%) and stearic acid (2.1–14.8%). The fatty acid composition of some *Dacryodes* species are shown in (Table **2**) (Tee *et al.* 2014).
6. *Garuga pinnata*: Hydrocarbons, *n*-alkanols, esters, a keto fatty acid, a secondary alcohol (6-propyltetradecan-7-ol) (Haribal *et al.*, 1984) and octanedioic acid-2-ethyl-*bis*-(2-ethylhexyl) ester (Adhikari *et al.*, 1990) were isolated from the stem bark.

Essential Oils

The investigation of the volatile components of the essential oils of several species have been reported. Hamm *et al.* (2005) analysed six different olibanum samples with certified botanical origin in order to define their mono-, sesqui- and diterpenic composition, as pertinent criteria of identification. *Boswellia carteri* and *Boswellia sacra* olibanum have quite similar chemical composition, with isoincensole acetate as the main diterpenic biomarker. Although *Boswellia serrata* olibanum also exhibits this biomarker, the presence of methylchavicol, methyleugenol and an unidentified oxygenated sesquiterpene distinguishes *B. serrata* olibanum from the two other species. The characteristic chemical compounds of *Boswellia papyrifera* are the diterpenic biomarkers, incensole and its oxide and acetate derivatives, *n*-octanol and *n*-octyl acetate. *Boswellia frereana* olibanum is devoid of diterpenes of the incensole family but contains a high amount of many dimers of α-phellandrene. The chemical composition of olibanum, which is demonstrated to be different for each *Boswellia* species allowed the determination of the taxonomic origin of frankincense samples purchased on various markets in East Africa, in the Near East and in Yemen (Hamm *et al.*, 2005). The most abundant components of steam volatiles from the barks of eight species of Mexican *Bursera* were monoterpenoids from which α-terpineol, terpinen-4-ol, α-thujene, linalool and limonene were most frequently isolated. A series of sesquiterpenes and long-chain hydrocarbons were isolated and identified from the barks of some of these species (Zúñiga*et al.*, 2005).

1. *Aucoumea klaineana* Pierre: The following compounds were identified from the essential oil (from the oleo resin collected from the plant growing in Gabon): *p*-cymene (30.2%), α-pinene (20.6%), α-phellandrene (11.2%), limonene (5.4%), α-terpineol (5.2%), terpinen-4-ol (2.8%) and camphor (0.6%). Other components 0.09%; epoxyterpinolene, 0.19%; menthe-1,5-dien-8-ol, 0.30%; (+)-terpinen-4-ol, 0.09%; *m*-cymen-8-ol, 0.33%; *p*-cymen-8-ol, 0.33%; α-terpineol, 4.34%; verbenone, 0.12% and *p*-acetyl anisole, 0.18% (Koudou *et al.*, 2009). This oil contained mainly monoterpenoids (96.06%) in which *p*-acetyl anisole is the single benzenic compound (0.18%). The predominant constituents in the essential oil were δ-3-carene (72.31%), *p*-cymene (3.76%), limonene (4.04%), terpinolene (6.28%) and α-terpineol (4.34%) (Koudou *et al.*, 2009). Six monoterpenes (α-pinene, β-pinene, limonene, α-phellandrene, β-phellandrene and 3-carene), one monoterpenic

Table **2**. Fatty acid composition of *Dacryodes* species (Tee *et al*., 2014).

Species	Source	Saturated Fatty Acids				Monounsaturated Fatty acids		Polyunsaturated Fatty Acids		Saturated Fatty Acids (%)	Un-Saturated Fatty Acids (%)
		C14:0	C16:0	C18:0	C20:0	C16:1	C18:1	C18:2	C18:3		
Dacryodes. edulis	Pulp	-	39.0	3.7	-	-	31.0	24.9	1.3	42.7	57.2
		-	44.0-45.0	-	-	-	31.0-36.0	16.0-21.0	-	44.0-45.0	47.0-57.0
		-	42.4	2.8	-	0.2	28.0	24.9	1.2	45.5	54.5
		0.1	47.9	2.1	0.2	0.1	31.3	17.5	0.3	50.9	49.1
		4.0	7.2	12.9	-	-	22.0	24.8	29.1	24.1	75.9
	Seeds	-	61.9	-	-	-	18.3	19.0	-	61.9	37.3
		-	43.2	4.6	11.6	-	22.0	12.6	-	59.4	34.6
Dacryodes. rostrata	Seeds	-	12.5	45.7	1.3	-	37.9	2.1	0.3	59.5	40.3
		1.0	10.7-12.7	30.9-40.3	2.1-3.1	-	43.6-49.5	2.8-3.3	-	-	-
		1.0	12.7	30.9	3.1	-	49.5	2.8	-	47.7	52.3
Dacryodes costata	Seeds	0.2	64.1	1.6	-	0.7	28.9	3.8	0.2	65.9	33.6

- Not known.

alcohol (α-terpineol) and two other derivatives (*p*-cymene and eucalyptol) were reported as the main volatile constituents of the oleoresin, collected in Gabon (Medzegue *et al.*, 2013). Also, the constituents of the essential oil (3.3%) of the resin harvested in Cameroon, were reported (Table **3**) (Dongmo *et al.*, 2010).

Table **3**. Chemical composition of the essential oils of *Aucoumea klaineana* and *Canarium schweinfurthii* (Dongmo *et al.*, 2010)

Compounds	*Aucoumea. klaineana*	*Canarium. Schweinfurthii**	*Canarium. Schweinfurthii***
Monoterpenes hydrocarbons	82.9	61.9	73.4
α-Thujene	0.2	-	-
α-Pinene	29.3	1.7	2.6
Camphene	0.6	-	-
Sabinene	0.3	2.0	0.2
β-Pinene	0.8	0.4	1.2
Myrcene	-	-	0.5
Menthene	1.6	-	-
α-Phellandrene	30.9	1.1	4.1
Δ^3 Carene	2.3	0.3	-
α-Terpinene	2.4	0.5	2.7
p-Cymene	9.2	9.8	25.3
Limonene	0.4	42.7	36.6
y-terpinene	0.3	1.9	0.2
Terpinolene	4.6	1.5	-
Oxygenated monoterpens	15.7	37.0	25.3
1,8-Cineole	9.0	0.3	0.5
Linalool	-	-	0.3
Camphor	0.8	-	-
Terpinen-4-ol	2.5	2.3	0.4
α-Terpineol	3.1	34.3	18.0
Carveol	0.3	-	1.4
Geraniol	-	-	0.5
Carvone	-	-	0.4
Pipertone	-	-	3.8

* Collected from Lolodorf (Southregion); ** Collected from Mbouda (West region of Cameroon).

2. *Boswellia ameero* Balf. f: Oils of *Boswellia socotrana* and *B. ameero* were characterized by a high content of monoterpenes. The main constituens of *B. socotrana* and *B. ameero* were (*E*)-2,3-epoxycarene (51.8%), 1,5-isopropyl-2-methylbicyclo[3.1.0]hex-3-en-2-ol (31.3%), and α -cymene (7.1%); (3*E*,5*E*)-2,6-dimethyl-1,3,5,7-octatetraene (34.9%), 1-(2,4-Dimethylphenyl)ethanol (20.3%),

3,4-dimethylstyrene (17.3%), α-campholenal (13.4%) and α-terpineol (12.4%) respectively (Table **4**) (Ali *et al.*, 2008).

Table **4**. Main Components of essential olils from oleogum resins of *Boswellia socotrana* (A), *Boswellia elongata* (B) and *Boswelli ameero* (C) (Ali *et al.*, 2008)

Compounds[a]	A (%)	B (%)	C (%)
α-Cymene	7.1	-	-
1,5-Isopropyl-2-methylbicyclo [3.1.0]hex-3-en-2-ol	31.3	-	-
4-Terpinenylacetate	3.9	-	-
α-Campholenal	-	-	13.4
(3*E*,5*E*)-2,6-Dimethyl-1,3,5,7-octatetraene	-	-	34.9
(*E*)-2,3-Epoxycarene	51.8	-	-
3,4-Dimethylstyrene	-	-	17.3
α-Terpineol	-	-	12.4
1-(2,4-Dimethylphenyl) ethanol	-	-	20.3
4-Methyl-benzoic acid	2.7	-	-
p-Menth-1(7)-en-2-one	2.6	-	-
α-Terpinylacetate	0.1	-	-
Caryophyllene	-	39.1	-
Methyl cycloundecane carboxylate	-	7.9	-
Verticiol	-	52.4	-
Total identified	98.5	99.4	98.3

3. *Boswellia carterii*: The hydrodistillate of *B. carterii* contains in addition to α-pinene β-pinene (existing in comparable percentages), *E*-β-ocimene (1.7%), limonene (1.5%) and several sesquiterpenes: α-copaene (0.35%), α-selinene (0.24%), maaliane (0.02%), viridiflorol (0.06%), α-muurolol (0.03%), β-bisabolene (0.15%), *cis*-calamenene (0.01%), spathulenol (0.03%), and *cis*-nerolidol (0.07%). Several diterpenes were detected in the oil especially those of the cembranoid skeleton such as, the previously reported cembrene (0.27%), isocembrene (0.28%). In addition, verticiol (1.22%), duva-4,8,13-trien-1,3α-diol (0.23%), thunbergol (4.07%), duva-3,9,13-trien-1,5α-diol (0.06%), duva-3,9,13-trien-1α-ol-5,8-oxide-1-acetate (0.5%), duva-3,9,13-trien-1,5α-diol-1-acetate (21.35%) were also reported (Basar *et al.*, 2001; Al-Harrasi and Al-Saidi, 2008). The essential oil (3%), obtained from frankincense (oleogum resin of *B. carterii* Birdwood, purchased from the local market of herbs and spices in Egypt) was found to contain monoterpenes (13.1%), sesquiterpenes (1%), and diterpenes (42.5%). The major components of the oil were duva-3,9,13-trien-1,5α-diol-1-acetate (21.4%), octyl acetate (13.4%), *o*-methyl anisole (7.6%), naphthalene decahydro-1,1,4a-trimethyl-6-methylene-5-(3-methyl-2-pentenyl) (5.7%), thunbergol (4.1%), phenanthrene-7-ethenyl-

1,2,3,4,4α,5,6,7,8,9,10,10α-dodecahydro-1,1,4α,7-tetramethyl (4.1%), α-pinene (3.1%), sclarene (2.9%), 9-*cis*-retinal (2.8%), octyl formate (1.4%), verticiol (1.2%) decyl acetate (1.2%), *n*-octanol (1.1%). The chemical profile of the oil is considered as a chemotaxonomical marker that confirmed the botanical and geographical source of the resin (Mikhaeil *et al.*, 2003). Earlier investigation of the oil of oleogum resin "Olibanum" (from Egypt) showed that it contains 62.1% esters, 15.4% alcohols, 9.9% monoterpene hydrocarbons, and 7.1% diterpenes (Abdel Wahab *et al.*, 1987). The following compounds were identified in the pyrolysate of Aden incense (gum resin of *B. carteri*): α-campholenaldehyde, cuminaldehyde, carvotanacetone, phellandral, *o*-methylacetophenone, carvone, perilla-aldehyde, eucarvone, 1-acetyl-4-isopropenylcyclopentene, piperitone, nopinone, cryptone, verbenone, γ-campholenaldehyde, thujone, myrtenoic acid, *p*-menth-4-en-3-one, 3,6,6-trimethylnorpinan-2-one, myrtenal, 2,4-dimethyl-acetophenone, pinocamphone or isopinocamphone, isopropylidenecyclohexane, α-amyrenone and 11-keto-α-amyrenone (Pailer *et al.*, 1981).

4. *Boswellia dalzielli* Hutch: Twenty-nine compounds were identified, with α-pinene (45.7%) and α-terpinene (11.5%) being the predominant compounds (Kubmarawa *et al.*, 2006).
5. *Boswellia elongata* Balf. f: The composition of oil was dominated by the diterpene verticiol (52.4%), the sesquiterpene caryophellene (39.1%) and methylcyclo-undecanecarboxylate (7.9%) (Table **4**) (Ali *et al.*, 2008).
6. *Boswellia frereana*: *p*-Cymene was the most abundant component among the ten terpenes identified in the oil (Strappaghetti *et al.*, 1982).
7. *Boswellia rivae*: Hydrocarbon and oxygenated monoterpenes were the most abundant classes of compounds identified in the oleogum resin oil (Camarda *et al.*, 2007).
8. *Boswellia sacra* (Omani Luban): Thirty-four monoterpenes and 16 sesquiterpenes were identified in the hydrodistillate oil (5.5%), obtained from the oleogum resin derived from the plant, growing in Oman. The oil contains a high proportion of monoterpenes (97.3%) in which *E*-β-ocimene and limonene were the major constituents. The monoterpenes were identified as 2-β-pinene (0.1%), α-thujene (6.6%), *E*-β-ocimene (32.3%), 2,4(10)-thujadiene (0.2%), camphene (0.6%), sabinene (5.2%), 1-β-pinene (1.8%), myrcene (6.9%), α-pinene (5.3%), 2-carene (0.8%), limonene (33.5%), *Z*-β-ocimene (0.2%), γ-terpinene (1.0%), terpinolene (0.4%), *p*-cymene (0.2%), 1,4-cyclohexadiene (0.1%), perillene (0.1%), isopentyl-2-methyl butanoate (0.1%), isomyl valerate (0.1%), 1,3,6-trimethylenecycloheptane (0.1%), β-thujone (0.1%), α-campholene aldehyde (0.2%), *allo*-ocimene (0.1%), *trans*-pinocarveol (0.1%), *p*-mentha-1,5-dien-8-ol (0.2 %), 4-terpineol (0.2%), sabinyl acetate (0.1%), myrtenal (0.1%), α-terpineol (0.1%), α-phellandrene epoxide (0.1%), verbenone (0.1%), *trans*-(+)-carveol (0.1%), carvone (0.1%) and 1-bornyl acetate (0.1%). The sesquiterpenes were identified to be α-cubebene (0.1%), α-copaene (0.3%), β-bourbonene (0.1%), β-elemene (0.3%), α-gurjunene (0.1%), *E*-caryophyllene (0.9%), α-humulene (0.2%), *allo*aromadendrene (0.0.1%), α-amorphene (0.1%), germacrene D (0.1%), β-selinene (0.1%), α-selinene (0.1%), α-

muurolene (0.1%), γ-cadinene (0.1%), caryophyllene oxide (0.01%) and γ-muurolene (0.1%) (Al-Harrasi and Al-Saidi, 2008).

The volatile constituents of *B. sacra* frankincense (purchased from the Egyptian local market) have been reported to contain 22 terpenes, among which α-pinene was the most abundant (Ammar *et al.*, 1994). Major botanical and scientific references currently identify two species of frankincense, *Boswellia carterii* and *Boswellia sacra*, as being synonymous. Chemical evaluation of Somalian (*Boswellia carterii*) and Omani/Yemeni (*Boswellia sacra*) species had been carried out to determine if there are any minor or major differences between the two species of frankincense. Components identified with their average percent for *B. sacra* are α-thujene (0.6%), α-pinene (68.2%), camphene (2.1%), sabinene (2.9%), β-pinene (2.0%), myrcene (0.7%), limonene+β-phellandrene (6.2%). Components identified, with their average percent for *B. carterii*, are α-thujene (7.9%), α-pinene (37.3%), camphene (0.8%), sabinene (4.9%), β-pinene (1.8%), myrcene (7.3%), limonene+β-phellandrene (14.4%). Initially, GC-MS analysis did not reveal major statistical differences. However, optical rotation values, *B. Sacra* (+30.1°) and *B. carterii* (-13.3°), demonstrated a greater significant difference. Enantiomeric ratio (+)/(-) values of α-pinene for *B. sacra* and *B. carterii* are 8.24 and 0.68, respectively, were also calculated aiding to conclusion that *B. sacra* and *B. carterii* are not synonymous but rather two distinct and individual frankincense species (Woolley *et al.*, 2012).

9. *Boswellia serrata* Roxb. ex Colebr: Thirty-five components were identified, comprising 82%, 91%, 77% and 82% of the essential oils of four samples collected from four different localities in India. α-Thujene was one of the major constituents in all samples, whereas α-pinene was recorded in only one sample (Singh *et al.*, 2007). The Indian olibanum oil was reported to differ from olibanum oils by its high content of α-thujene (Verghese *et al.*, 1987). Thirty-five constituents were identified from the essential oil of the bark. The oil predominantly comprised monoterpenoids, of which α-pinene (73.3%) was the major constituent. Other monoterpenoids identified included β-pinene (2.05%), *cis*-verbenol (1.97%), *trans*–pinocarveol (1.80%), borneol (1.78%), myrcene (1.71%), verbenone (1.71%), limonene (1.42%), thuja-2,4(10)-diene (1.18%) and *p*-cymene (1.0%), while α-copaene (0.13%) was the only sesquiterpene identified in the oil (Kasali *et al.*, 2002).
10. *Boswellia socotrana* Balf. f: The main constituents of the essential oil from oleogum resin of the plant is shown in Table **4** (Ali *et al.*, 2008).
11. *Bursera aromatica* Proctor: The essential oil from the leaves, bark and fruits of *B. aromaica*, collected from Jamaica amounted to 0.03%, 0.09% and 1.12% (w/w) respectively. Thirty-eight constituents of the leaf oil (92.1%), 26 constituents of the bark oil (96.5%), and 27 constituents of the fruit oil (93.5%) were identified. The predominant compounds were nonane (14.7%, 5.2% and 23.7%), α-copaene (15.8%, 23.7% and 14.0%), ß- caryophyllene (21.7%, 12.8% and 6.8%), 5-cadinene (11.3%, 21.5% and 4.3%) and viridiflorol (5.9%, 11.8% and 7.9%) in the oils from the leaves, bark and fruits, respectively. In addition to the components

listed above, β-pinene (7.0%) and limonene (8.0%) were also among the major components of the fruit oil (Junor *et al.*, 2010).

Bursera copallifera: The volatile components of the leaves are shown in Table **5** (Noge and Becerra, 2009).

Table **5**. Composition (%) of the volatile components of the leaves some *Bursera* species (Noge and Becerra, 2009)

	(%)				
Compound	1	2	3	4	5
α-Thujene	0.2	-	-	5.3	-
α-Pinene	0.7	1.6	6.6	10.3	67.8
Camphene	-	-	-	1.2	1.2
Sabinene	-	-	-	2.8	1.2
β-Pinene	-	4.7	-	21.9	5.7
β-Myrcene	-	-	0.5	-	2.0
α-Phellandrene	0.3	1.2	15.0	-	-
p-Cymene	-	-	0.6	-	-
Limonene	-	-	-	0.4	0.9
β-Phellandrene	-	-	1.9	2.0	0.2
β-Ocimene	-	4.9	-	-	-
Sesquiterpene	-	2.6	-	-	-
α-Copaene	1.7	-	2.7	-	-
Sesquiterpene	1.7	6.4	0.7	0.5	-
β-Caryophyllene	9.6	15.0	14.4	18.3	4.3
α-Humulene	12.5	0.7	0.5	0.6	-
Sesquiterpene	0.4	-	0.5	-	-
Sesquiterpene	1.5	0.7	-	-	-
Germacrene D	56.2	50.5	36.6	31.9	15.1
Bicyclogermacrene	6.2	8.8	1.2	0.7	0.8
Sesquiterpene	2.4	-	-	1.2	-
Sesquiterpene	-	1.5	2.7	-	-
Sesquiterpene	1.0	1.3	-	0.6	-
Sesquiterpene	1.4	-	-	0.5	-
Sesquiterpene	-	-	-	1.0	-
Unknown	-	-	2.6	-	-
Unknown	-	-		0.9	-
Monoterpenes	1.2	12.4	24.6	43.9	79.0
Sesquiterpeneس	94.6	87.5	59.3	55.3	20.2

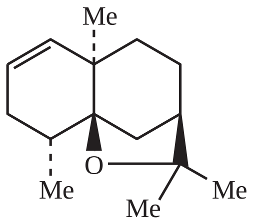
1. *Bursera copallifera*, 2. *Bursera excelsa*, 3. *Bursera mirandae*, 4. *Bursera ruticola*, 5. *Bursera. fagaroides* var. *purpusii*

12. *Bursera delpechiana* Poisson ex Engl. (Indian lavender): The chemical composition of the volatile constituents of the plant is shown in Table **6** (Becerra and Noge, 2010).

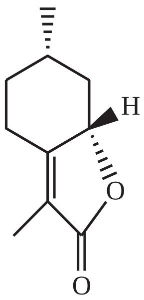
Table **6**. Chemical composition of *Bursera delpechiana* and *Bursera linanoe* (Becerra and Noge, 2010)

Compounds	*B. delpechiana*	*B. linanoe*
1-Undecene	0.49	3.10
Linalool	2.20	0.16
Linalyl acetate	90.34	92.16
α-Copaene	0.54	1.30
Germacrene D	1.96	0.72
Identified compounds	95.53	97.44

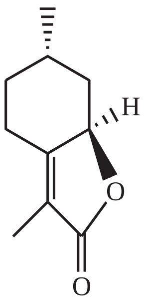
13. *Bursera excelsa*: The volatile components of the leaves are shown in Table **5** (Noge and Becerra, 2009).
14. *Bursera fagaroides* var. *purpusii*: The volatile components of the leaves are shown in Table **5** (Noge and Becerra, 2009).
15. *Bursera graveolens* (Kunnth) Triana et Planch: Five compounds were isolated from the volatile oil of wood chips, that provide its characteristic spicy, sweet and balsamic odor *viz*. (−)-dihydro-*α*-agarofuran, (−)-5,11-epoxy-4*α*,5*β*,10*α*-eudesm-1-ene (**1**), (−)-4*α*-hydroxydihydroagarofuran, (−)-3*β*,4*β*-oxidoagarofuran and (−)-10-epi-*γ*-eudesmol (Yukawa *et al*., 2004a). The following characteristic spicy, sweet and balsamic aroma compounds of the woods were isolated from the diethyl ether extract: (6S)-5,6-dihydro-3,6-dimethyl-2(4*H*)-benzofuranone, (+)-mintlactone (**2**), (-)-isomintlactone (**3**) (6*S*,7α*S*)-5,6,7,7α-tetrahydro-7a-hydroxy-3,6-dimethyl-2(4*H*)-benzofuranone (Yukawa *et al*., 2003). 3-hydroxymintlactone (**4**), 2,3 di-dehydromintlactone (**5**) (Yukawa and Iwabuchi, 2003), (-)-juneol (**6**), dihydro-juneol (**7**), 6β-hydroxy-4(15)-eudesmen-1-one (**8**), 6β-hydroxynoreudesman-4-one (**9**) (Yukawa *et al*., 2004b), 1-acetyl-4-isopropenyl-1-cyclopentene, 2-methyl-5-isopropenyl-1-cyclopenten-1-carboxaldehyde, 6,10-epoxy-7(14)-isodaucane and 10-hydroxy-6,10-epoxy-7(14)-isodaucane (Yukawa *et al*., 2006). One hundred compounds were identified in three different extracts (di-ethyl ether, extraction, simultaneous steam distillation extraction and roasted aroma extraction (dry distillation). The mono- or sesquiterpenoids contributed to woody, herbal and minty aromas of the woody material. On the other hand, the roast aroma produced by burning chips included several aroma compounds, such as cyclotene and vanillin (Yukawa *et al*., 2006). The essential oil of the stems was found to consist of monoterpenes (78.2%) and sesquiterpenes (9.6%). The major constituents were limonene (58.6%), and α-terpineol (10.9%) (Young *et al*., 2007). The chemical composition of the essential oil from the plant, growing in Cuba is shown in Table **7** (Monzote *et al*., 2012).
16. *Bursera graveolens* (H. B. K.) Tr. et Pl. var. *villosula* Cuatr: The volatile oil of the heart-wood contains (±)-limonene (57%), (+)-α-terpineol (18%) and (±)-carvone (5%), as well as about 30 minor components (Crowley, 1964).



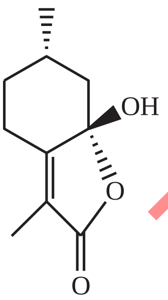
1 5,11-Epoxy-4α,5β,10α-eudesm-1-ene



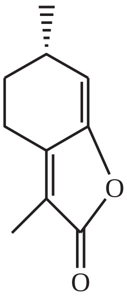
2 (+)-Mintlactone



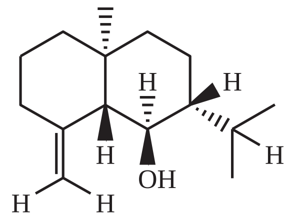
3 (-)-Isomintlactone



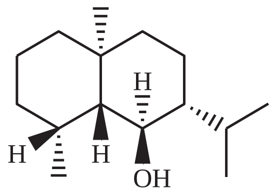
4 3-Hydroxymintlactone



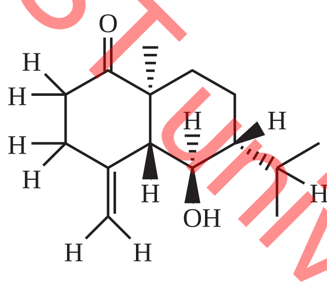
5 2,3-Didehydromintlactone



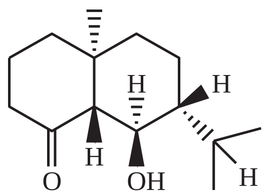
6 Juneol



7 Dihydrojuneol



8 6 β-hydroxy-4(15)-eudesmen-1-one



9 6 β-hydroxynoreudesman-4-one

17. *Bursera linanoe* (La Llave) Rzed., Calderón & Medina: The chemical composition of the volatile constituents of the plant is shown in Table **6** (Becerra and Noge, 2010).
18. Bursera *micropbylla micropbylla* A. Gray (Elephant tree, Torote): The essential oil of leaves and twigs consists of 80 per cent terpenes, 9 per cent sesuiterpenes and oxygenated compounds, an 8 per cent gums and resins. The terpene fractions consist largely of *d*, α- and β-phellandrene, tetrahydrocuminic acid (phellandric acid), and sesquiterpenes (Bradley and Haagen-Smit, 1951). The major components of the essential oil from the oleogum resin were β-caryophyllene (35.7-72.9%) and myrecene (0.4-14.4%) (Tucker *et al.*, 2009).
19. *Bursera mirandae*: The volatile components of the leaves are shown in Table **5** (Noge and Becerra, 2009).
20. *Bursera neglecta*: Analysis of 4 oils obtained from resins of the plant and 4 *Commiphora* species showed that all four oils were generally characterized by large amounts of α-pinene. Other constituents that were important markers were α-thujone and *p*-cymene from *B. neglecta* and some *Commiphora* species (Provan *et al.*, 1987a).

Table **7**. Chemical composation of essential oil from *Bursera graveolens*. (Monzote *et al*., 2012)

Compound	%	Compound	%
(3*Z*)-Hexenol	0.5	β-Elemene	14.1
(2*Z*)-Hexenol	0.1	α-Gurjunene	0.2
α-Pinene	0.1	β-Ylangene	0.2
Sabinene	0.3	2,5-Dimethoxy-*p*-cymene	0.1
β-Pinene	0.2	β-Copaene	0.2
Myrcene	0.7	α-Guaiene	0.1
α-Phellandrene	0.1	Unidentified	0.5
Limonene	26.5	α-Humulene	0.3
(*Z*)-β-Ocimene	0.9	(*E*)-β-Farnesne	0.1
(*E*)-β-Ocimene	13.0	*cis*-Cadina-1(6),4-diene	0.1
γ-Terpinene	tr	*cis*-Muurola-4(14),5-diene	0.2
p-Cymenene	tr	4,5-di-*epi*-Aristolochene	0.2
α-Pinene oxide	0.4	β-Chamigrene	0.9
(*E*)-6-Methyl-3,5-heptadien-2-one	0.1	Germacrene D	0.4
trans-*p*-Mentha-2,8-dien-l-ol	0.1	β-Selinene	1.4
(*Z*)-Epoxyocimene	0.2	α-Selinene	2.4
cis-*p*-Mentha-2,8-dien-l-ol	tr	*trans*-β-Guaiene	1.8
(*E*)-Epoxyocimene	0.4	Germacrene A	3.9
Menthone	0.3	γ-Cadinene	0.4
Menthofuran	5.1	7-*epi*-α-Selinene	0.1
cis/*trans*-Isopulegone	0.7	δ-Cadinene	1.2
α-Terpineol	0.3	*trans*-Cadina-1,4-diene	0.1
neo-Dihydrocarveol	0.1	α-Cadinene	tr
trans-Dihydrocarvone	0.1	α-Calacorene	tr
Unidentified	1.1	Spathulenol	0.2
trans-Carveol	0.3	Viridiflorol	0.2
cis-Carveol	0.1	Unidentified	0.5
Pulegone	1.7	1-*epi*-Cubenol	0.3
Carvone	0.1	t-Muurolol	1.2
Piperitone	0.1	α-Muurolol (=Torreyol)	0.3
Unidentified	0.7	Cedr-8(15)-en-9α-ol	1.1
Limonen-10-ol	0.1	α-Cadinol	2.4
Thymol	tr	Cedr-8(15)-en-9α-ol acetate	0.3
Perilla alcohol	0.1	Benzyl benzoate	0.1
Piperitenone	0.1	Phenanthrene	tr
Isoledene	0.1	Palmitic acid	0.2
α-Copaene	2.3	Total identified	90.5
β-Bourbonene	0.9		

21. *Bursera penicillata* (Sesse & Moc. Ex. Dc.) Engl. (Indian lavender, Linaloe): The essential oil from the husk chiefly consists of oxygenated monoterpenes (91.04%), monoterpene hydrocarbons (0.5%), sesquiterpene hydrocarbons (3.4%) and oxygenated sesquiterpenes (4.9%). The principal component of the oil is linalyl acetate (65.9%) and accompanied by linalool (7.6%), nonalactone (6.5%), neryl acetate (4.5%), a noticeable amount of 2-dodecanol (4.2%), while *cis*-linalool oxide, dihydrocarvone, myrtenol were detected in much smaller amounts (Jayaveera *et al.*, 2008). The volatile compounds from the leaves are shown in Table **8** (Islam and Becerra, 2011).

Table **8**. The composition of the leaf extracts of *Bursera penicillata, Bursera vejar-vazquezlii and Bursera trifoliata* (Islam and Bacerra, 2011)

Compounds	*B. penicillata*	*B.vejar-vazquezlii*	*B. trifoliata*
Heptane	25.40	19.72	24.05
2-Heptanone	3.31	-	-
2-heptanol	4.23	-	-
1-Methylhexyl acetate	2.02	-	-
α-Thujene	1.82	-	-
α-Pinene	0.87	-	-
Sabinene	0.68	-	1.29
β-Myrcene	1.40	-	-
β-Phillandrene	42.08	38.93	41.75
Carene	2.03	-	-
Caryophyllene	4.02	6.94	5.57
Nonane	-	3.44	6.20
Benzaldehyde	-	-	-
Limonene	-	2.44	2.60

22. *Bursera ruticola*: The volatile components of the leaves are shown in Table **5** (Noge and Becerra, 2009).
23. *Bursera schlechtendalii*: The following compounds were detected in the leaves and resin extracts: β-phellandrene (61.7, 61.0%), limonene (15.6, 18.0), β-myrecene (8.3, 6.3), sabinene (6.2, 9.5), α-pinene (4.7, 2.8) and nonane (3.4, 2.% respectively) (Evans *et al.*, 2000),
24. *Bursera simaruba* (L.) Sarg.: Sixteen compounds were identified, corresponding to about 94% of the fruit oil of the plant collected from Costa Rica. The major components were α-terpinene (26.2%), γ-terpinene (20.4%), α-pinene (18.2%) and *p*-cymene (15.9%) (Rosales and Ciccio, 2002). Thirty-eight componentds were identified from the leaf oil, of which limonene (46.7%), β-caryophyllene (14.7%), α-humulene (13.2%) and germacrene D (7.6%) are the major components (Sylvestre *et al.*, 2007). From the oils of the leaves, bark and fruits (collected from the Long Mountain region of Jamaica), 46, 54 and 19 components were identified which constituted 93.6%, 97.9% and 100% of the total oils. The leaf oils were

dominated by sesquiterpenes (70.1%), the major ones being *trans*-cadina-1(6),4-diene (9.7%) followed by β-caryophyllene (9.0%), α-humulene (6.2%), β-elemene (5.6%) α-cadinol (4.7%), α-selin-11-en-4-ol (4.2%), caryophyllene oxide (3.2%) and δ-selinene (3.1%). The major monoterpenes were α-pinene (10.2%), myrcene (5.2%) and β-pinene (3.4%). The major monoterpene components of the bark were α-pinene (32.1%), β-pinene (13.5%) and isolimonene (5.6%) while the major sesquiterpenes were viridiflorol (7.1%), β-caryophyllene (4.9%), β-selinene (4.3%), α-humulene (3.1%) and caryophyllene oxide (3.1%). The fruit oil was characterized by a high portion of monoterpenes, the major ones being α-pinene (27.8%), β-pinene (24.1%), terpinen-4-ol (13.3%), sabinene (8.1%), iso-sylvestrene (4.9%), limonene (4.4%) and γ-terpinolene (3.5%) (Junor *et al.*, 2008). The essential oil composition of *B. simaruba* from Monteverde, Costa Rica, was markedly different from those previously reported from Jamaica or Guadeloupe. The leaf oil was dominated by the monoterpene *o*-cymene (65.2%), while the bark oil had α-phellandrene (29.1%), (*E*)-caryophyllene (19.3%), *o*-cymene (13.1%), and α-thujene (11.9%) as major components (Setzer, 2014).

25. *Bursera tomentosa*: The most abundant constituents of the fruit essential oil (0.2%) were *cis*-ocimene (47.6%), *n*-nonane (28.2%) and germacrene-D (11.1%) (Moreno *et al.*, 2010).
26. *Bursera trifoliata*: The volatile compounds from the leaves are shown in Table **8** (Islam and Becerra, 2011).
27. *Bursera vejar-vazquezii*: *Bursera trifoliate*: The volatile compounds from the leaves are shown in Table **8** (Islam and Becerra, 2011).
28. *Bursera velutina* Bullock: The leaf is a rich source of volatile oil (4.5 ±0.6% (w/w). Chemical analysis indicated that 2-phenylethanol (29.5%), α-phellandrene (28.8%) and β-phellandrene (11.0%) were the most abundant compounds in the leaves (Noge *et al.*, 2011).
29. *Canarium album* (Lour.) Raeusch.: About 50 compounds were identified in the essential oil obtained from fresh leaves. The main components were β-myrcene (23.7%) and β-caryophyllene (15.0%). The olfactorially compounds, found with concentration higher than 0.1% were (*Z*)-3-hexenyl acetate, 1-hexyl acetate, terpinen-4-ol, salicyl methylate, β-ionone, nerolidol, (*Z*)-3-hexenyl benzoate, linalyl acetate, τ-muurulol, 6,10,14-trimethyl-2-pentadecanone, and phytol (Thang *et al.*, 2004b). Twenty-nine compounds representing 95.2% of the essential oil, from the resin, were identified. Monoterpenoids made up 93.2% of the oil, with β-pinene (33.3%), α-terpinene (19.4%), γ-terpinene (14.1%), and terpinen-4-ol (11.9%) as the main components. Sesquiterpenoids made up 2.0% of the oil, and the content of each individual was below 0.5% of the oil (Giang *et al.*, 2006).
30. *Canarium bengalense* Roxb.: Thirty-seven components were identified from the volatile oil from the fresh leaves, of which the major components were sabinene (15.9%), caryophyllene (17.5%) and *epi*-bicyclosesquiterpene (10.4%). Predominant minor constituents included Δ^3-carene (3.6%), *p*-cymene (3.7%), γ-terpinene (6.2%), terpinen-4-ol (3.7%), α-humulene (3.1%), germacrene B (2.6%), γ-elemene (7.3%), and caryophyllene oxide (2.0%) (Thang *et al.*, 2004a).

31. *Canarium boivinii* Engl.: Limonene, dipentene and α-pinene were identified from the resin (Billet *et al.*, 1971).
32. *Canarium parvum* Leen.: The main components were β-caryophyllene (18.7%), (*E*)-β-ocimene (12.9%), (*Z*)-β-ocimene (11.9%), germacrene D (8.8%) and α-humulene (8.4%) in the leaf; β-caryophyllene (30.4%), α-copaene (20.5%) and (E)-β-ocimene (7.7%) in the stem. However, germacrene D (23.2%), α-amorphene (14.9%), α-copaene (9.8%) and β-elemene (8.6%) were present in the resin (Thang *et al.*, 2014).
33. *Canarium pimela* Leenh.: Nineteen compounds were identified in the essential oil of the leaves. Caryophyllene(33.47%),α-pinene (18.03%), d-limonene (16.82%), 3-thujene (11.74%) and α-phellandrene (6.51%) were the main constituents (Yang *et al.*, 2007).
34. *Canarium schweinfurthii* Engl.: The essential oils (5.3% and 7.2%) of the resins from two localities in Cameroon, contain as major compounds *p*-cymene, limonene and α-terpineol with different content (Table **3**) (Dongmo *et al.*, 2010).
35. *Canarium tramdenanum* Dai et Yakovl.: The essential leaf contains β-caryophyllene (16.8%), α-phellandrene (15.9%), γ-elemene (13.1%) and limonene (11.8%), while limonene (25.7%), α-phellandrene (21.7%), α-pinene (12.3%) and β-caryophyllene (10.9%) were present in the stem. However, δ-elemene (14.6%) and bulnesol (16.0%) are the main constituents in the resin (Thang *et al.*, 2014).
36. *Dacryodes buettneri* H. J. Lam.: The major volatile components of the fruit were α-pinene (29.2%) and limonene (24.3%) (Cravo *et al.*, 1992). The essential oil, obtained from resin of the plant from Gabon is characterized by a high proportion of terpinen-4-ol (27.33%) along with *p*-cymene (19%), α-pinene (13.23%), sabinene (4.40%) and isoascaridol (4%) (Table **9**) (Obame *et al.*, 2007b; Tee *et al.*, 2014).
37. *Dacryodes edulis* (G. Don) H. J. Lam (African pear): The essential oil extracted from the whole fruit mainly consists of α-pinene (22.3%), β-pinene (13.7%); α-phellandrene (10.8%) and limonene (7.2%). Also, reported α-pinene (fresh/boiled/roasted): 60.3%/44.9%/37.1%), β-pinene (8.2/21.1/16.2), myrcene (15.0/7.3/20.9) and limonene (3.6/6.3/3.4), to be the main constituents of the essential oil extracted from fresh, boiled and roasted fruit. The essential oil from the seed is mainly composed of α-pinene (13.7–21.5%), β-pinene (3.1–19.7%), limonene (27.5%) and α-phellandrene (12.1%). In addition, dimethyl sulfide (4.1%/7.0%) and hexanal (4.6%/8.1%) could be identified in the pulp headspace of boiled and roasted *D. edulis* fruits (Jirovetz *et al.*, 2003, 2005) (Table **9**). The major constituents in the resinl oil, obtained from the plant, growing in Gabon, were sabinene (21.76%), terpinene-4-ol (19.79%), Î±-pinene (17.47%) and *p*-cymene (11.29%) (Koudou *et al.*, 2008).
38. *Dacryodes hexandra*: α-Pinene is the major constituen of the oil resin (Table **9**) (Tee *et al.*, 2014).
39. *Dacryodes igaganga* Aubrev. Et Pellegr.: The major volatile components of the fruit were α-copaene (15.5%) and α-humulene (13.8%) (Cravo *et al.*, 1992).
40. *Protium alstonii*: The resin contains *p*-cymene (31.5%) and *trans*-dihydro-α-terpineol (25.8%) (Zoghbi *et al.*, 2005).

Table **9**. Volatile components from essential oil of some *Dacryodes* species (Tee *et al.*, 2014)

Species	Source	α-Pinene	Sabinene	Terpinene-4-ol	*p*-Cymeme	β-Pinene	γ-Terpinene	Limonene	α-Phellandrene	2,4-Decadienal	Myrcene
Dacryodes. edulis	Resin	17.5	21.8	19.8	11.3	4.3	5.8	5.7	0.2	-	-
	Whole fruit	22.3	0.5	0.9	3.7	13.7	tr	7.2	10.8	6.7	-
	Untreated fruit	60.3	1.4	0.1	0.5	8.2	tr	3.6	0.2	-	15.0
	Boiled fruit	44.9	3.8	tr	0.2	21.1	0.6	6.3	0.8	-	7.3
	Roasted fruit	37.1	1.1	tr	0.1	16.2	0.1	3.4	0.4	-	20.9
	Seeds	21.5	tr	1.2	tr	19.7	0.6	27.5	12.1	tr	-
		13.7	0.5	0.9	1.8	3.1	0.7	8.5	-	-	4.8
Dacryodes buettneri	Resin	13.2	4.4	27.3	19.0	42	1.2	1.8	1.6	-	-
Dacryodes. hexandra	Resin	64.0	-	-	-	-	ND	tr	ND	-	-

Tr: trace compound; ND: not detected

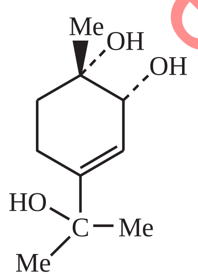
41. *Protium apiculatum*: *p*-Cymene (25.4%) is the major component of the oleoresin essential oil (Silva *et al.*, 2009).
42. *Protiuum aracouchine*: Among the 29 compounds identified in the oil, 95.9% were sesquiterpenes as well, with spathulenol (31.8 ±1.6%), α-*cis*-bergamotene (8.8 ± 0.2%) and viridiflorol (9.±0.7%) as the major components (de Freitas *et al.*, 2011).
43. *Protium confusum*: Forty-six to sixty-three constituents were identified ranging from 73.8% to 98.5% of the essential oils from leaves, fruits, stems and bark. Limonene (60.2%) was the main component in the fruit oil, whereas spathulenol (19.3%), β-caryophyllene oxide (14.1%) and β-caryophyllene (8.0%) reached the highest percentages in the oil from leaves. The volatile oils from bark and stems showed the same major constituents: *p*-cymen-8-ol (14.4% and 6.1%, respectively), spathulenol (9.5% and 9.0% respectively), and hexadecanoic acid (8.4% and 7.8%, respectively) (Santana *et al.*, 2009).
44. *Protium crassipetalum*: The oils of the leaves and branches showed predominance of α-copaene (19.6 and 15.2 %) and trans-caryophyllene (16.4 and 10.1 %), respectively, besides spathulenol (13.9 %), detected in the oil from the leaves (de Carvalho *et al.*, 2013).
45. *Protium decandrum* (Aubl.) Marchand: The major constituent identified in the oil of the leaves and thin branches was α-pinene (78.6%) (Zoghbi *et al.*, 2005). The oils from leaves showed varying content of terpin-4-ol (rachis: 64.8 %; leaflets: 33.0 %). *trans*-α-Bergamotene was the major component identified in the oil from branches (22.1 %) and resin (47.7 %) (de Carvalho *et al.*, 2010).
46. *Protium giganteum*: Among the 32 compounds identified in the oil, 93.6% were sesquiterpenes, with β-caryophyllene (26.0 +/- 0.8%), globulol (9.3 +/- 0.2%), α-cadinol (7.0 +/- 0.5%), α-humulene (6.4 +/- 0.1%) and germacrene D (6.2 +/- 0.3%) as the major components (de Freitas *et al.*, 2011).
47. *P. grandifolium* : *p*-Cymene (46.5%) was the major component of the essential oil from the oleoresin (Silva *et al.*, 2009).
48. *Protium heptaphyllum* (Aubl.) Marchand: The essential oils from the different parts of the plant, growing in several countries, particularly in Brazil, have been extensively studied. The major volatile constituents obtained from the leaves were terpinolene (15.45%), β-elemene (22.09%) and β-caryophyllene (11.11%), while the main component of the stem oil was terpinolene (40.28%) (Zoghbi *et al.*, 1995). The major constituent identified in the fruits was α-terpinene (47.6 %), whereas oil from leaf contained mainly sesquiterpenes such as 9-*epi*-caryophyllene (21.4 %), *trans*-isolongifolanone (10.7 %) and 14-hydroxy-9-*epi*-caryophyllene (16.7 %) (Table **10**) (Pontes *et al.*, 2007). The major constituents identified in the essential oil of leaves were mono and sesquiterpenes such as myrcene (18.6%), β-caryophyllene (18.5%) whereas, oils from resin and fruit contained mainly monoterpenes such as α-pinene (10.5%), limonene (16.9%), α-phellandrene (16.7%), and terpinolene (28.5%) in the resin oil, and α-pinene (71.2%) in the fruit oil (Bandeira *et al.*, 2001). The composition of the oils of two sources of oleoresin varied according to fresh or aged resin. The oil of fresh resin was rich in α-terpinene (18.0%), *p*-cymene (36.0%) and γ-terpinene (12.0%), whereas the aged

Table **10**. Percentage composition of the essential fruit and leaf oils of *Protium heptaphyllum* (Pontes *et al*., 2007)

Compounds	Fruits	Leaves	Compounds	Fruits	Leaves
(*E*)-Salvene	-	0.5	9-*epi*-(*E*)-Caryophyllene	-	21.4
α-Pinene	1.1	-	γ-Muurolene	-	0.6
Verbenene	1.1	-	α-Terpinyl acetate	5.0	-
Myrcene	2.2	-	α-Longipinene	1.5	-
α-Terpinene	47.6	-	Neryl acetate	0.8	-
p-Cymene	1.5	-	Carvacrol acetate	1.5	0.5
β-Phellandrene	-	9.2	Isoledene	-	2.7
Limonene	3.7	0.8	Linalool isobutyrate	1.6	-
(*Z*)-β-Ocimene	2.5	2.0	α-Copaene	-	7.3
trans-Decahydro-naphthalene	0.6	-	β-Bourbonene	-	1.0
α-Pinene oxide	0.8	-	β-Cubebene	-	0.1
Chrysanthenone	1.0	-	β-Elemene	-	0.1
l-Dihydro-linalool	1.0	-	α-Zingiberene	-	0.1
trans-Verbenol	1.3	-	(*Z*)-α-Bisabolene	-	3.5
Karahanaenone	1.1	-	δ-Cadinene	-	1.4
cis-Pinocarveol	1.8	-	Cadina-1,4-diene	-	3.1
Verbenone	1.6	-	α-Cadinene	-	1.0
p-Cymen-9-ol	1.2	-	(*E*)-Nerolidol	-	2.0
trans-Carveol	1.1	-	Carotol	-	0.7
trans-Chrysanthenyl acetate	2.5	-	Guaiol	-	3.7
(*Z*)-Ocimenone	0.5	-	β-Oplopenona	-	1.1
(*E*)-Ocimenone	1.0	-	*trans*-Isolongifolanone	-	10.3
Perilla aldehyde	1.1	-	14-hydroxy-9-*epi*-(*E*)-Caryophyllene	-	16.7
3-Thujyl acetate	0.5	-	Valeranone	-	2.0
trans-Ascaridole	1.2	-	8-Cedren-13-ol	-	0.7
cis-Pinocarvyl acetate	0.9	-	Curcuphenol	-	0.7
iso-Dihydro carveol acetate	3.7	-	Isolongifolol	-	4.1
Terpin-4-ol acetate	0.1	-	14-Hydroxy-α-muurolene	-	0.7
β-Longipinene	3.5	-	Not identified	3.6	2.0

resin oil contained *p*-cymene (11.0%), terpinolene *p*-cymen-8-ol (11.0%) and dillapiole (16.0%) (Siani *et al.*, 1999). Fourteen compounds were characterized, representing 95.8% of the total essential oil from the resin: α-thujene, 0.4; α-pinene, 0.9; sabinene, 1.1; β-pinene, 0.4; α-phellandrene, 10.4; α-terpinene, 13.7; 1,8-cineole, 58.7; terppinolene, 0.7; linalool, 1.0; *cis*-limonene oxide, 0.2; camphor, 0.2; α-terpineol, 1.0; piperitol, 0.6 and γ-terpineol, 7.7% (Rao *et al.*, 2007).

Essential oils from the resin of two subspecies *viz. Protium heptaphyllum* (Aubl.) Marchand subsp. *ulei* (Swat) Daly (PHU), and *Protium heptaphyllum* (Aubl.) Marchand subsp. *heptaphyllum* (PHH) amounted to 8.6% and 11.3% respectively; the chemical compositions of both oils are shown in Table **11** (Marques *et al.*, 2010). Also, the identification of volatile components of the leaves, flowers, resin of the stem, and bark of the branches of *P. heptaphyllum* tree growing in Colombia, was reported. The main constituents identified in the volatile fraction of the leaves were guaiol (14,4%), α-copaene (8,6%), 1,10-di-*epi*-cubenol (8,1%), β-caryophyllene (5,7%), and γ-cadinene (5,4%). Germacrene D (13,9%), germacrene B (13,4%), bicyclogermacrene (11,8%), and limonene (8,3%) were determined in the flowers, while *p*-cymene (30,1%), α-pinene (22,1%), and limonene (14,4%) were identified in the resin; germacrene D (27,7%), 1,10-di-*epi*-cubenol (7,9%), guaiol (7,4%), and γ-cadinene (6,9%) were found in the bark. The analysis of the resin showed a high percent of monoterpenes (~ 60%); while the leaves presented a high content of oxygenated sesquiterpenes (~60%); flowers and bark showed a high composition of sesquiterpenes (40-50%) (Tafurt-García and Muñoz-Acevedo, 2012). A monoterpene, *p*-menth-3-ene-1,2,8-triol (**10**), was also isolated from the resin, fruits, leaves and trunk (Bandeira *et al.*, 2002).



10 *p*-Menth-3-ene-1,2,8-triol

49. *Protium heptaphyllum* subsp. *ulei*: The main constituents in leaves were α-copaene (11.8 %), *trans*-caryophyllene (16.9 %) and germacrene B (12.8%) (de Carvalho *et al.*, 2013).
50. *Protium javanicum* Burm. f.: The volatile oil of the leaves constituted mainly of monoterpenes such as β-ocimene (49.87%) and α-pinene (0.36%) and sesquiterpenes such as β-caryophyllene (24.95%), germacrene (4.01%), α-humulene (2.98%), β-elemene (2.38%), caryophyllene oxide (0.81%), α-amorphene (0.46%), and spathulenol (2.64%) (Sukmajaya *et al.*, 2012).

Table **11**. Chemical composition of essential oil of the *Protium heptaphyllum* (Marques *et al*., 2010)

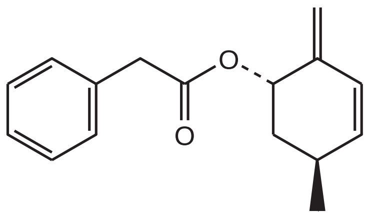
Compound	PHU %	PHH %	Compound	PHU %	PHH %
Thujene	-	1.88	*trans*-*p*-Menthan-8-ol		2.46
α-Pinene	3.96	-	*p*-Cymen-8-ol	13.62	
β-Pinene	3.42	0.60	α-Terpineol	1.00	
cis-Pinene	-	1.17	Verbenone	0.39	
p-Menth-3-ene	-	3.17	Chrysanthenyl acetate	0.72	
α-Phellandrene	2.02	7.41	*n*-Tridecane		1.75
α-Terpinene	1.49	1.68	Methyl eugenol	0.76	
p-Cymene	4.75	39.93	*n*-Tetradecane		13.38
Pseudocumene	3.06		β-(*E*)-Caryophyllene		1.16
Dihydro-4-carene		11.69	α-Humulene		0.43
1,8-Cineole	3.07		γ-Gurjunene		0.45
Limoene	11.87		*n*-Pentadecane		4.49
γ-Terpinene	2.62		β-Bisabolene		0.44
p-Metha-2,4(8)-diene		0.85	α-Bisabolene		0.25
Terpinolene *p*-mentha-1,3,8-triene	42.31 0.68	4.22	Elemicin *n*-Hexadecane		0.27 0.85
			Total (%)	95.74	98.53

PHU: *Protium heptaphyllum* subsp. *ulei*; PHH: *Protium heptaphyllum heptaphyllum*

The essential oil of young leaves contained 11 compounds: α-pinene (0.75 %), β-pinene (0.54 %), δ-3-carene (0.38 %), octatriene (1.35%), *trans*-β-ocimene (77.63 %), β-elemene (1.23 %), *trans*-caryophyllene (12.62 %), α-humulene (1.18 %), germacrene (3.25 %), ethanone (0.65 %) and isospathulenol (0.42 %) while the essential oil of old leaves contained 21 compounds: α-pinene (0.71 %), β-pinene (0.44 %), β-myrcene (0.15 %), cis-ocimene (2.06 %), *trans*-β-ocimene (52.79 %), *trans*-caryophyllene (30.02 %), α-humulene (2.80 %), germacrene (4.64 %), α-farnesene (0.85 %), β-elemene (0.16 %), tridecatrienenitrile (0.19 %), ethanone (0.49 %), caryophyllene oxide (0.83 %), nerolidol (0.12 %), spathulenol (1.25 %), isospathulenol (1.18 %), kauran (0.30 %), isospathulenol (0.16 %), spathulenol (0.34 %) and α-farnesene (0.23 %) (Setianingsih *et al*., 2013).

51. *Protium neglectum*: Twenty-eight compounds were identified, accounting for 99.3 % of the total oil (yield 1.0 % w/w). The most abundant compounds were the oxygenated monoterpenes (78.4%), with piperitenone (25.4%) as the major constituent, followed by thymol (17.5%), durenol (15.6%), methyl eugenol (9.2%), α-terpineol (6.9%) and *p*-cymene (5.2%) (Suárez *et al*., 2007).

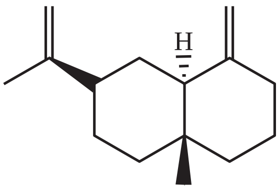
52. *Protium pilosissimum*: The oils samples were marked by presence of β-sesquiphellandrene (24.3 %) in leaves and selin-11-en-4-α-ol of branches (de Carvalho *et al.*, 2013).
53. *Protium pilosum*: The essential oil of leaves and thin branches was rich in α-pinene (31.7%), *p*-cymene (31.2%) and α-phellandrene (24.1%) (Zoghbi *et al.*, 2005).
54. *Protium polybotryum:* Khusimone (35.9 %) was found to be the major constituent in the oil (de Carvalho *et al.*, 2013).
55. *Protium spruceanum* (Benth.) Engl.: The major components identified in the oils of leaves and thin branches were sabinene (33.9%), terpinen-4-ol (10.3%) and β-caryophyllene (10.8%). The main compounds identified in the oils of bark wood and fruits were sabinene (33.8%, 56.1%) and limonene (19.4%, 22.1%), respectively. The major components from the resin oil were camphor (14.5%) and epi-α-cadinol (20.4%) (das Graças *et al.*, 2002). Also, it was reported that sabinene (56.3%), was the major constituent identified in the oil of the leaves and thin branches (Zoghbi *et al.*, 2005).
56. *Protium strumosum*:The resin contains limonene (75.5%) (Zoghbi *et al.*, 2005).
57. *Protium subserratum* (Engl.) Engl.: The main constituents found in the extract obtained from the resin were β-phellandrene (56.3%) and α-phellandrene (20.8%) (Zoghbi *et al.*, 1998).
58. *Santiria trimera* (Oliv.) Aubrév: The leaf essential oil was dominated by sesquiterpenes (76.5%), among which α-humulene (34.6%) and β-caryophyllene (14.9%) were the major components. The bark essential oil was almost exclusively monoterpenic, with α-pinene (51.5%) and α-terpineol (16.8%) as main constituents (Bikanga *et al.*, 2010).
59. *Tetragastris panamensis* (Engl.) Kuntz: The most abundant components identified in the extract obtained from the resin were β-caryophyllene (27.5%) and α-pinene (6.7%) (Zoghbi *et al.*, 1998).
60. *Trattinickia burserifolia*: A monoterpene, 2(*S*)-phenylacetoxy-4(*R*)-*p*-mentha-1(7),5-diene (**11**), was isolated from the oleoresin (Lima *et al.*, 2004).



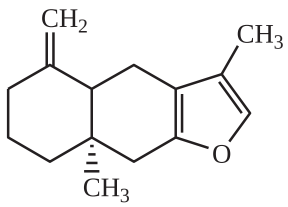
11 2(*S*)-Phenylacetoxy-4(*R*)-*p*-mentha-1(7),5-diene

Sesquiterpenes

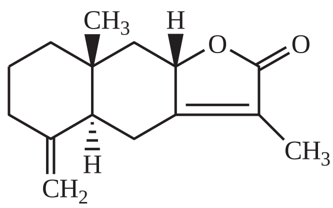
Several sesquiterpenes have been identified from the essential oils of several species, as mentioned above. Germacrene D was one of the predominant components (15.1-56.2%) of the leaves of five *Bursera* species, studied by Noge and Becerra (2009). In addition, other sesquiterpenes were also isolated from some species of the family. The following sesquiterpes were identified from the resin of *Trattinickia rhoifolia* Wiild.: eudesma-4(15),7(11)-dien-8α,12-olide-olide (de Delgado *et al.*, 1995), α-selinene, β-selinene (**12**), atractylon (**13**), asterolide (**14**), biatractylolide (**15**), atractylenolide III (**16**), eudesma-7(11),8-dien-12,8-olide, α-copaene, α-cubebene (**17**), α-ylangene (**18**), (11ξ*H*)-eudesm-3-en-12-oic acid, (11ξ*H*)-dihydro-β-costic acid, β-costic acid (**19**), 8β,9α-dihydroxyeudesma-4(15),7(11)-dien-12,8-olide (**20**), 8β,9β-epoxyeudesma-4(15),7(11)-dien-12,8-olide (**21**), 8,8'-bis [eudesma-4(15),7(11)-dien-12,8β-olide] (**22**), (11*S*)-8-oxoeudesma-4(15),7(11)-dien-12-oic acid (**23**), and (11*R*)-8-oxoeudesma-4(15),7(11)-dien-12-oic acid (**24**) (Rosquete *et al.*, 2010).



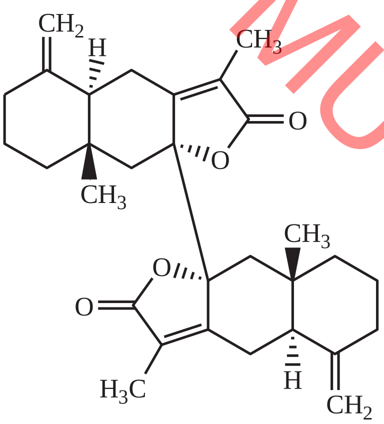
12 β-Selinene



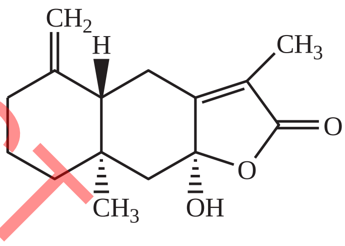
13 Atractylon



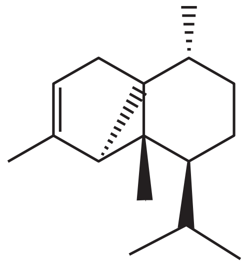
14 Asterolide



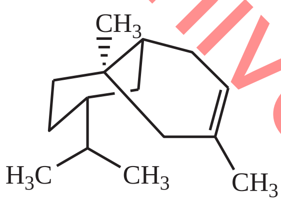
15 Biatractylolide



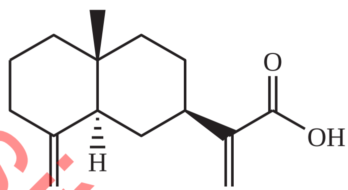
16 Atractylenolide III



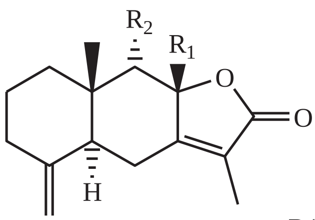
17 α-Cubebene



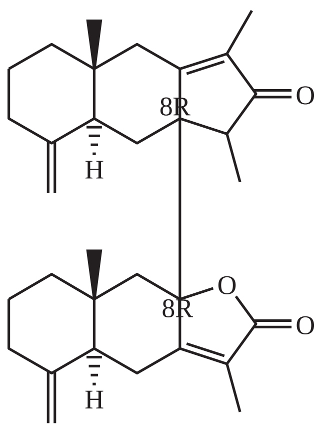
18 α-Ylangene



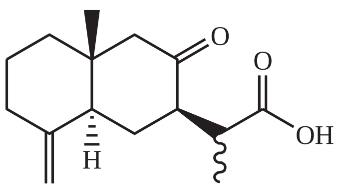
19 β-Costic acid



		R1	R2
20	**8β,9α-Dihydroxyeudesma-4(15),7(11)-dien-12,8-olide**	β-OH	α-OH
21	**8β,9β-Epoxyeudesma-4(15),7(11)-dien-12,8-olide**	β-OAc	α-OAc



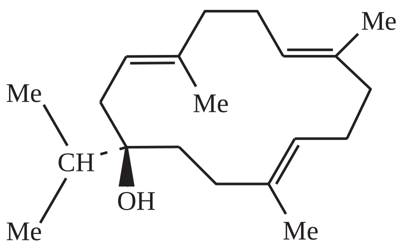
22 8,8'-Bis [eudesma-4(15),7(11)-dien-12,8β-olide]



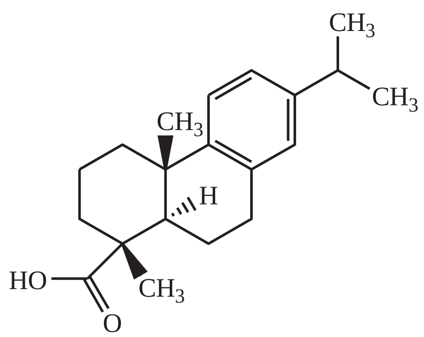
23 (11S)-8-Oxoeudesma-4(15),7(11)-dien-12-oic acid
24 (11R)-8-Oxoeudesma-4(15),7(11)-dien-12-oic acid

Diterpenes

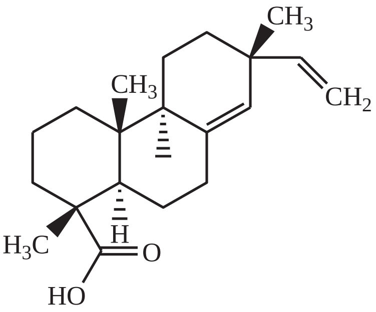
1. *Boswellia carterii*: Cembrenol (**25**, (*S*)-1-isopropyl-4,8,12-trimethyl-cyclotetradeca-3*E*,7*E*,11*E*-trien-1-ol (Klein and Obermann, 1978), a verticillane-type diterpene, verticilla-4(20),7,11-triene, was isolated from the essential oil of resinoid (olibanum) (Basar *et al.*, 2001). Also, two tricycic diterpenes, dehydroabietic acid (**26**) and sandaracopimaric acid (**27**) (Guo *et al.*, 2007) and two cembrane-type diterpenes incensole (**28**) and incensole acetate (Akihisa *et al.*, 2006; Camarda *et al.*, 2007) were identified in the resin.
2. *Boswella dalzielii***:** Incensole was also isolated from the stem bark (Alemike *et al.*, 2006).
3. *Boswellia papyrifera*: Incensole and incensole acetate were isolated from the resin oil (Camarda *et al.*, 2007).
4. *Boswellia serrata:* Serratol (**29**) (Pardhy and Bhattacharyya, 1978a), isoincensole and isoincensole acetate (Camarda *et al.*, 2007) were identified from the resin.
5. *Bursera kerberi:* The stems afforded (1*S*,3*E*,7*E*,11*S*,12*R*)-(+)-verticilla-3,7-dien-12-ol; (1*S*,3*E*,7*E*,11*R*)-(+)-verticilla-3,7,12(18)-triene; (1*R*,3*E*,7*E*,11*R*,12*Z*)-(+)-verticilla-3,7,12-triene and (1*R*,7*E*,11*Z*)-(-)-verticilla-4(20),7,11-triene (Hernández-Hernández *et al.*, 2005).
6. *Bursera suntui:* Several verticillane and oxygentated verticillene derivatives were isolated from the stems: (1*S*,3*E*,7*E*,11*S*,12*S*)-(+)-verticilla-3,7-dien-12-ol (**30**); (1*S*,3*E*,7*E*,11*S*,12*S*)-(+)-verticilla-3,7-dien-12,20-diol (**31**); (1*S*,3*E*,7*E*,11*S*,12*S*)-(+)-verticilla-3,7-dien-12,20-diol 20-acetate (**32**); three hydrocarbon derivatives, [(1*S*,3*E*,7*E*,11*R*)-(+)-verticilla-3,7,12(18)-triene (**33**); (1*R*,3*E*,7*E*,11*R*,12*Z*)-(+)-verticilla-3,7,12-triene (**34**) and (1*R*,7*E*,11*Z*)-(-)-verticilla-4(20),7,11-triene (**35**)] (Hernández-Hernández *et al.*, 2005); (1*S*,3*Z*,7*S*,8*S*,11*S*,12*S*)-(+)-7,8-epoxyverticill-3-en-12,20-diol (**36**); (1*S*,3*Z*,7*S*,8*S*,11*S*,12*S*)-(+)-7,8-epoxyverticill-3-en-12,20-diol 20-acetate (**37**), (1*S*,3*Z*,7*S*,11*S*,12S)-(+)-verticilla-3,8(19)-dien-7,12,20-triol (**38**), and (1*S*,3*Z*,7S,11*S*,12*S*)-(+)-verticilla-3,8(19)-dien-7,12,20-triol 20-acetate (**39**) (García-Gutiérrez *et al.*, 2008).



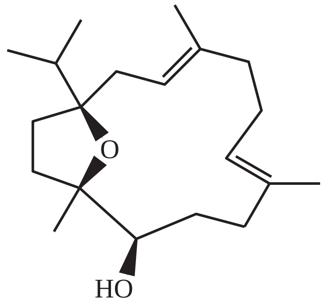
25 Cembrenol



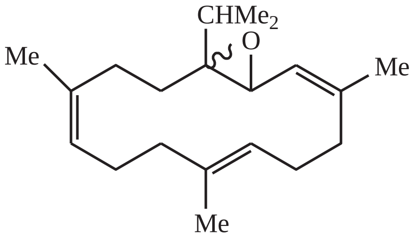
26 Dehydroabietic acid



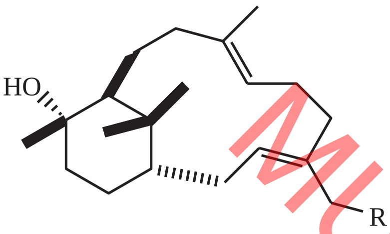
27 Sandaracopimaric acid



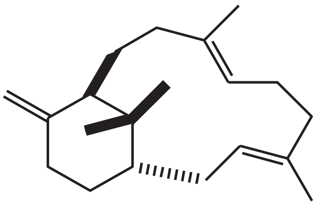
28 Incensol



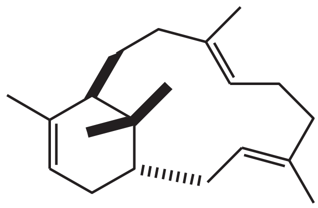
29 Serratol



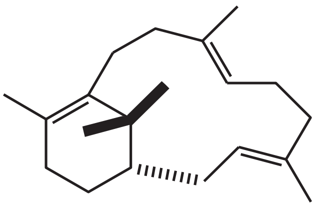
30 R=H
31 R=OH
32 R=OAc



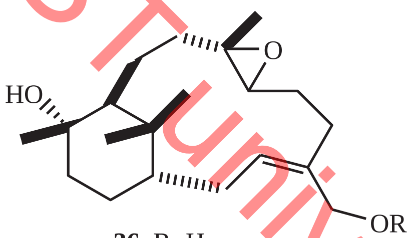
33



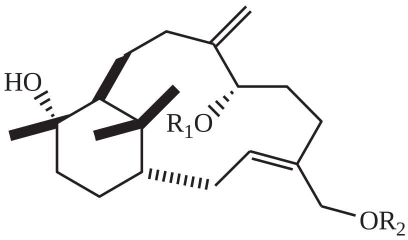
34



35



36 R=H
37 R=Ac



38 R_1=H, R_2=H
39 R_1=H, R_2=Ac

Triterpenes and Sterols

The oleoresin, exuded by the majority of species contained a rich mixture of triterpenes (especially of the oleanane, ursane and euphane series) (Pernet, 1972). Several other triterpenes belonging to lupine and tirucalline skeleta were also isolated from the resin (e.g. Badria *et al.*, 2003). Fifteen triterpene acids, *viz*., seven of the β-boswellic acids (ursane-type), two of the α-boswellic acids (oleanane-type), two of the lupeolic acids (lupane-type), and four of the tirucallane-type were isolated from the resin of *Boswellia carterii* (Banno *et al.*, 2006). Zhang *et al.* (2013) reviewed the characteristic 47 triterpenoids in frankincense harvested from various *Boswellia* species (Table **12**). The major constituents of the latex of 4 *Bursera* species are 3α-hydroxylupene (epilupeol) and α-amyrin (Tursch and Tursch, 1961).

The resins of 10 *Protium* and *Trattinnickia* species consisted exclusively of triterpenes, showing a common predominance of four major compounds in all the samples, corresponding to α-amyrin, β-amyrin, α-amyrenone and β-amyrenone. This profile was complemented with minor amounts of the tetracyclic β-elemolic and α-elemolic acids, maniladiol, brein and other oxidised trace compounds (Siani *et al.*, 2012). The triterpenoids of some species of the family Burseraceae are listed in (Table **13**).

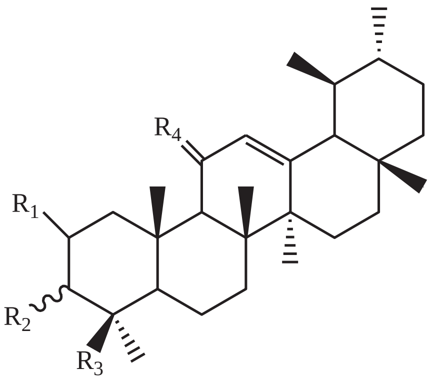
Table **12**. Characteristic triterpenoids in frankincense harvested from some *Boswellia* species Zhang *et al.*, 2013)

No.	Common name	Resource
	Pentacyclic triterpenes	
1	β-Boswellic acid (β-BA) (**40**)	*B .carterii, B. sacra, B. serrata*
2	3-acetyl-β-BA (Aβ-BA) (**41**)	*B. serrate, B .carterii*
3	11-keto-β-BA (Kβ-BA) (**42**)	*B. carterii, B. serrata*
4	3-acetyl-11-keto-β-BA (AKβ-BA) (**43**)	*B. carterii, B. serrata*
5	12-ursene-2-diketone (**44**)	*B. serrata*
6	3-acetyl-11α-methoxy-β –BA (**45**)	*B. carterii*
7	2α,3α-dihydroxy-urs-12-en-24-oic acid (**46**)	*B. serrata*
8	urs-12-en-3α,24-diol (**47**)	*B. serrata*
9	α-amyrenone (**48**)	*B. carterii, B. serrata*
10	3-epi-α-amyrin (**49**)	*B. carterii, B. serrata*
11	α-amyrin (**50**)	*B. carterii, B. serrata*
12	3-acetyl-11-hydroxy-BA (**51**)	*B. serrata*
13	3-acetyl-9,11-dehydro-β-BA (**52**)	*B. carterii*
14	9,11-dehydro-β-BA (**53**)	*B. carterii*
15	18Hα,3β,20β-ursanediol (**54**)	*B. carterii*
16	α-Boswellic acid (α-BA) (**55**)	*B. carterii, B. serrata*
17	3-acetyl α-BA(Aα-BA) (**56**)	*B. serrate, B. carterii*
18	β-amyrenone (**57**)	*B. carterii, B. serrata*
19	3-epi-β-amyrin (**58**)	*B. carterii, B. serrata*
20	β-amyrin (**59**)	*B. carterii, B. serrata*
21	3α,24-dihydroxy-olean-12-ene (**60**)	*B. serrata*
22	olibanumol E (**61**)	*B. carterii*
23	9,11-dehydro-α-BA (**62**)	*B. serrata*
24	3-acetyl-9,11-dehydro-α-BA (**63**)	*B. serrata*
25	lupeolic acid (**64**)	*B. carterii*
26	acetyl-lupeolic acid (**65**)	*B. carterii*
27	lupenone (**66**)	*B. frereana*
28	epi- lupeol (**67**)	*B. frereana*
29	lupeol (**68**)	*B. frereana, B. carterii*
30	3-acetyl-28-hydroxy-lupeolic acid (**69**)	*B. carterii*
31	3-acetyl-27-hydroxy-lupeolic acid (**70**)	*B. papyrifera*
32	methyl-3α-O-acetyl-27-hydroxy-lupeolic acid (**71**)	*B. papyrifera*
33	olibanumol F (**72**)	*B. carterii*
34	olibanumol G (**73**)	*B. carterii*

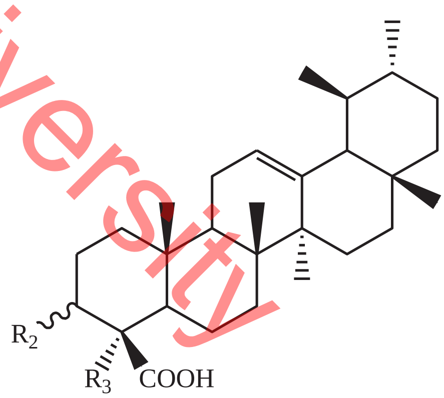
Table **12**. Characteristic triterpenoids in frankincense harvested from some *Boswellia* species Zhang *et al*., 2013) (cont.)

No.	Common name	Resource
	Tetracyclic triterpenes	
35	α-elemolic acid (**74**)	*B. carterii*, *B. serrata*
36	elemonic acid (3-oxo-tirucallic acid) (**75**)	*B. carterii*, *B. serrata*
37	β-elemolic acid (**76**)	*B. carterii*, *B. serrata*
38	3β-acetoxy-tireucallic acid (**77**)	*B. carterii*
39	3α-acetoxy-tirucallic acid(B) (**78**)	*B. serrata*
40	3α-hydroxy-tir-7,24-dien-21-oic acid (**79**)	*B. carterii*
41	3α-acetoxy-tirucallic acid(A) (**80**)	*B. carterii*
42	3-oxo-tir-7,9(11),24-trien-21-oic acid (**81**)	*B. carterii*
43	3β-O-acetyl-16(S),20(R)-dihydroxy-dammar-24-ene (**82**)	*B. frereana*
44	3β,20(S)-dihydroxy-dammar-24-ene (**83**)	*B. frereana*
45	3β-O-acetyl-20(S)-hydroxy-dammar-24-ene (**84**)	*B. frereana*
46	20(S)-protopanaxadiol (**85**)	*B. frereana*
47	20,22-epoxyeupha-24-ene-3-one (**86**)	*B. serrata*

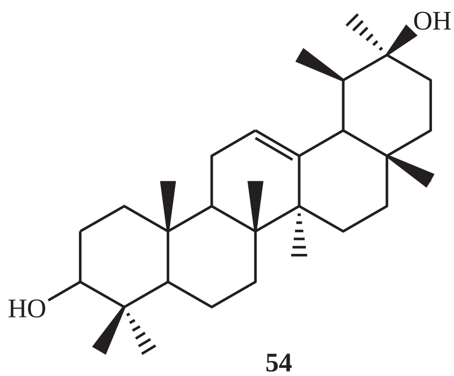
Boswellia *carterii*, Boswellia *frereana*, Boswellia *papyrifera*, Boswellia *sacra*, Boswellia *serrate* and Boswellia *serrata*



	R_1	R_2	R_3	R_4
40	H	α-OH	COOH	H,H
41	H	α-OAc	COOH	H,H
42	H	α-OH	COOH	O
43	H	α-OAc	COOH	O
44	H	=O	CH_3	O
45	H	α-OAc	COOH	α-OCH_3,H
46	α-OH	α-OH	COOH	H,H
47	H	α-OH	CH_2OH	H,H
48	H	=O	CH_3	H,H
49	H	α-OH	CH_3	H,H
50	H	β-OH	CH_3	H,H
51	H	α-OAc	COOH	OH,H



	R_3
52	α-OAc
53	α-OH



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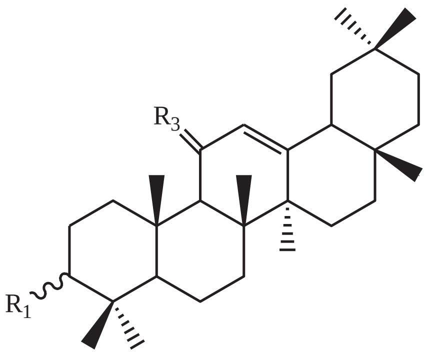
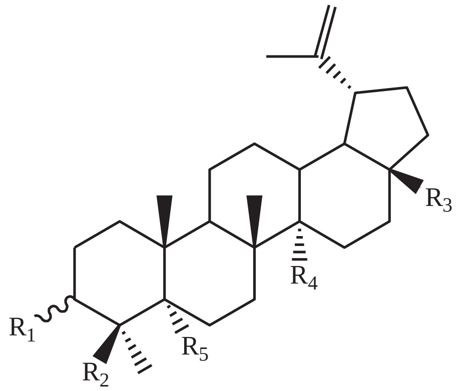
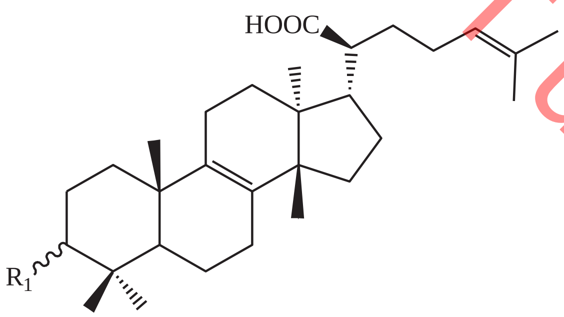


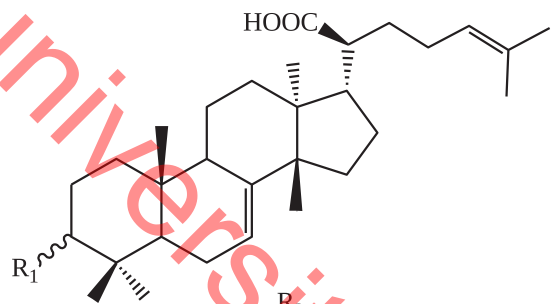
	R_1	R_2	R_3
55	α-OH	COOH	H,H
56	α-OAc	COOH	H,H
57	=O	CH3	H,H
58	α-OH	CH3	H,H
59	β-OH	CH3	H,H
60	α-OH	CH2OH	H,H
61	α-OH	CH3	α-OCH3, H
62	α-OH	COOH	H
63	α-OAc	COOH	H



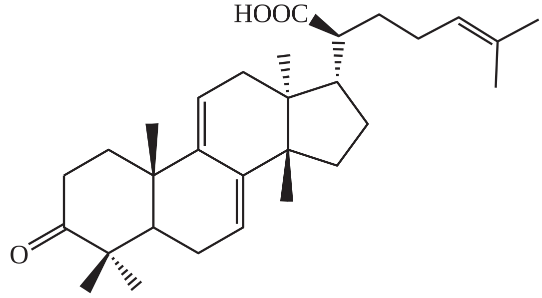
	R_1	R_2	R_3	R_4	R_5
64	α-OH	COOH	CH_3	CH_3	H
65	α-OAc	COOH	CH_3	CH_3	H
66	=O	CH_3	CH_3	CH_3	H
67	α-OH	CH_3	CH_3	CH_3	H
68	β-OH	CH_3	CH_3	CH_3	H
69	α-OAc	COOH	CH_2OH	CH_3	H
70	α-OAc	COOH	CH_3	CH_2OH	H
71	α-OAc	$COOCH_3$	CH_3	CH_2OH	H
72	α-OOCH	CH_3	CH_3	CH_3	H
73	α-OH	CH_3	CH_3	CH_3	OH



	R_1
74	α-OH
75	=O
76	β-OH
77	β-OAc
78	α-OAc



	R_2
79	α-OH
80	α-OAc



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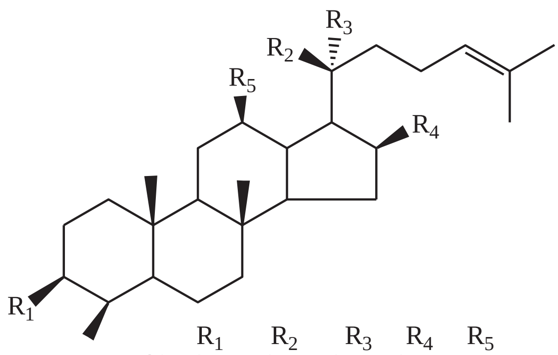
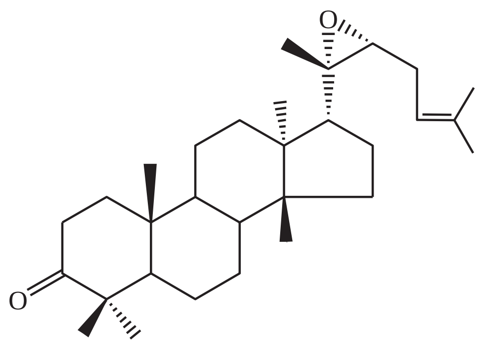


	R_1	R_2	R_3	R_4	R_5
82	OAc	CH_3	OH	OH	H
83	OH	OH	CH_3	H	H
84	OAc	OH	CH_3	H	H
85	OH	OH	CH_3	H	H



86

A steroid saponin, stigmasta-5,24(28)-diene-3β-*O*-α-D-glucopyranosyl-α-L-rhamnopyranoside was identified from *Boswellia serrata* (Gangwal and Vardhan, 1995b). In addition to the common phytosterols *viz.* β-sitosterol, β-sitosterol-β-D-glucoside, campesterol and stigmasterol, isolated from many species of the family Burseraceae, some other were isolated. Stigmasta-5-ene-3β,7α-diol, stigmasta-5-ene-3β,7β-diol and stigmastane-3β,6α-diol were isolated from the twigs of *Garuga forrestii* (Yin *et al.*, 2008). Sitost-4-en-3-one (β-Sitostenone) was identified from the stems of *Boswellia ovalifoliata* (Reddy *et al.*, 2003) and stem bark of *Boswellia serrata* (Ara *et al.*, 2009).

Cedrelone (a limonoid, $C_{26}H_{30}O_5$) was isolated from the roots of *Balsamodendron pubescens*(Joshi and Hegde, 1979).

Flavonoids

The anthocyanins, petunidin, cyanidin, and peonidin hexosides were isolated from the fruits (Missang *et al.*, 2003). The isolated flavonoids of some species of the family burseraceae are listed in (Table **14**).

Lignans

Liganas of some species of family Burseraceae are shown in (Table **15**).

Coumarins, and Other Phenolic Compounds

Several phenolic compounds including coumarins, coumarinolignoids (phenolic compounds formed from a lignan structure with a coumarin formed in place of one of the two phenylpropanoids), phenolic acids and others have been isolated from many species of this family. The following are some examples of these compounds;

1. *Balsamodendron pubescens*: Siderin (4,7-dimethoxy-5-methyl coumarin) from the roots (Joshi and Hegde, 1979).
2. *Boswellia dalzielii* Hutch: Gallic acid, protocatechuic acid and 4'-methoxy-(*E*)-resveratrol 3-*O*-rutinoside (**133**) from the stem bark (Alemike *et al.*, 2006).
3. *Boswellia ovalifoliolata* Bal. & Henry: Three macrocyclic diaryl ether heptanoids, ovalifoliolatin A (**134**), ovalifoliolatin B (**135**) and acerogenin C (**136**) from the stems (Reddy *et al.*, 2003).

Table **13**. Triterpenes of some species of the family Burseraceae

Species	Plant Part	Triterpenes	References
1. *Aucoumea klaineana*	Ol	α-Amyrin, β-amyrin, β-amyrenone, masticadienediol, 3α-hydroxytirucalla-8,24-dien-21-oic acid (β-elemoic acid), 3 α-hydroxytirucalla-7,24-dien-21-oic acid, 3-oxotirucalla-7,24-dien-21-oic acid, tirucalla-7,24-dien-3,21-dione-21,23-oxide (flindissone lactone), 3α-hydroxy-21-oxotirucalla-7,24-dien-21,23-oxide (flindissol lactone), 21-hydroxy-3-oxotirucalla-7,24-dien-21,23-oxide (flindissone as a mixture of the C-21 epimers), 22ξ-hydroxytirucalla-7,24-dien-3,23-dione, flindissol, and maniladiol (3β,16β-dihydroxyolean-12-ene)	Tessier *et al.* (1982); Liang *et al.* (1988b)
2. *Boswellia carterii*	Ol	α-Boswellic acid (**8**), acetyl α-boswellic acid, β-boswellic acid (**1**), acetyl β-boswellic acid (**2**), 11-keto-β-boswellic acid (**3**), acetyl 11-keto-β-boswellic acid (**4**), acetyl 11α-methoxy-β-boswellic acid (**5**) 9,11-dehydro-β-boswellic acid (**6**), acetyl 9,11-dehydro-β-boswellic acid (**7**), lupeolic acid (**10**), acetyl lupeolic acid (**11**), α-elemolic acid (**12**), β-elemonic acid (**13**), 3α-hydroxytirucalla-7,24-dien-21-oic acid (**14**) and 3α-hydroxytirucalla-8,24-dien-21-oic acid (**16**), 4(23)-dihydroburic acid, 3-oxotirucallic acid, lupeol, 3-hydroxy-tirucallic acid, pinnicolic acid A, 3-ox-olanosta-8,24-dien-21-oic acid and trametenolic acid B	Fattorusso *et al.* (1983); Badria *et al.* (2003); Akihisa *et al.* (2006); Guo *et al.* (2007)
3. *Boswellia freerana*	Ol	3β,20(*S*)-Dihydroxydammar-24-ene, its 3-acetyl derivative, (20*S*)-protopanaxadiol, 3β-acetoxy-16(*S*),20(*R*)-dihydroxydammar-24-ene, lupeol, lupenone and epi-lupeol	Proietti *et al.* (1981); Fattorusso *et al.* (1985)
4. *Boswellia ovalifoliata*	St	3α-Hydroxyurs-12-ene	Reddy *et al.* (2003)

Table **13**. Triterpenes of some species of the family Burseraceae (cont.)

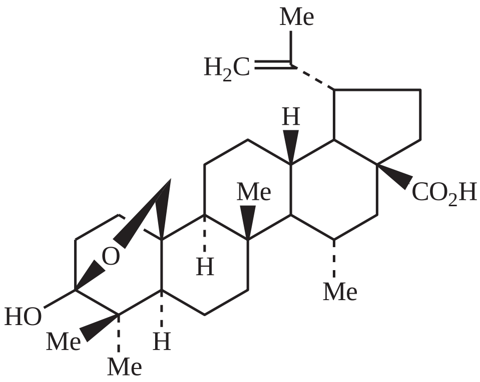
Species	Plant Part	Triterpenes	References
5. *Boswellia papyrifera*	Stb	3α-Acetoxy-27-hydroxylup-20(29)-en-24-oic acid (3), 11-keto-β-boswellic acid, β-elemonic acid, 3α-acetoxy-11-keto-β-boswellic acid and β-boswellic acid	Atta-ur-Rahman *et al*. (2005)
6. *Boswellia serrata*	Ol	β-Boswellic acid, acetyl β-boswellic acid (**2**), 11-keto-β-boswellic acid, acetyl 11-keto-β-boswellic acid, 24-noroleana-3,9(11),12-triene, 24-norursa-3,9(11),12-triene, and 24-norursa-3,12-diene-11-one, α-amyrin, 2α,3α-dihydroxy-urs-12-ene-24-oic acid, urs-12-ene-3α,24-diol, 3α-acetyl-9,11-dehydro-β-boswellic acid, 3α-acetyl-9,11-dehydro-α-boswellic acid, 3α-acetyl-11-keto-β-boswellic acid and 20,22-epoxyeupha-24-ene-3-one	Pardhy and Bhattacharyya (1978b); Mahajan *et al.* (1995); Belsner *et al.* (2003); Singh and Bhakuni (2006a); Hanuš *et al.*(2007); Kaushik *et al.* (2008)
	....	11-Keto-β-boswellic acid, 3-*O*-acetyl 11-keto-β-boswellic acid, α-boswellic acid, β-boswellic acid, 3-*O*-acetyl α-boswellic acid and 3-*O*-acetyl β-boswellic acid	Subbaraju *et al.* (2004)
	B	α-Amyrenol, acetyl β-boswellic acid and 20,24-dihydroxyeupha-2,8,22-triene	Singh and Bhakuni (2006b)
	Stb	β-Amyrin	Ara *et al.* (2009)
7. *Bursera arida*	B, S, L,T	Betulonic acid and benulin (**87**)	Ionescu *et al.* (1977)
8. *Bursera delpechiana*	Ol	11-Oxo-acetyl ursolic acid, 11-oxo-ursolic acid, α-amyrin, 3β-acetoxyurs-11-en-28,13-olide, acetyl ursolic acid, ursonic acid, ursolic acid 3β-Acetoxy-11α, 12α-epoxyurs-28, 13-olide and 3β-acetoxy-12β-hydroxyurs-28, 13-olide	Syamasundar *et al.* (1991); Syamasundar and Mallavarapu (1995)
9. *Bursera graveolens*	B	3-Oxotirucalla-8,24-din-21-oic acid (β-elemonic acid), 3α-hydroxytirucalla-8,24-din-21-oic acid (α-elemolic acid), 3α-hydroxytirucalla-7,24-din-21-oic acid lupeol and epi-lupeol	Nakanishi *et al.* (2005); Robles *et al.* (2005)

Table **13**. Triterpenes of some species of the family Burseraceae (cont.)

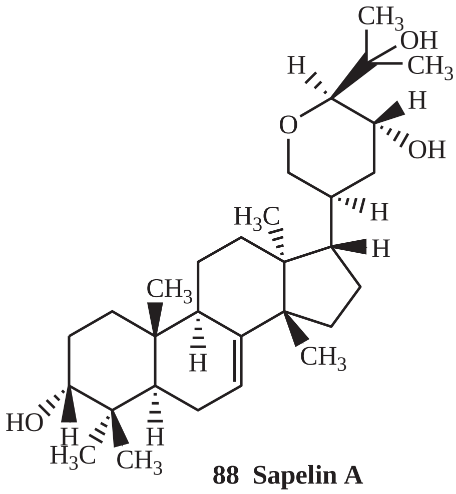
Species	Plant Part	Triterpenes	References
10. *Bursera klugii*	L	Sapelin A (**88**) and sapelin B (**89**)	Jolad *et al.* (1977a)
11. *Bursera schlechtendalii*	…	α-Amyrin	McDoniel and Cole (1972)
12. *Bursera serrata*	Stb	β-Amyrin and β-sitostenone (**90**)	Ara *et al.* (2009)
13. *Bursera simaruba*	Ol	α-Amyrin, β-amyrin, lupeol, epilupeol, epiglutinol (**91**) and lup-20(29)-en-3β,23-diol (**92**)	Peraza-Sánchez *et al.* (1995)
14. *Canarium album*	…	Urs-12-ene-3α, 16β-diol and olean-2-ene-3α, 16β-diol and others	Tamai *et al.* (1989)
15. *Canarium boivinii*	Ol	α-Amyrin, β-amyrin, elemadienonic and elemadienolic acids	Billet *et al.* (1971)
16. *Canarium nigrum*	…	β-Amyrin	Trần *et al.* (2007)
17. *Canarium schwinfurthii*	Ol	α-Amyrin, oleanolic acid, α-amyrenone, erythrodiol, 3-oxo-tirucalla 8,24-dien 21-oic acid, 3α-hydroxytirucalla 7,24-dien 21-oic acid, 3α-hydroxytirucalla 8,24-dien 21-oic acid and 3α-acetoxytirucalla 7,24-dien 21-oic acid	Sawadogo *et al.* (1985)
18. *Canarium strictum*	Ol	α-Amyrin, β-amyrin, β-amyrin acetate, β-amyrin formate and lanosterol	Malhotra *et al.* (1987)
19. *Canarium subulatum*	B	β-Amyrin	Sritularak *et al.* (2013)
20. *Dacryodes edulis*	PO	α-Amyrin, cycloartenol, glutinol and tirucallol	Loemba Ndembi and Silou (2006)
21. *Dacryodes hopkinsii*	Ol	α-Amyrin, β-amyrin, lupeol and tirucallol	Lima *et al.* (2004)
22. *Dacryodes normandii*	Ol	21-Oxo-3,4-*seco*-olean-4(23),12-dien-3-oic acid, and 21-oxo-3,4-*seco*-ursan-4(23),12-dien-3-oic acid	Parsons *et al.* (1991)

Table **13**. Triterpenes of some species of the family Burseraceae (cont.)

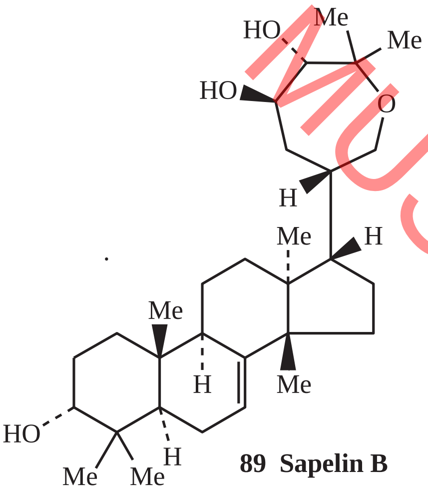
Species	Plant Part	Triterpenes	References
23. *Garuga forrestii*	T	13α,14β,17α-Lanosta-7,24-diene-1β,3β-diol	Yin *et al.* (2008)
24. *Garuga pinnata*	Ol	α-Amyrin, its 3α-epimer, butyrospermol (**93**) and dammaradienol (**94**)	Bhat and Joshi (1985)
	Stb	13α,14β,17α-Lanosta-7,24-diene-1β,3β-diol and 13α,14β,17α-lanosta-7,24-diene-3β,11β,16α-triol	Venkatraman *et al.* (1992, 1994)
25. *Protium apiculatum*	…	Lupeol and cabraleadiol	Lima *et al.* (2001)
26. *Protium crenatum*	Ol	Friedelin (**95**), α-amyrin, β-amyrin,brein (**96**), maniladiol (**97**), 3-oxo-tirucalla-8,24-diene-21-oic acid, 3β-hydroxy-tirucalla-8,24-diene-21-oic acid, 3β-acetoxy-tirucalla-8,24-diene-21-oic acid, 3α-hydroxy-tirucalla-7,24-diene-21-oic acid (**98**), 29-hydroxy-3-oxo-tirucalla-8,24-diene-21-oic acid methyl ester and 3β,19α-dihydroxy-hop-22(29)-ene	Mora *et al.* (2001); Usubillaga *et al.* (2004)
27. *Protium heptaphyllum*	Ol	α-Amyrin, β-amyrin, maniladiol, brein, ursa-9(11):12-dien-3b-ol, oleana-9(11):12-dien-3b-ol, 3a-hydroxy-tirucalla-8,24-dien-21-oic acid, 3a-hydroxy-tirucalla-7,24-dien-21-oic, 3 β,24-dihydroxy-urs-12-ene (**99**), 3-oxo-20S-hydroxytaraxastane (**100**) and 3 β,20S-dihydroxytaraxastane (**101**)	Maia *et al.* (2000); Susunaga *et al.* (2001); Bandeira *et al.* (2002); Lima *et al.* (2014)
	B,L,St	Lupeol	Almeida *et al.* (2002)
28. *Protium iciacariba*	…	α-Amyrin, β-amyrin and lupeol	Lima *et al.* (2001)
29. *Protium kleinii*	Ol	α-Amyrin, β-amyrin, 3-oxo-11β,16β- dihydroxy-urs-12-ene (**102**), 3-oxo-11β-hydroxy-urs-12-ene (**103**), 3-oxo-11β-hydroxy-olean-12-ene (**104**), and 3β,16β-dihydroxy-olean-12-ene (brein)	Lima *et al.* (2005)
30. *Protium strumosum*	Ol	α-Amyrin and β-amyrin	Silva *et al.* (2009)
31. *Protium tenuifolium*	Ol	α-Amyrin and β-amyrin	Silva *et al.* (2009)



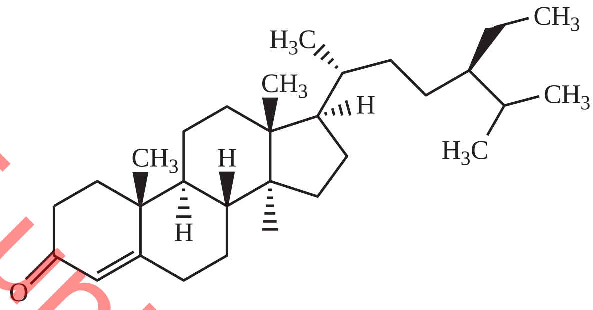
87 Benulin



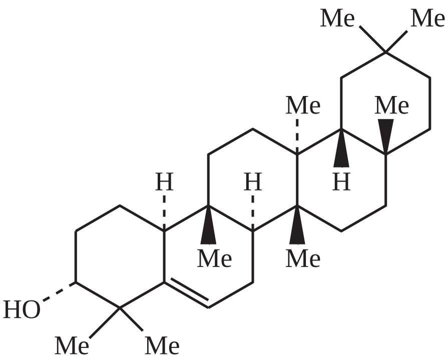
88 Sapelin A



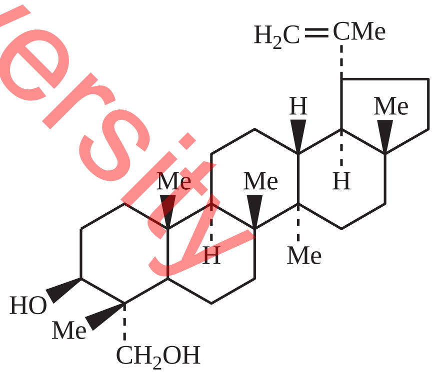
89 Sapelin B



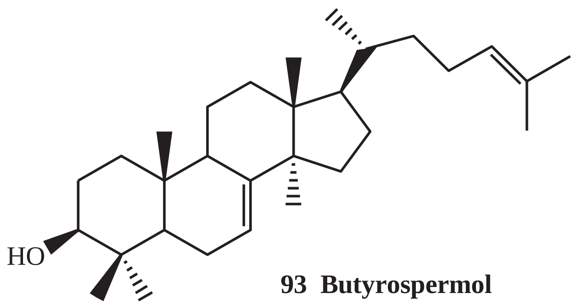
90 β-Sitostenone



91 Epiglutinol



92 Lup-20(29)-en-3β,23-diol

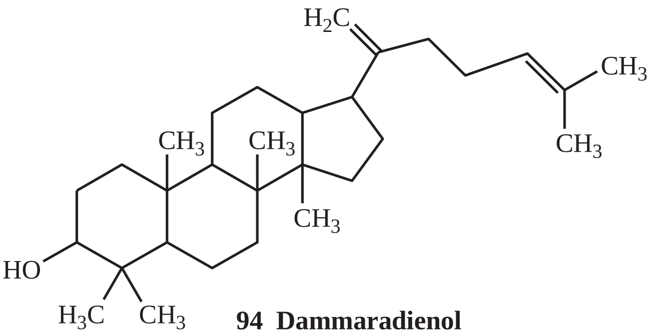


93 Butyrospermol

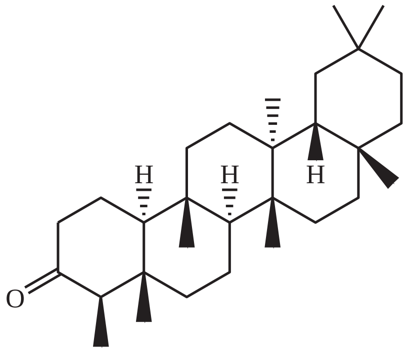
Table **13**. Triterpenes of some species of the family Burseraceae (cont.)

Species	Plant Part	Triterpenes	References
32. *Santiria trimera*	Stb	20(*R*),24(*E*)-3-Oxo-9β-lanosta-7,24-dien-26-oic acid and 20(*R*),24(*E*)-6β-acetoxy-3-oxo-9β-lanosta-7,24-dien-26-oic acid	Da Silva *et al.* (1990)
33. *Tetragastris altissima*	…	Friedelin, secoisobryononic acid (**105**) and taraxerol (**106**)	Lima *et al.* (2001)
34. *Trattinnickia burserifolia*	Ol	α-Amyrenone, α-amyrin, 3-*epi*-α-amyrin, 3α,16β-dihydroxyurs-12-ene (**107**), the oleananes β-amyrenone, β-amyrin, 3-*epi*-β-amyrin,3α,16β-dihydroxyolean-12-ene, the tirucallane acids 3α-hydroxytirucall-8,24-dien-21-oic, 3α-hydroxytirucall-7,24-dien-21-oic and 3-oxotirucall-8,24-dien-21-oic, the dammaranes dammarenediol-II, 3α,20(S)-dihydroxydammar-24-ene, 3β-phenylacetoxyurs-12-ene (**108**), 3β-phenylacetoxyolean-12-ene (**109**) and 3β,16β,11α-trihydroxyurs-12-ene (**110**)	Lima *et al.* (2004)
35. *Trattinnickia peruviana*	B	α-Amyrin and β-amyrin	dos Santos and Ribeiro (1994)
36. *Trattinnickia rhoifolia*	Ol	α-Amyrin, β-amyrin, 3-*epi*-α-amyrin, 3-*epi*-β-amyrin, lupenone, 3α-hydroxytirucall-8,24-dien-21-oic acid, 3α-hydroxytirucall-7,24-dien-21-oic acid and maniladiol	Lima *et al.* (2004); Rosquete *et al.* (2010)

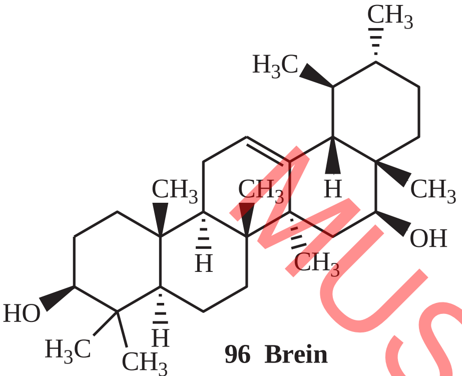
B: bark; L: leaves; Ol: oleogum resin; PO: pulp oil; St: stem; Stb: stem bark; T: twigs



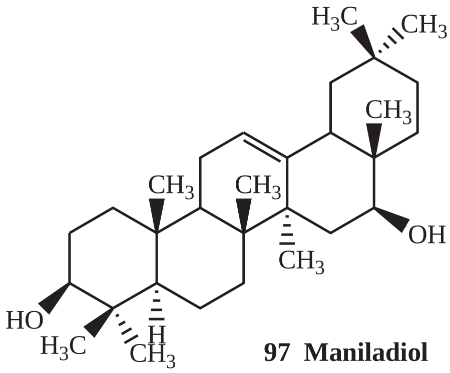
94 Dammaradienol



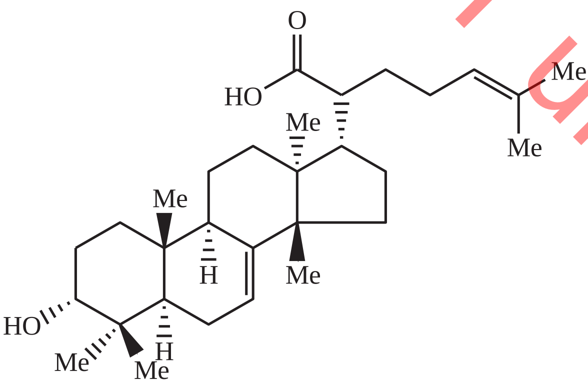
95 Friedelin



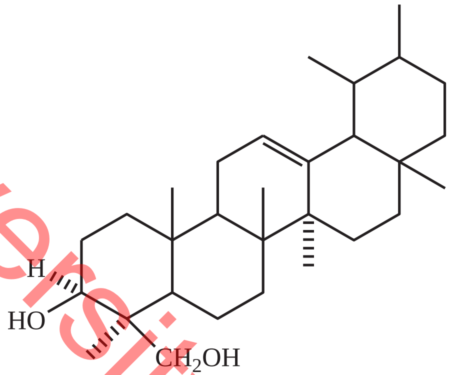
96 Brein



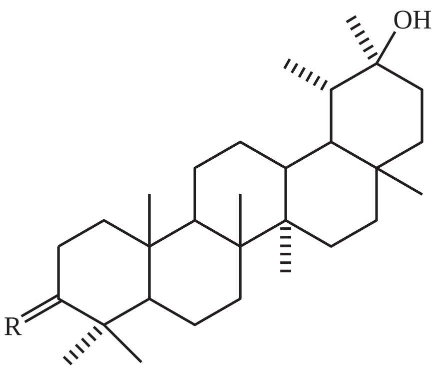
97 Maniladiol



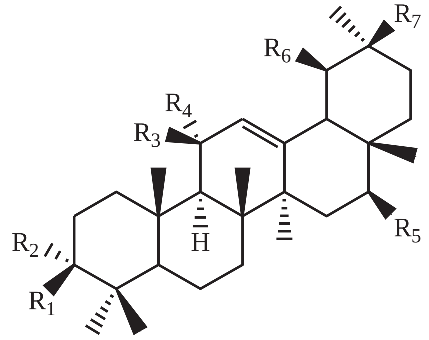
98 3α-Hydroxytirucalla-7,24-dien-21-oic acid



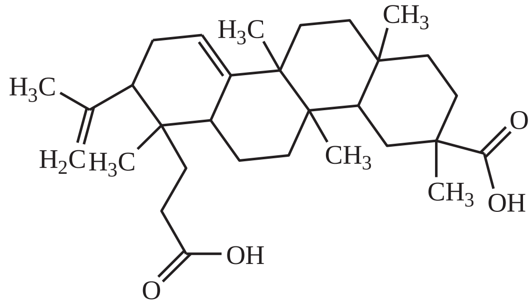
99 3 β,24-Dihydroxy-urs-12-ene



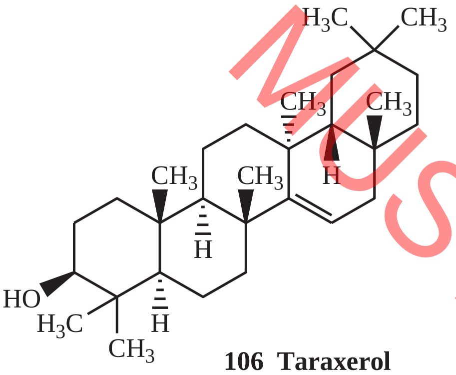
	R
100 3-oxo-20S-Hydroxytaraxastane	O
101 3 β,20S-Dihydroxytaraxastane	OH, H



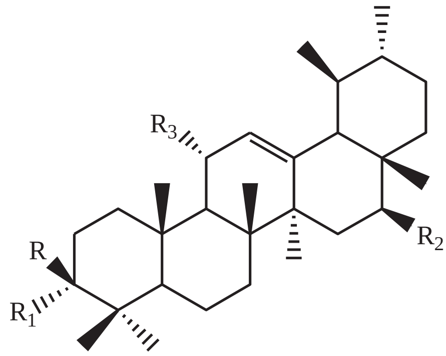
102 R_1=R_2=O, R_3=R_5=OH, R_4=R_7=H, R_6=CH_3
103 R_1=R_2=O, R_3=OH, R_4=R_5=R_7=H, R_6=CH_3
104 R_1=R_2=O, R_3=OH, R_4=R_5=R_6=H, R_7=CH_3



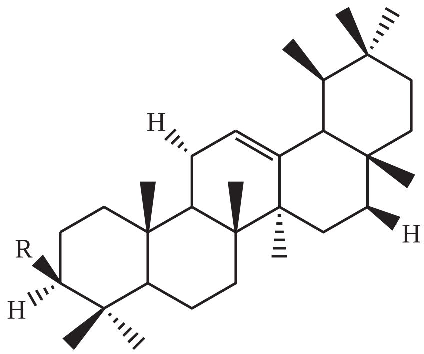
105 Secoisobryononic acid



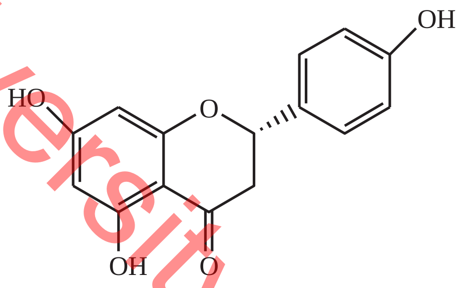
106 Taraxerol



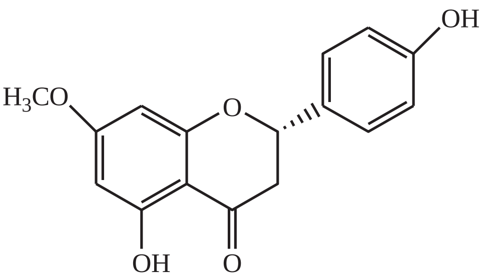
107 R_1, R_2=OH, R, R_3=H
108 R=$OCOCH_2Ph$, R_1, R_2, R_3=H
110 R, R_2, R_3=OH, R_1=H



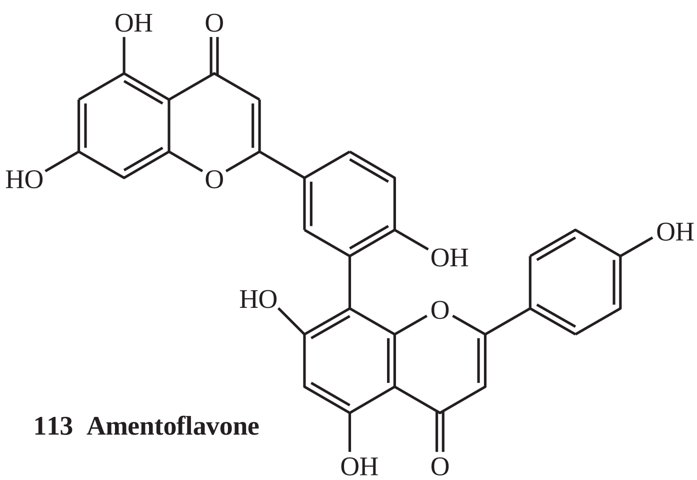
109 R=$OCOCH_2Ph$



111 Naringenin



112 Genkwanin



113 Amentoflavone

Table **14**. Flavonoids of some species of the family Burseraceae

Species	Plant Part	Flavonoids	References
1. *Bursera arida*	B,L,St,T	Naringenin (**111**)	Ionescu *et al.* (1977)
2. *Bursera leptophloeos*	Br	8-(3″-hydroxy-3″-methylbutyl)-5,7,4′-trihydroxydihydroflavonol, 6″,6″-dimethyldihydropyran (2″,3″:7,8)-5,4′-dihydroxydihydroflavonol, 8-(3″-hydroxy-3″-methylbutyl)-5,7,4′-trihydroxyflavonol, 6″,6″-dimethyldihydropyran (2″,3″:7,8)-5,4′-dihydroxyflavonol, 8-(γ,γ-di-methylallyl)-5,7,4′-trihydroxyflavonol, and two new related compounds 8-(γ,γ-dimethylallyl)-5,7,4′-trihydroxydihy-droflavonol and 5″-isopropenyldihydrofuran-(2″,3″:7,8)-5,4′-dihydroxydihydroflavonol	Souza *et al.* (1989)
3. *Canarium album*	L B, Br	Hyperin (quercetin 3-*O*-gaactoside) 4’,5-Dihydroxy-7-methoxyflavanol-*O*-glucopyranoside	Hoang (2004) Hoang (2005)
4. *Canarium nigrum*	Ol	Genkwanin (**112**)	Trần *et al.* (2007)
5. *Canarium schweinfurthii*	S	Amentoflavone	Helene *et al.* (2000)
6. *Dacryodes edulis*	Fr	Quercetin and quercetin rhamnoside, hyperin, isoquercitrin, isorhamnetin rhamnoside and isorhamnetin hexoside	Missang *et al.* (2003); Atawodi *et al.* (2009)
7. *Garuga pinnata*	L	Amentoflavone (**113**)	Ansari *et al.* (1978)
8. *Protium heptaphyllum*	Dp	Quercetin and quercetin-3-*O*-rhamnoside	Bandeira *et al.* (2002)
9. *Trattinnickia glaziovii*	L	Podocarpusflavone A (amentoflavone 4’”-methyl ether)	Siani and Ribeiro (1995)

B: bark; Br: branches; Dp: different parts; Fr: fruits; L: leaves; S: seeds; St: stems

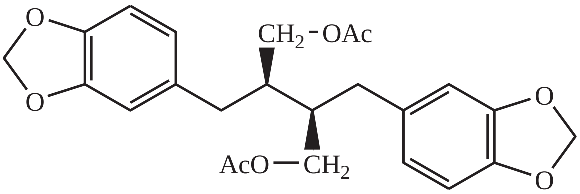
Table **15**. Lignans of some species of the family Burseraceae

Species	Plant Part	Lignans	References
1. *Bursera ariensis*	E	Arinesin (**114** , a bilignan, (2R,3R)-bis-2.3-(3.4-methylenedioxybenzyl-)-1.4-butanediol diacetate)	Hernández *et al.* (1983)
2. *Bursera fagaroides*	…	β-Peltatin-A-methylether and 5'-desmethoxy- β-peltatin-A-methylether	Bianchi *et al.* (1969)
3. *Bursera fagaroides* var. *fagaroides*	Stb	Podophyllotoxin-type lignans: podophyllotoxin (**115**), β-peltatin-A-methylether (**116**), 5′-desmethoxy-β-peltatin-A-methylether (**117**), desmethoxyyatein (**118**), desoxypodophyllotoxin (**119**), burseranin (**120**), and acetyl podophyllotoxin (**121**)	Rojas-Sepúlveda *et al.* (29012)
4. *Bursera graveolens*	St	Burseranin and picropolygamain (**122**)	Nakanishi *et al.* (2005)
5. *Bursera microphylla*	…	Deoxypodophyllotoxin and burseran (**123**) [3-(3,4-methylenedioxybenzyl)-4-(3',4',5'-trimethoxybenzyl) tetrahydrofuran]	Bianchi *et al.* (1968); Cole *et al.* (1969)
6. *Bursera morelensis*	E	Deoxypodophyllotoxin (**124**) and morelensin (**125**)	Jolad *et al.* (1977b)
7. *Bursera schlechtendalii*	…	(—)-*trans*-2-(3″,4″,5″-trimethoxy-benzyl)-3-(3′,4′-methylenedioxybenzyl)butyrolactone and (-)-*trans* -2- (3″,4″ -dimethoxybenzyl) -3- (3′,4′-methylenedioxybenzyl) butyrolactone	McDoniel and Cole (1972)
8. *Bursera simaruba*	B	Bursehernin (**126**), β-peltatin-*O*-β-D-glucopyranoside, hinokinin (**127**) and yatein (**128**)	Ciccio and Rosales (1995); Madini *et al.* (2009)
	Ol	Picropolygamin	Peraza-Sánchez and Peña-Rodríguez (1992)
9. *Bursera tonkinensis*	R	Burselignan, burseneolignan and 4'-demethyldesoxypodophyllotoxin	Jutiviboonsuk *et al.* (2005)

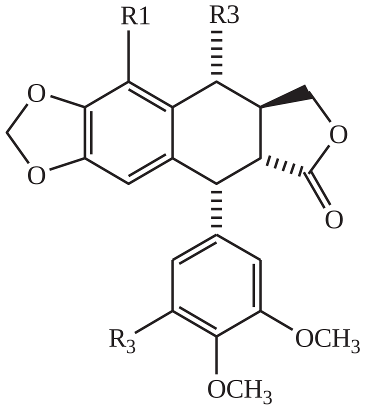
Table **15**. Lignans of some species of the family Burseraceae (cont.)

Species	Plant Part	Lignans	References
10. *Canarium schweinfurthii*	Ol S	Pinoresinol and secoisolariciresinol Ligballinol (**129**)	Atawodi (2011) Helene *et al.* (2000)
11. *Canarium subulatum*	B	(-)-Cubebin (**130**)	Sritularak *et al.* (2013)
12. *Protium tenuifolium*	W	(+)-(2*S*,3*S*)-2-(3'',4''-methylenedioxyphenyl)-3-(3',4'-methylenedioxyacetophenone)-butyrolactone (**131**) and a mixture of (-)-cubebin epimers	Siqueira *et al.* (1995)
13. *Protium unifoliolatum*	W	5-methoxyjusticidin A (an arylnaphthalene lignan, 9-(1,3-benzodioxol-5-yl)-4,5,6,7-tetramethoxynaphtho[2,3-C] furan-1(3*H*)-one	Siani *et al.* (1998)
14. *Tetragastris altissima*	…	(-)-Savinin (**132**)	Lima *et al.* (2001)

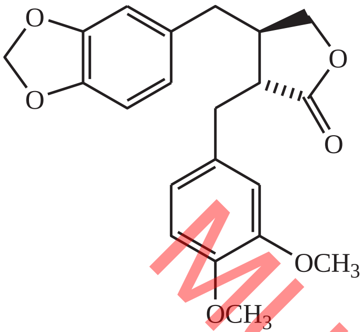
E: exudate; Ol: oleoresin; R: roots; St: stems; Stb: stem bark; W: wood.



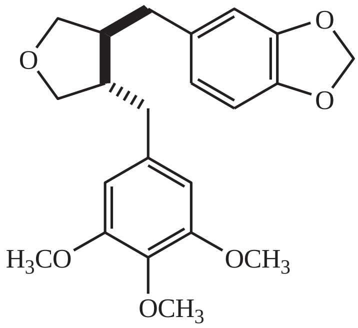
114 Ariensin



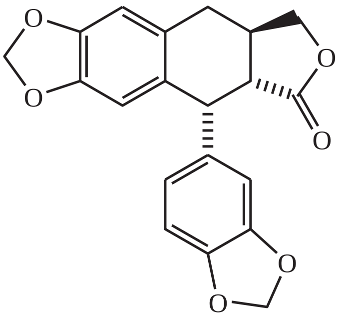
115 R_1=H, R_2=OH, R_3=OCH_3
116 R_1=OCH_3, R_2=H, R_3=OCH_3
117 R_1=OCH_3, R_2=R_3=H
119 R_1=R_2=H, R_3=OCH_3
121 R_1=H, R_2=OAc, R_3=OCH_3



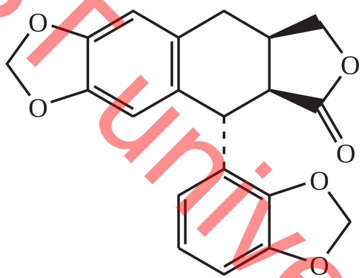
118



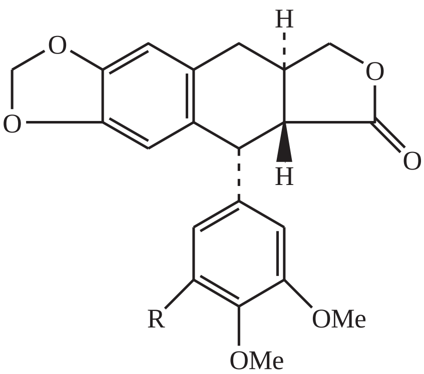
123 Burseran



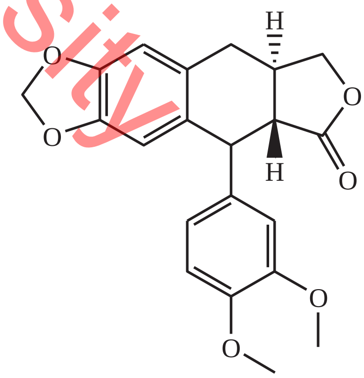
120 Burseranin



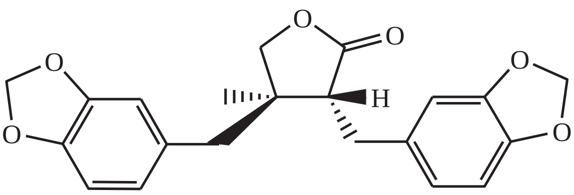
122 Picropolygamain



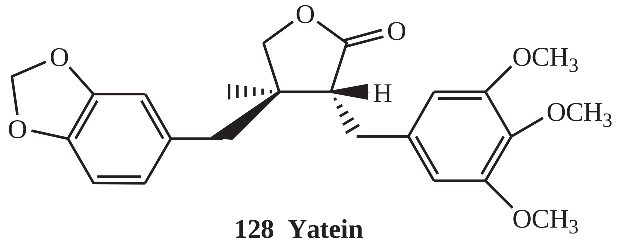
124 Deoxypodophyllotoxin R=OMe
125 Morelensin R=H



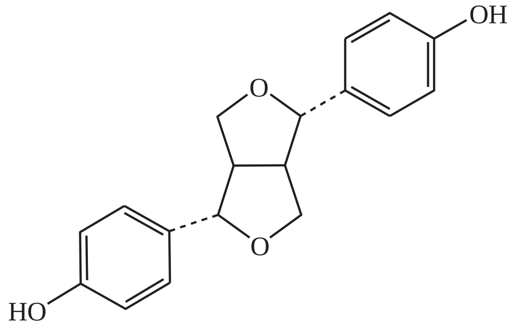
126 Bursehernin



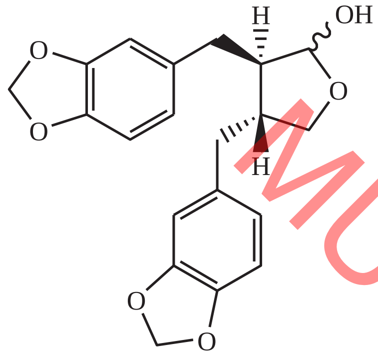
127 Hinokinin



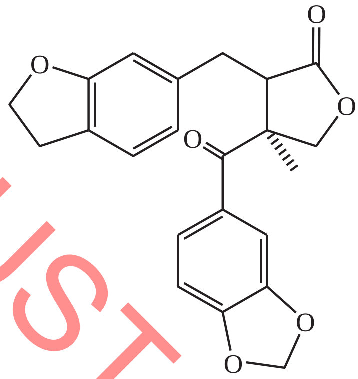
128 Yatein



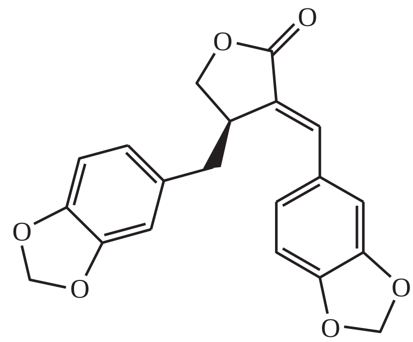
129 Ligballinal



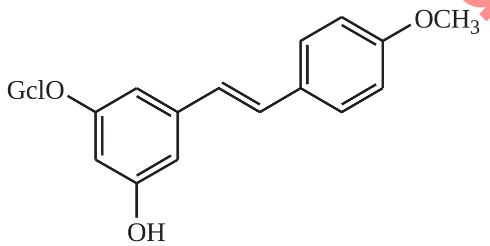
130 (-)-Cubebin



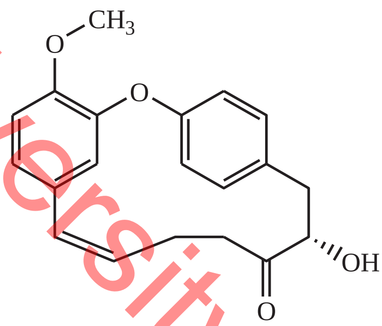
131 Butyrolactone



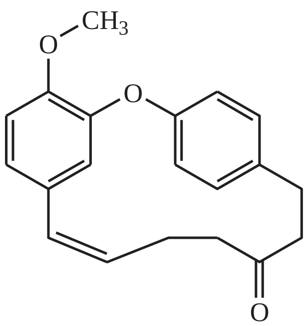
132 Savinin



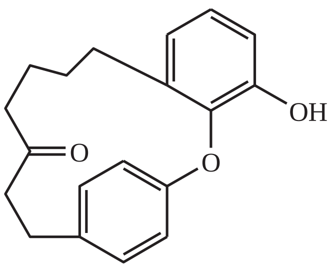
133 4'-Methoxy-(*E*)-resveratrol 3-O-rutinoside



134 Ovalifoliolatin A



135 Ovalifoliolatin B



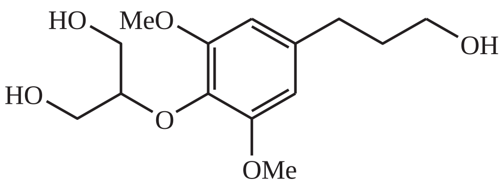
136 Acesogenin C

4. *Boswellia papyrifera*: Two stilbene glycosides, *trans*-4‘,5-dihydroxy-3-methoxy-stilbene-5-*O*-{α-L-rhamnopyranosyl-(1→2)-[α-L-rhamnopyranosyl-(1→6)]-β-D-glucopyranoside and *trans*-4‘,5-dihydroxy-3-methoxystilbene-5-*O*-[α-L-rhamno-

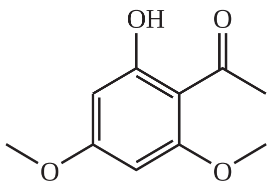
pyranosyl-(1→6)]-β-D-glucopyranoside from the stem bark (Atta-ur-Rahman *et al.*, 2005).

5. *Bursera serrata* Wall. : Scopoletin from the stem bark (Ara *et al.*, 2009).
6. *Bursera simaruba* Sarg.: 3,4-Dimetoxyphenyl-1-*O*-β-D-(6-sulpho)-glucopyranoside, 3,4,5-trimetoxyphenyl 1-*O*-β-D-(6-sulpho)-glucopyranoside and 3,4-diidroxyphenylethanol-1-*O*-β-D-(6-sulpho)-glucopyranoside from the bark (Maldini *et al.*, 2009).
7. *Bursera tonkinensis* Guillaum: Bursephenylpropane (**137**) from the roots (Jutiviboonsuk *et al.*, 2005).
8. *Canarium album* (Lour) Raench: Brevifolin (**138**), ellagic acid from the leaves (Hoang, 2004) and 3,4,5-trimethoxyphenyl-*O*-glucopyranoside from the bark and branches (Hoang, 2005).
9. *Canarium benghalense* Roxb.: Gallic acid, ethyl gallate, gallincin, ellagic acid and 1,2,3,4,6-penta-*O*-galloyl-β-D-gallopyranose (Du *et al.*, 2003).
10. *Canarum nigrum* (Lour.) Engl.: 3,4,5-Trimethoxyphenyl-*O*-β-D-glucopyranosides (Trần *et al.*, 2007).
11. *Canarium schweinfurthii* Eng: Catechol, *p*-hydroxybenzaldehyde, dihydroxyphenylacetic acid, tyrosol, *p*-hydroxybenzoic acid, dihydroxybenzoic acid, vanillic acid, phloretic acid from the oil (Atawodi, 2011); a phenylpropanoid, schweinfurthinol (1-(4-hydroxyphenyl)-2,3-dihydroxypropan-1-one), *p*-hydroxybenzaldehyde, *p*-hydroxybenzoic acid, 3-(4-hydroxyphenyl)-prop-2-enal (*p*-hydroxycinnamaldehyde) and coniferaldehyde from the seeds (Helene *et al.*, 2000).
12. *Canarium subulatum* Guillaumin: Scopoletin (**139**), scopolin (**140**), 3,4-dihydroxybenzoic acid, 3,3'-di-*O*-methylellagic acid-4'-*O*-*α*-L-rhamnopyranoside (**141**), 3,3'-di-*O*-methylellagic acid-4'-*O*-*β*-D-glucopyranoside (**142**), 3-*O*-methylellagic acid-4'-*O*-*α*-L-arabinofuranoside (**143**), and 3-*O*-methylellagic acid-4¢-*O*-*β*-D-xylopyranoside (**144**) from the bark (Sritularak *et al.*, 2013).
13. *Dacryodes edulis* (G. Don) H. J. Lam (Bush butter): Catechol, methyl gallate, and ellagic acid from the fruits (Atawodi *et al.*, 2009).
14. *Garuga forrestii*: Catechin, (*Z*)-ferulic acid tetracosyl ester, (*E*)- ferulic acid tetracosyl ester, 4-hydroxybenzoic-3-methoxy acid and 4-methoxyindicane (Yin *et al.*, 2008).
15. *Garuga gamblei* King: Two diaryl ethers, garugamblin I (**145**) (I or Ia) and garugamblin II (**146**) (II or IIa) from the bark (Kalchhauser *et al.*, 1988).
16. *Garuga pinnata* Roxb.: Several diarylheptanoids of the biophenyl ether and biphenyl type, e.g. garuganins I-VI (**147-152**) (Haribal *et al.*, 1985; Mishra *et al.*, 1985; Krishnaswamy *et al.*, 1987; Venkatraman *et al.*, 1993), 6′-hydroxygaruganin V (**153**), 9′-desmethylgarugamblin I (**154**) and 1,9′-didesmethylgaruganin III (**155**) (Ara *et al.*, 2006), 1-demethylgarunganin III (**156**) (Ara *et al.*, 2012) and 9'-demethylgaruganin I (**157**) (Khatun *et al.*, 2013) from the stem bark and leaves.
17. *Protium heptaphyllum* March.: (-)-Catechin, coumarins (e.g. scopoletin) and coumarinolignoids (Almeida *et al.*, 2002; Bandeira *et al.*, 2002).
18. *Protium opacum*: A coumarinolignoid, propacin (**158**) from the trunk wood (Zoghbi *et al.*, 1981).

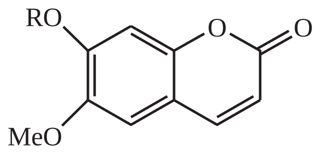
19. *Protium unifoliolatum*: A coumarinolignoid 5-methoxypropacin (**159**) from the wood (Magalhães *et al.*, 2006).
20. *Trattinnickia glaziovii*: Ellagic acid and 3,3',4-tri-*O*-methyl ellagic acid from the leaves (Siani and Ribeiro, 1995).



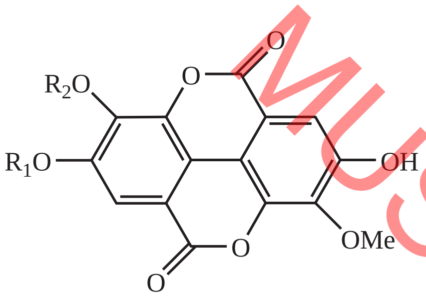
137 Bursephenylpropane



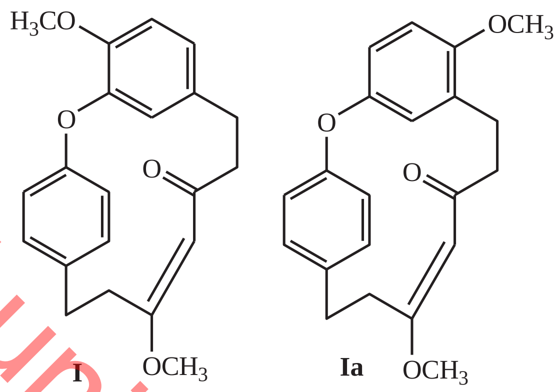
138 Brevifolin



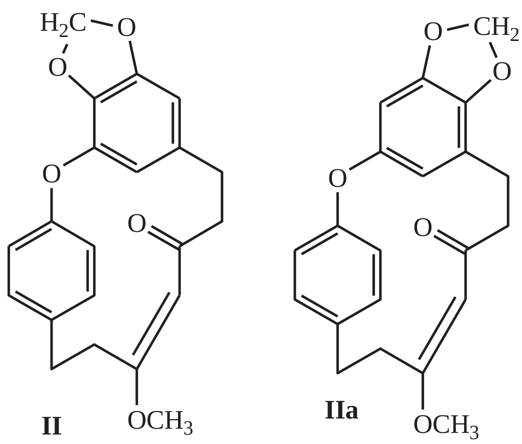
139 Scopoletin R=H
140 Scopolin R=Glucose



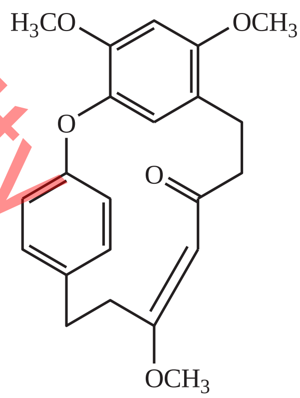
141	R_1=Rhamnose	R_2=Me
142	R_1=Glucose	R_2=Me
143	R_1=Arabinofuranose	R_2=H
144	R_1=Xylose	R_2=H



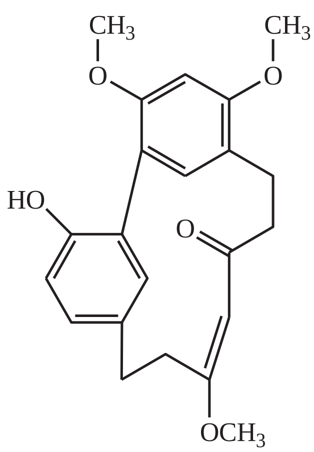
145 Garugamblin I



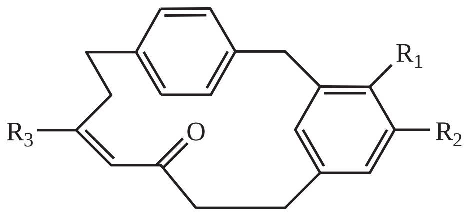
146 Garugamblin-II



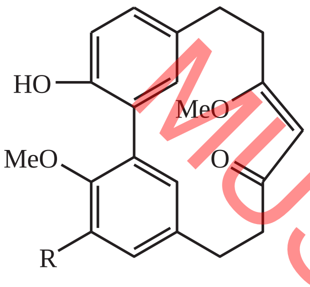
147 Garuganin-I



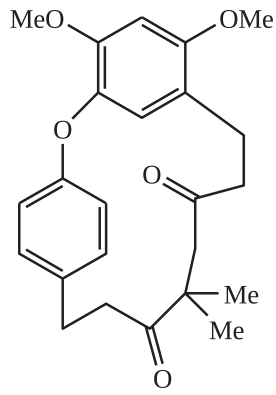
148 Garuganin-II



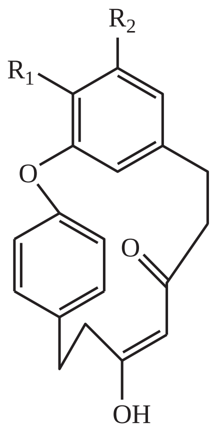
149 Garuganin III R_1=R_2=R_3=OMe
150 Garuganin IV R_1=H, R_2=R_3=OMe
154 9'-Desmethylgarugamblin-I R_1=OMe, R_2=H, R_3=OH
156 1-Desmrthylgaruganin IIIR_1=OH, R_2=R_3=OMe



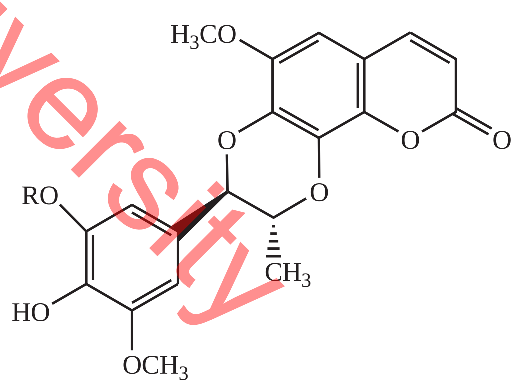
151 Garuganin V R=H
153 6'-Hydroxygaruganin V R= OH



152 Garuganin VI



155 1,9'-didesmethylgaruganin III
R_1=OH, R_2=OMe
157 9'-Demethylgaruganin I
R_1=OMe, R_2=H



158 Propacin R=H
159 5'- Methoxypropacin R=OCH_3

Other Constituents

Pheophorbide A and B methyl esters (**160**,**161**) [hydrolyzed chlorophylls without phytol (chlorophyllides) that have also lost the magnesium] were isolated from *Garuga pinnata* Roxb. (Wongsinkongman *et al.*, 2002).