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Review Article

Ethnopharmacological, phytochemical, pharmacological and toxicological aspects of *Lantana camara* L.: A comprehensive Review

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Abstract

Lantana camara L. grows luxuriantly at elevations up to 2000 m in tropical, sub-tropical and temperate regions across the globe. It is a woody straggling plant with diverse flower colors and cultivated world-wide for its ornamental value. The stems and branches are sometimes armed with prickles or spines. *Lantana camara* is traditionally used as folk remedy for different types of diseases and disorders like cancers, fever, influenza, stomach-ache, chicken pox, measles, fever, cold, rheumatism, asthma, high blood pressure, bronchitis, anthelmintic and insecticide. The phytochemical investigation of the *L. camara*, as carried out so far, has allowed the identification of more than 250 compounds with varying structural skeletons which include, but are not limited to, terpenoids, flavonoids, phenylethanoid glycosides, iridoid glycosides, and steroids. Moreover, *L. camara* exhibits a diversity of biological activities like antimicrobial activity, anti-protozoal activity, antioxidant, antifeedant, wound healing, anthelmintic, antiplorifertive and many other activities. The present review provides in depth information on ethnopharmacological, phytochemical, pharmacological and toxicological aspects of *L. camara*.

Keywords: *Lantana camara*, ethnopharmacology, chemical constituents, structures, biological activity

Introduction

Lantana camara L. grows luxuriantly at elevations up to 2000 m in tropical, sub-tropical and temperate regions of world like Central and South America, Europe, Great Britain, New Zealand, West Indies, Africa, islands of the Pacific, Australia and southern Asia, including India [1, 2]. It is a woody straggling plant with various flower colors, red, pink, white, yellow and violet. The stems and branches are sometimes armed with prickles or spines. It is a significant weed and now cultivated world-wide as ornamental plant having of which 650 varieties in over 60 countries [3].

Taxonomical Description [2, 4]:

Kingdom :	Plantae
Subkingdom :	Tricheobionta
Super division :	Spermatophyte
Division :	Magnoliophyta
Class :	Magnoliopsida
Subclass :	Asteridae
Order :	Lamiales
Family :	*Verbenaceae*
Genus :	*Lantana*
Species :	*Lantana camara* L.

Synonyms

Camara vulgaris and *Lantana scabrida*

Common names

It is commonly called as sleeper weed, lantana, and wild sage. The plant is distributed all over the world hence its vernacular names vary from place to place.

Some of them are given below [2, 4].

English: Lantana, Red sage, Shrub verbena, White sage, Wild sage, Yellow sage.

Spanish: Cuasquito, Supirosa.

French: Caca martin, Corbeille d'or, Galabert, Lantana, Vieille fille

Hindi: Raimuniya

Sanskrit: Chaturangi and Vanacehdi

Bengali: Chotra

Tamil: Arippu and Unnichedi

Malayalam: Aripoov, Poochedi, Konginipoo and Nattachedi

Manipuri: Thirei, Samballei and Nongballei

Marathi: Tantani and Ghaneri

Telegu: Pulikampa

Kanada: Kakke and Natahu

Habitat

L. camara is a low, erect or subscandent, vigorous shrub which can grow to 2-4 meters in height. The leaf is ovate or ovate oblong, 2-10 cm long and 2-6 cm wide, arranged in opposite pairs. Leaves are bright green, rough, finely hairy, with serrate margins and emit a pungent odour when crushed. The stem in cultivated varieties is often non-thorny and in weedy varieties with recurved prickles. It is woody, square in cross section, hairy when young, cylindrical and up to 15 cm thick as it grows older. Lantana is able to climb to 15 m with the support of other vegetation. Flower heads contain 20-40 flowers, usually 2.5 cm across; the colour varies from white, cream or yellow to orange pink, purple and red. Flowering occurs between August and March, or all year round if adequate moisture and light are available. Pollinators include lepidopteran species and thrips. The fruit is a greenish blue-black colour, 5-7 mm in diameter, drupaceous, shining, with two nutlets; seed setting takes place between September to May with 1-20 seeds on each flower head. Mature plants produce up to 12,000 seeds annually. Seed germination occurs when sufficient moisture is present; germination is reduced by low light conditions. The root system is very strong with a main taproot and a mat of many shallow side roots [2].

Ethnopharmacology

The plant has been used in many parts of the world to treat a wide variety of diseases and disorders [3]. A decoction of the plant is given as treatment for tetanus, rheumatism, and malaria [5]. In India the leaves of the plant are boiled for tea and the decoction is a remedy against cough. It is also used as a lotion for wounds. Pounded leaves are applied to cuts, ulcers and swellings [6]. *L. camara* found use in folk remedies for cancers and tumors. A tea prepared from the leaves and flowers is taken against fever, influenza and stomach-ache. In Central and South America, the leaves are made into a poultice to treat sores, chicken pox and measles. Fevers, cold, rheumatisms, asthma and high blood pressure are treated with preparations from the plant. In Ghana, infusion of the whole plant is used for bronchitis and the powdered root in milk is given to children for stomach-ache [3, 7]. It has been claimed that a steroid, lancamarone, from the leaves exhibts cardiotonic properties [8]. Traditionally it is also used as a tonic, in abdominal pains, as anthelmintic and insecticide [9]. An alkaloid from the stem, bark and roots shows antipyretic and antispasmodic properties [10].

Chemical Constituents of *Lantana Camara*

The phytochemical investigation of the *L. Camara*, as carried out so far, has afforded some 259 compounds with varying structural skeletons. These compounds are classified into terpenoids (1-183; **Figure 1**) [**Table-1**], flavonoids (184-192; **Figure 2**) [**Table-1**], Phenylethanoid glycosides (193-199; **Figure 3**) [**Table-1**], furano-naphthoquinones (200-209; **Figure 4**) [**Table-1**], iridoid glycosides (210-215; **Figure 5**) [**Table-1**], steroids (216-225; **Figure 6**) [**Table-1**], aliphatic compound (226-249; **Figure 7**) [**Table-1**] and miscellaneous (250-259; **Figure 8**) [**Table-1**].

Table 1: Chemical constituents of *L. camara*

Compound	Parts used	Reference
Terpeniods		
Monoterpene and sesquiterpene from essential oil		
Geraniol (1)	F	[11]
iso-Safrole (2)		[11]
Geranyl acetate (3)		[11]
(E,E)-Farnesyl acetone (4)		[11]
α-Thujene (5)	L	[11, 12]
α-Pinene (6)		[11, 12]
Camphene (7)		[11, 12]
β-Pinene (8)		[11, 12]
Myrcene (9)		[11, 12]
α-Phellandrene (10)		[11, 12]
(Z)-β-Ocimene (11)		[11, 12]
γ-Terpinene (12)		[11, 12]
Terpinolene (13)		[11]
Safrole (14)		[11]
Geranyl formate (15)		[11]
δ-Elemene (16)		[11, 12]
β-Bisabolene (17)		[11]
(E)-Sesquithujen-12-ol (18)		[11]
Lilac alcohol (19)		[13]
Lilac alcohol formate A (20)		[13]
Cis-β-terpineol (21)		[13]
Linalyl alcohol (22)		[13]
Cis-verbenol (23)		[13]
p-menth-1-ene-8-ol (24)		[13]
Copaene (25)		[13]
Germacrene (26)		[13]
(-) -β-caryophyllene (27)		[13]
α-caryophyllene (28)		[13]
Davana ether (29)		[13]
D-nerolidol (30)		[13]
α-pinene epoxide (31)		[13]
Cryptone(32)		[12]
Eremoligenol (33)		[12]
guaiadiene <6,9>(34)		[12]
iso-caryophyllene (35)		[12]
Khusimene (36)		[12]
Khusimone (37)		[12]
neo-allo-ocimene (38)		[12]
neo-dihydro carveol (39)		[12]
α-guaiene (40)		[12]
α-terpinene (41)		[12]

α-terpinolene (42)		[12]
α-terpinyl acetate (43)		[12]
α-ylangene (44)		[12]
β-acorenol (45)		[12]
β-atlantol (46)		[12]
β-phellandrene (47)		[12]
β-selinene (48)		[12]
γ-amorphene (49)		[12]
γ-pinene (50)		[12]
β-ocimene (51)		[12]
p-Cymene (52)	L, F	[11, 12]
(E)-β-Ocimene (53)		[11, 12]
Linalool (54)		[11, 12]
Camphor (55)		[11, 12]
Borneol (56)		[11]
α-Terpineol (57)		[11]
Nerol (58)		[11]
Eugenol (59)		[11]
α-Cubebene (60)		[11]
α-Copaene (61)		[11, 12]
α-Cedrene (62)		[11, 12]
α-Cadinene (63)		[11]
α-Bergamotene (64)		[11]
Geranyl propionate (65)		[11]
(Z)-β-Farnesene (66)		[11]
(E)-β-Farnesene (67)		[11]
α-Zingiberene (68)		[11]
β-Curcumene (69)		[11]
Sesquiphellandrene (70)		[11]
Calacorene (71)		[11]
(E)-Nerolidol (72)		[11]
Acora-3,5-diene-11-ol (73)		[11]
β-Caryophyllene oxide (74)		[11]
Viridifloral (75)		[11]
Humulene oxide II (76)		[11]
Helifolen-12-al (77)		[11]
Cubenol (78)		[11]
T-Cadinol (79)		[11]
1-epi-Cubenol (80)		[11, 12]
epi-α-Cadinol (81)		[11]
α-Cadinol (82)		[11]
α-Bisabolol (83)		[11]
epi-α-Bisabolol (84)		[11]
(E)-Farnesol (85)		[11]
epi-α-Bisabol-1-one (86)		[11]

γ-Curcumenal (87)		[11]
n-Nuciferyl acetate (88)		[11]
Sabinene (89)	L, F, S	[11, 12]
δ-3-Carene (90)		[11, 12]
Terpinen-4-ol (91)		[11, 13, 12]
β-Elemene (92)		[11, 12]
β-Caryophyllene (93)		[11, 12]
α-Humulene (94)		[11, 12]
***allo*-Aromadendrene (95)**		[11, 12]
Germacrene D (96)		[11, 12]
γ-Elemene (97)		[11, 12]
Germacrene B (98)		[11, 12]
Spathulenol (99)		[11, 13, 12]
Caryophyllene oxide (100)	L, S	[13, 12]
1,8-cineole (101)		[12]
***allo*-aromadendrene epoxide (102)**		[12]
Bicycloelemene (103)		[12]
Bicyclogermacrene (104)		[12]
Italicene (105)		[12]
Limonene (106)		[12]
Linalool propanoate (107)		[12]
α-cis-bergamotene (108)		[12]
β-gurjunene (110)		[12]
δ-cadinene (111)		[12]
1,4-cadinadiene (112)	S	[12]
Junipene (113)		[12]
Neophytadiene (114)		[12]
selina-3,7(11)-diene (115)		[12]
β-guaiene (116)		[12]
β-silinene (117)		[12]
γ-cadinene (118)		[12]
γ-gurjunene (119)		[12]
Triterpenes		
Lantadene A (120)	L, S, R	[14-24]
Lantadene B (121)	L, S	[15-19,23-25]
Lantadene C (122)	L, S	[18, 24, 26, 27, 28]
Lantadene D (123)	L	[18, 27, 29]
22β-angeloyloxy-3βhydroxyolean-12-en-28-oic acid (124)	L, S,	[15, 18]
22β-dimethylacryloyloxy3β-hydroxyolean-12-en-28oic acid (6)	L, S, R	[15, 18, 30]
22β-hydroxyoleanonic acid (125)	L	[19, 29, 31]
Oleanonic acid (127)	AP, L, S	[16, 20, 32- 34]

Oleanolic acid(128)	AP, L, S, R,	[16, 20, 33,35-39]
Oleanolic acid acetate (129)	L	[40]
22β-hydroxy-3-oxoolean-12-en-28-oic acid (130)	L, S, R	[15, 30]
24-hydroxy-3-oxoolean-12en-28-oic acid (131)	L, S	[15,16]
	AP	
Icterogenin(132)	L, S	[19, 21, 37]
		[24]
22β-dimethylacryloyloxy-24hydroxy-3-oxo-olean-12-en-28-oic acid (133)	L	[24]
22β-*O*-angeloyl-oleanoic acid (134)	R	[30]
22β-*O*-senecioyloleanoic acid (135)		
Hederagenin (136)		[41]
25hydroxy-3-oxoolean-12-en28-oic acid (137)		
21, 22β-epoxy-3βhydroxyolean-12-en -28-oic methyl ester (138)		[42]
Camarin (139)	L	[43]
Lantanone (140)		
22β-tigloyloxylantanolic acid (141)		[44]
Camarilic acid (142)	AP	[18]
Lantanilic acid (143)	L, S, R,	[30, 35, 45, 46]
Lantanolic acid (144)	AP, R	[30, 35, 36, 43, 47, 48]
Camaric acid (145)	AP, S	[35, 36, 46]
Camarolic acid (146)	L	[43]
Lantrigloylic acid (147)		
22β-dimethylacryloyloxylantanolic acid (148)		[45]
Ursangilic acid (149)	AP	[40]
Lancamaric acid (150)		
Camangeloyl acid (151)		
Camarinin (152)	AP, S	[43]
Lantadienone (153)	AP	[49]
Camaradienone (154)		
Pomonic acid (155)	R	[35]
3β,19α-hydroxy ursolic (156)		[23]
Lantaiursolic Acid (157)		
Ursonic Acid (158)	AP	[12]
Lantacin (159)		[36]
Pomolic acid (160)	AP, S, R	[23, 28, 36]
3,24-dioxo-urs-12-en-28-oic acid (161)	L	[50]
α-amyrin (162)	L, F, S	[51, 52]
Methyl 3-oxourslate (163)	L	[53]
Camaranoic acid (164)	AP	[54]
Lantoic acid (165)		[43, 55]
Camarinic acid (166)	L, S	[35, 45, 46]
22β-dimethylacryloyloxylantic acid (167)	L	[44]
Lantic acid (168)		[46, 53]
Camaracinic acid (169)	AP	[20]
Methyl ursoxylate (170)		[40]

Ursoxy acid (171)		
Ursethoxy acid (172)		
Methyl camaralate (173)		
Camariolic acid (174)		
Camarolide (175)		
Betulinic acid (176)	AP, S	[16, 20, 37]
Betulonic acid (177)	L, S	[15, 37]
Betulonol (178)	S	[37]
Lantabetulic acid (179)	L , S	[15]
Lupeol Analogue (180)	L	[15]
Euphane lactone B (181-181a)		[56]
Euphane lactone C (182-182a)		
Euphane lactone A (183)		
Flavonoids		
Lantanoside (184)	AP	[57]
Linaroside (185)		
3-methoxy-quercetin (186)	L	
3-methoxy-3,7-dimethoxy-quercetin (187)		
3,7,4'trimethoxy-quercetin (188)		
Pectolinarigenin (189)		[58]
Pectolinarin (190)		
Camaroside (191)		[19]
Camaraside (192)		[44]
Phenylethanoid glycosides		
Calceolarioside E (193)	L	[59]
Isonuomioside A (194)		
Isoverbascoside (195)		[59]
Derhamnosylverbascoside (196)		
Lantanaside (197)		[44]
Verbascoside (198)	L, S	[59, 60, 61]
Martynoside (199)	L, S	[61]
Furanonaphthoquinones		
6-methoxydiodantunezone (200)	R	[62]
6-methoxy-8-hydroxy-diodantune zone (201)		
7-methoxydiodantunezone (202)		
7-methoxy-5-hydroxy-isodiodantune zone (203)		
7-methoxy-8-hydroxy-diodantune zone (204)		
6-methoxy-7-hydroxy-diodantune zone (205)		
8-hydroxy-13(methyldimethyl-hydroxy)-diodantunezone (206)		
5-hydroxy-13-(methyldimethyl-hydroxy)-diodantunezone (207)		
Diodantunezone (208)		
Isodiodantunezone (209)	R	[62]
Iridoid glycosides		
Geniposide (210)	R	[63]
Theviridoside (211)		[63]
Theveside (212)	L, S, R	[63, 64]
8-epiloganin (213)	R	[63]
Lamiridoside (214)		
Shanzhiside methyl ester (215)		
Steroids		

β-sitosterol (216)	L, F, S	[36, 51, 52]
β-sitosterol-3-*O*-β-D-glucopiranoside (217)	AP	[40]
β-sitosterole (218)	S	[36]
β-sitosterol-3-*O*-β-D-Dglicoside (219)		
β-sitosterol acetate (220)	L	[52]
Stigmasterol acetate (221)		
Stigmasterol (222)		[43]
3β-hydroxystigmast-5-en-7one (223)		
Campesterol (224)		
Lancamarone (225)		[35]
Aliphatic compound		
Long chain Acids		
Octanoic Acid (226)	S	[36]
Cotriacontanoic Acid (227)	AP	[40]
Tetracosanoic Acid (228)		
Palmitic Acid (229)		
Docosanoic Acid (230)		
Octadecanoic Acid (231)		
Oleic acid (232)	F	[11]
Hexadecanoic acid (233)		
Tetradecanoic acid (234)		
Pentadecanoic acid (235)	L, F	
Arachidic acid (236)	L, F, S	[51, 52]
Long chain Alcohol and other aliphatic compounds		
1-triacontanol (237)	L, F, S	[51, 52]
n-Heptanol (238)	F	[11]
***cis*-3-Hexenol (239)**	L	
1-Nonadecanol (240)		
n-Nonadecane (241)	F	
n-Hexadecane (242)	L	
n-Octadecane (243)	L, F	
n-Heptadecane (244)		
Tetradecane (245)		
n-Decane (246)		
Hexadecanal (247)	F	
Heptadecan-2-one (248)		
(Z)-3-Hexenyl acetate (249)	L	
Miscellaneous compounds		
1-naphthalenol	L	[14]
1-(3-glucosyloxy-4-hydroxycinnamyl) glucose (251)	F	[65]
1-caffeylrhamnose (252)		[66]
***p*-coumaric acid (253)**	L	[67]
Ethyl-B-D-Galactoside (254)	S	[36]
Ajugose (255)	R	[63]
Verbascose (256)		
Verbascotetrose (257)		
Lantanose A E B (258)		
Stachyose (259)		

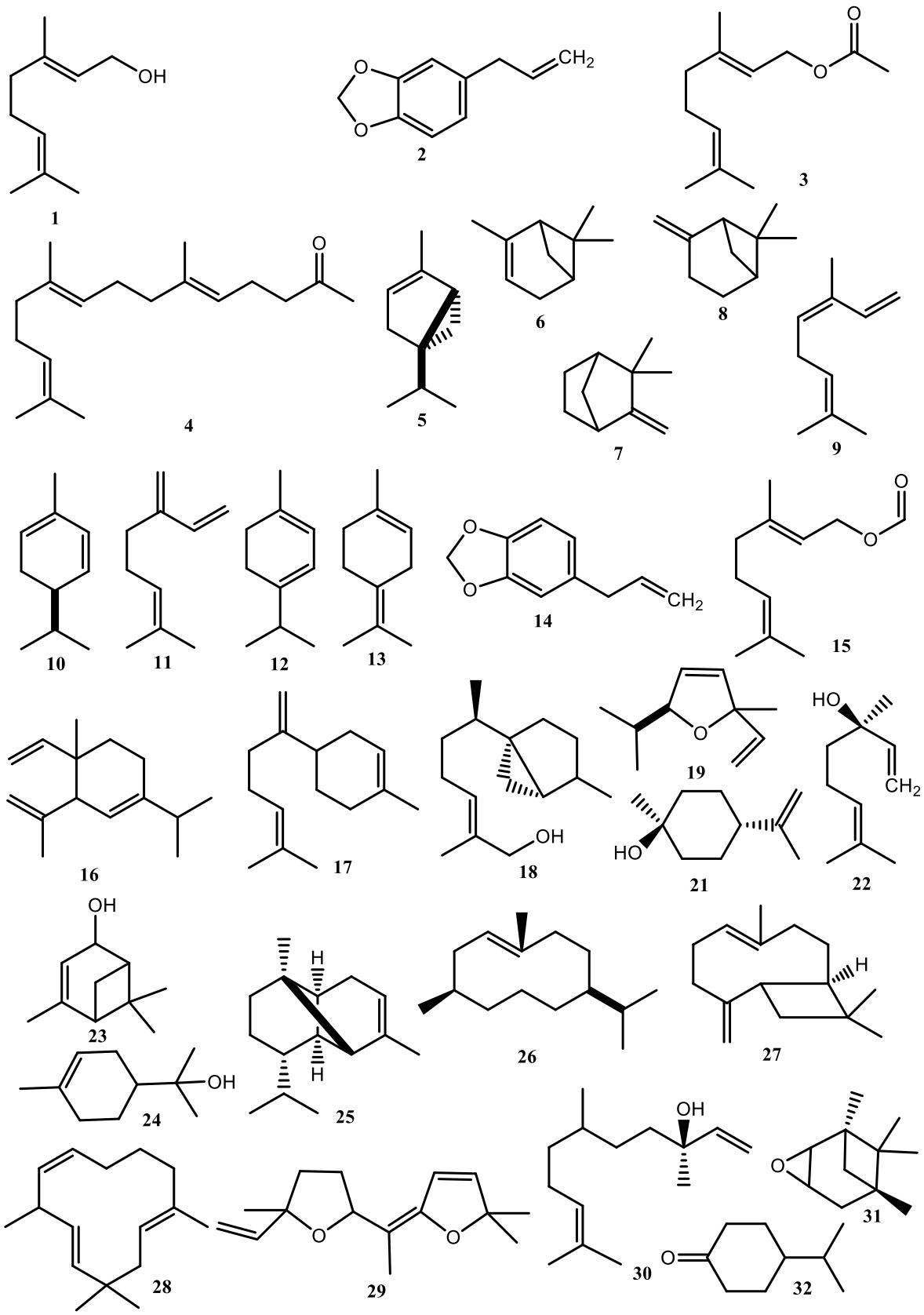


Figure 1: Structures of terpenoids from *L. camara.*

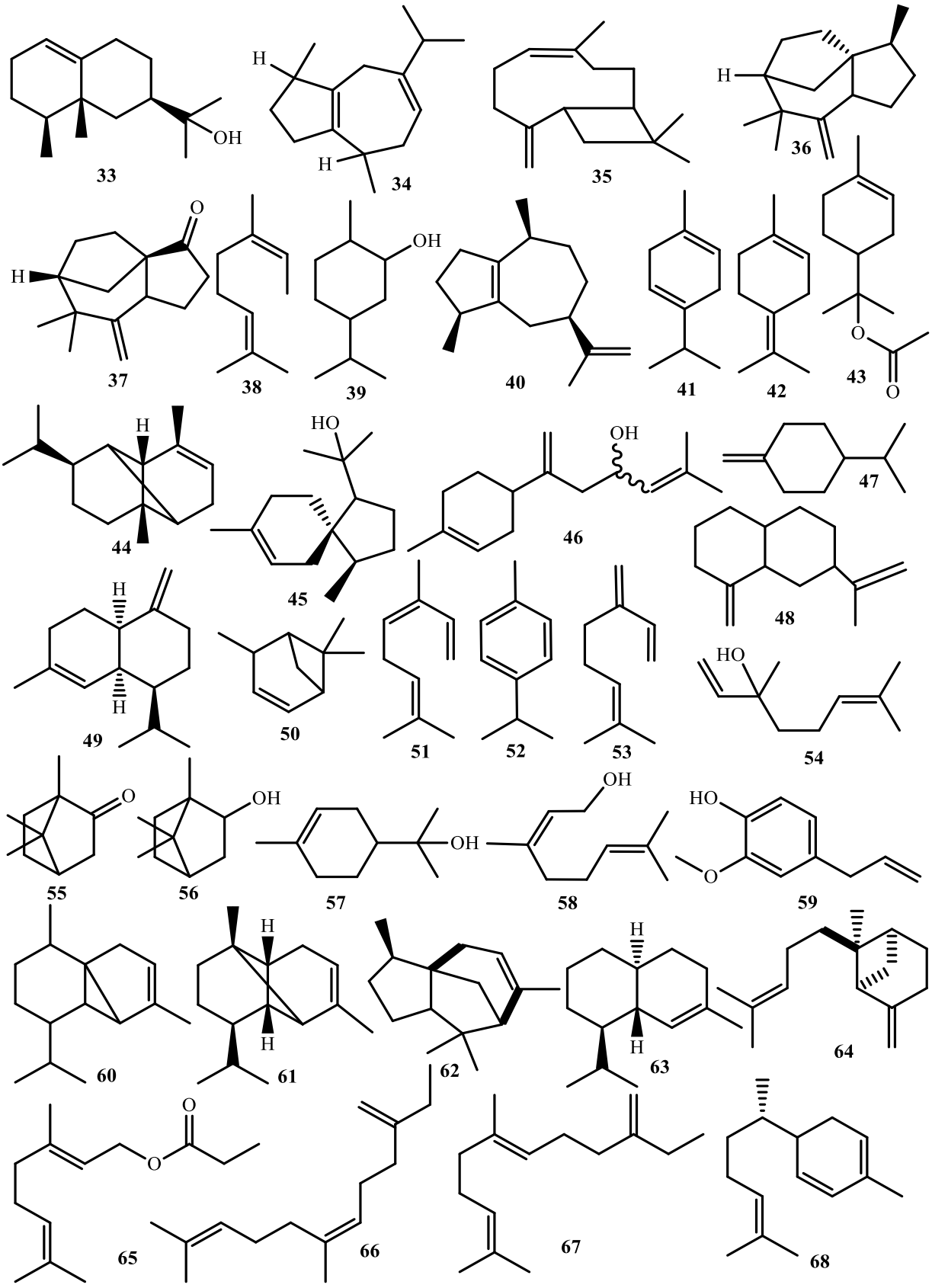


Figure 1: Structures of terpenoids from *L. camara* (Cont.)

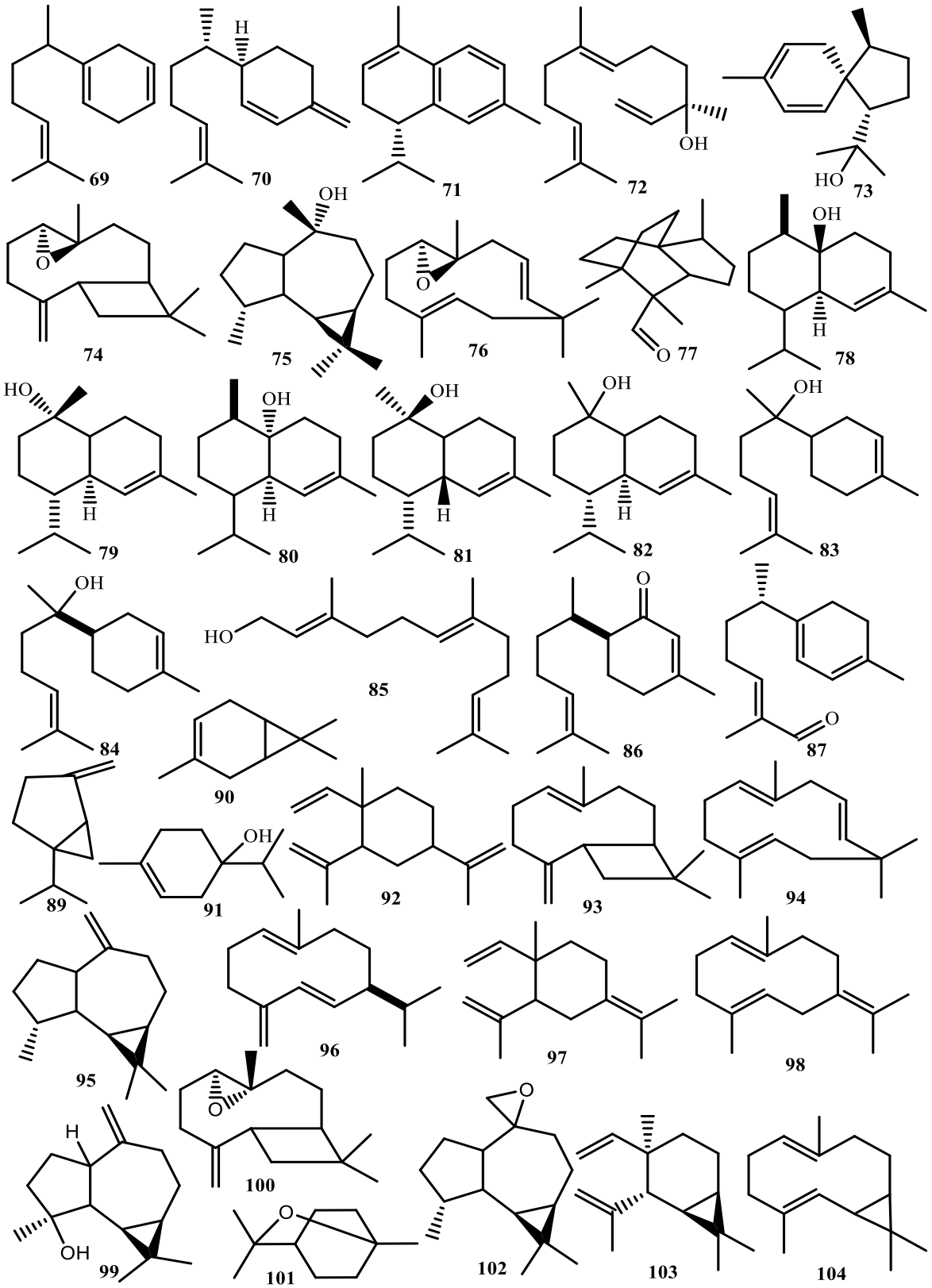
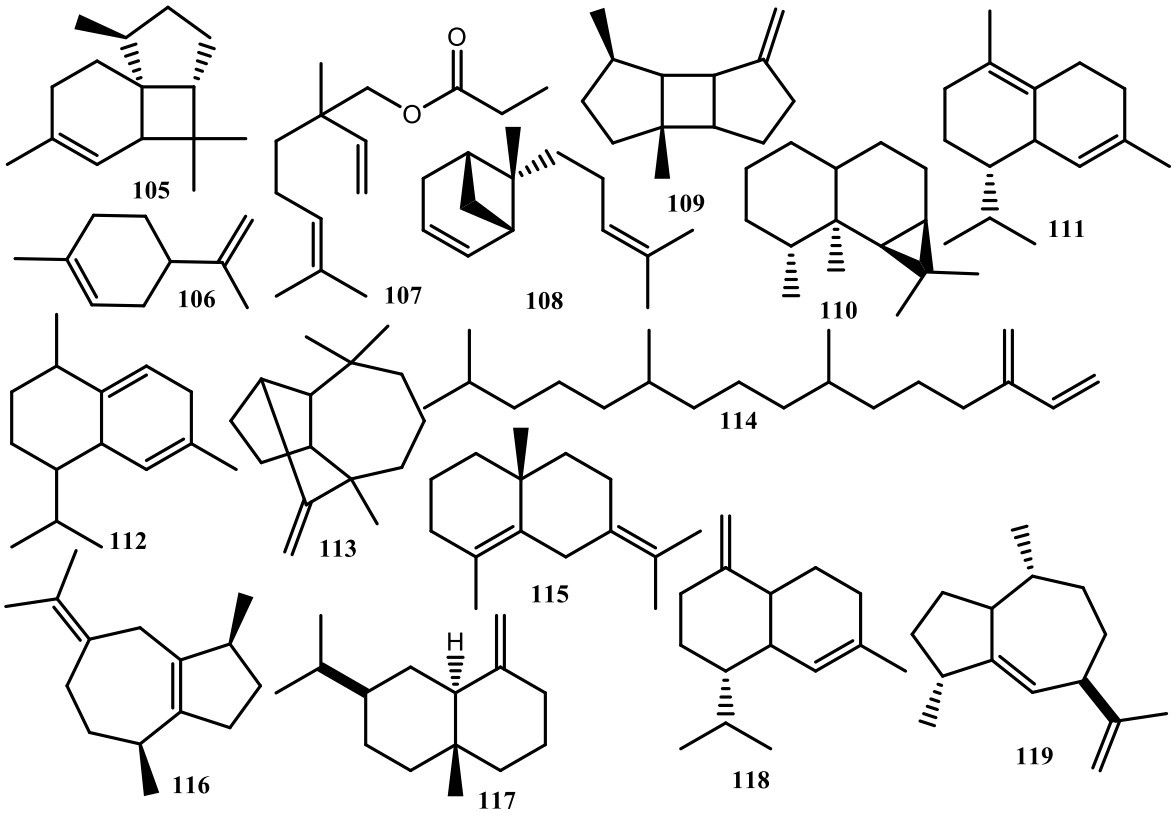
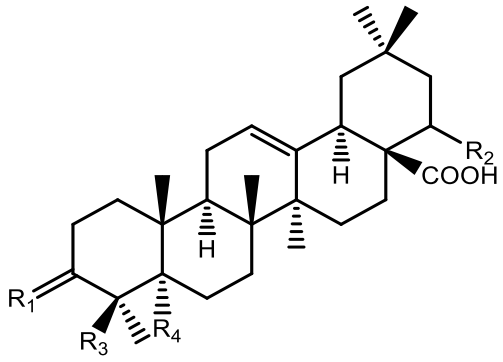


Figure 1: Structures of terpenoids from *L. camara* (Cont.)

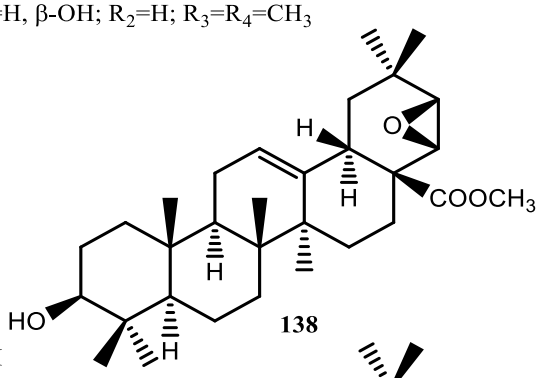


Triterpenes

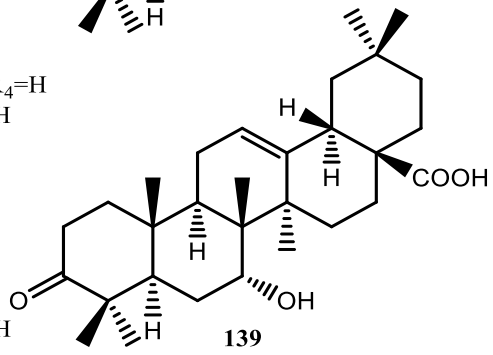


120 R_1=O; R_2=β-OCOC(CH_3)=$CHCH_3$; R_3=CH_3; R_4=H
121 R_1=O; R_2=β-OCOCH=$C(CH_3)_2$; R_3=CH_3; R_4=H
122 R_1=O; R_2=β-OCOCH(CH_3)CH_2CH_3; R_3=CH_3; R_4=H
123 R_1=O; R_2=β-OCOCH=$(CH_3)_2$; R_3=CH_3; R_4=H
124 R_1=H, β-OH; R_2=β-OCOC(CH_3)=$CHCH_3$; R_3=CH_3; R_4=H
125 R_1=H, β-OH; R_2=β-OCOCH=$C(CH_3)_2$; R_3=CH_3; R_4=H
126 R_1=O; R_2=β-OH; R_3=CH_3; R_4=H
127 R_1=O; R_2=R_4=H; R_3=CH_3
128 R_1=H, β-OH; R_2=R_4=H; R_3=CH_3
129 R_1=H, $OCOCH_3$; R_2=R_4=H; R_3=CH_3
130 R_1=O; R_2=β-OH; R_3=R_4=CH_3
131 R_1=O; R_2=H, R_3=CH_2OH, R_4=CH_3
132 R_1=O; R_2=β-OCOC(CH_3)=$CHCH_3$; R_3=CH_2OH; R_4=H
133 R_1=O; R_2=β-OCOCH=$C(CH_3)_2$; R_3=CH_2OH; R_4=CH_3

134 R_1=H, H; R_2=β-OCOC(CH_3)=$CHCH_3$; R_3=CH_3; R_4=H
135 R_1=H,H; R_2=β-OCOCH=$CHCH_3$; R_3=CH_3; R_4=H
136 R_1=H, β-OH; R_2=H; R_3=R_4=CH_3

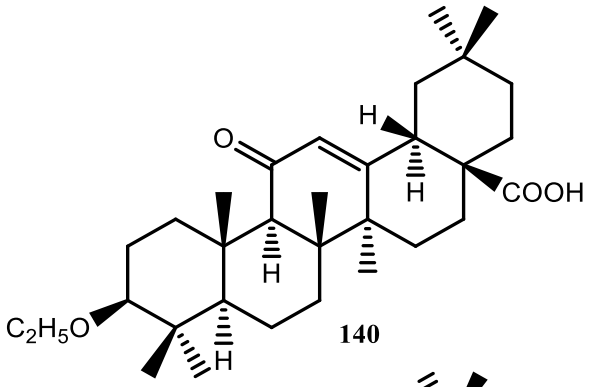


138



139

Figure 1: Structures of terpenoids from *L. camara* (Cont.)



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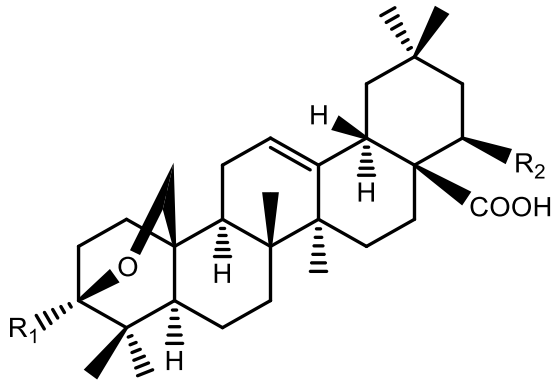
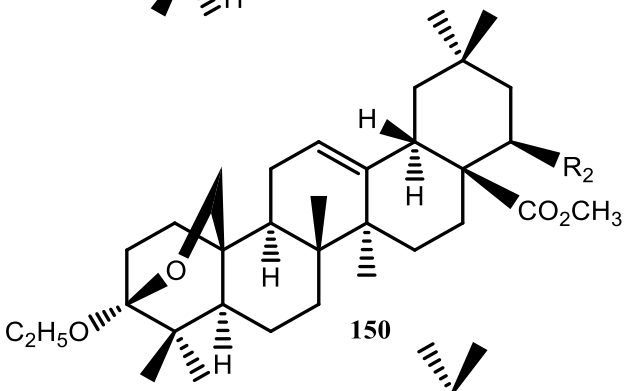


141 R_1=α-OH; R_2=β-OCOC(CH_3)=$CHCH_3$
142R_1=α-OCH_3; R_2=β-OCOC(CH_3)=$CHCH_3$
143 R_1=α-OH; R_2=β-OCOCH=$C(CH_3)_2$
144 R_1=α-OH; R_2=H
145 R_1=α-OH; R_2=β-OCOC(CH_3)=$CHCH_3$
146 R_1=α-OH; R_2=β-OCOC(=CH_2)$CHOHCH_3$
147 R_1=α-OH; R_2=β-OCOCH=$C(CH_3)_2$
148 R_1=β-OH; R_2=β-OCOCH=$C(CH_3)_2$
149 R_1=α-OCH_2CH_3; R_2=β-OCOC(CH_3)=$CHCH_3$



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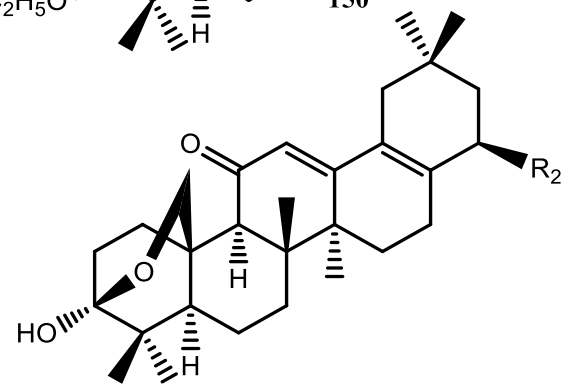
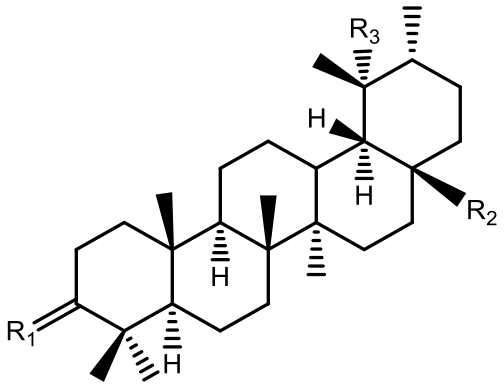
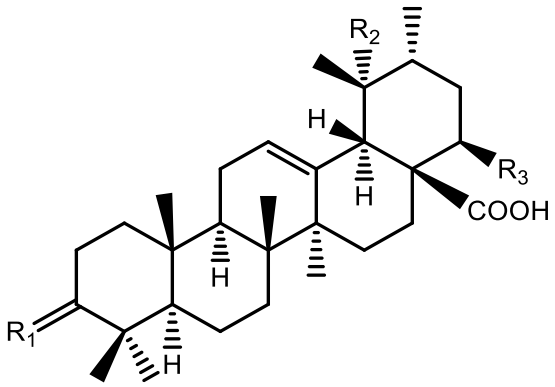


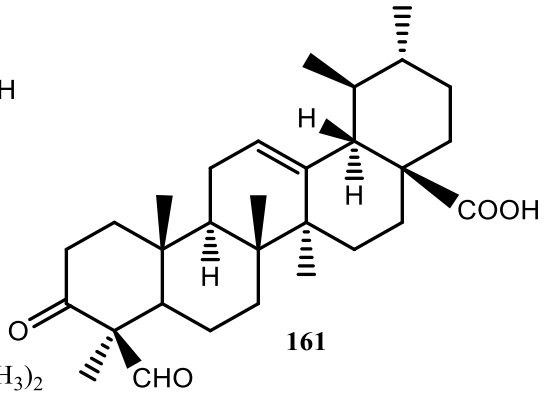
153 R=β-OCOCH(CH_3)$_2$
154 R=H



155 R_1=O; R_2=H; R_3=OH
156 R_1=H,H; R_2=H; R_3=OH
163 R_1=O; R_2=CH_3; R_3=H



157 R_1=$OCOCH_2CH(CH_3)_2$; R_2=OH; R_3=H
158 R_1=O; R_2=R_3=H
159 R_1=H, β-OH; R_2=OH; R_3=â-OCOCH=$C(CH_3)_2$
160 R_1=H, β-OH; R_2=OH; R_3=H



161

Figure 1: Structures of terpenoids from *L. camara* (Cont.)

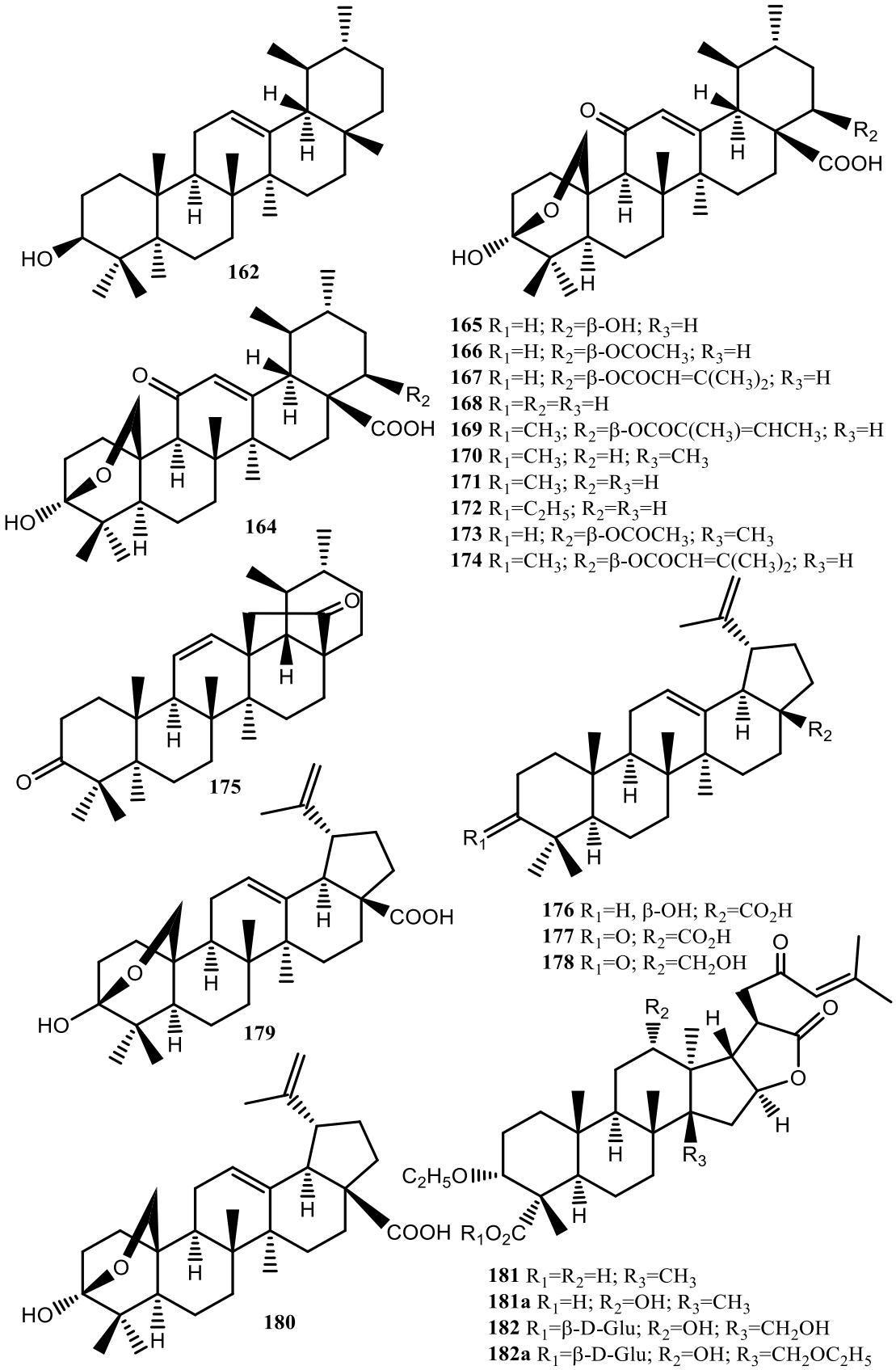
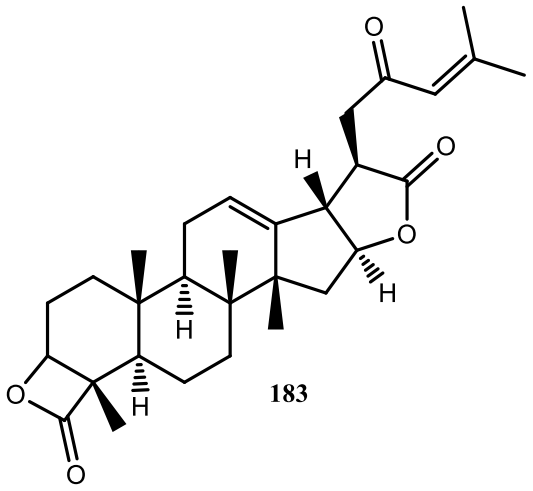
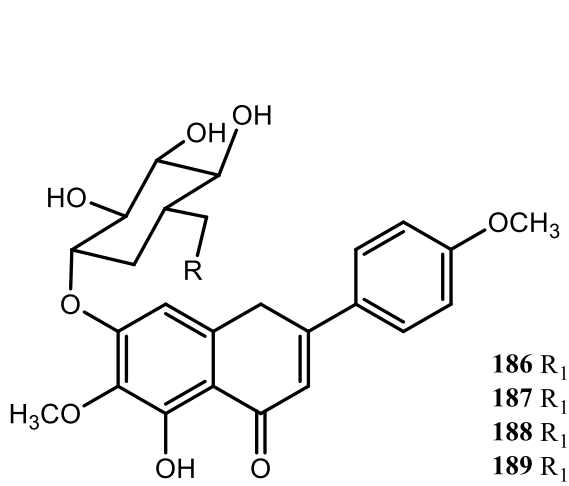


Figure 1: Structures of terpenoids from *L. camara* (Cont.)

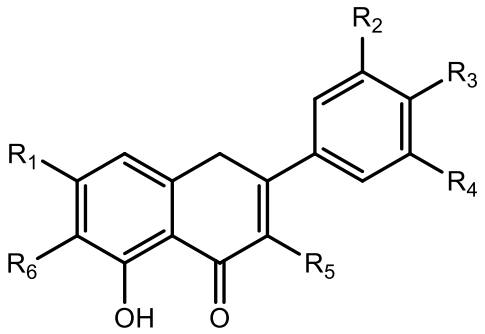


183

Figure 1: Structures of terpenoids from *L. camara* (Cont.)

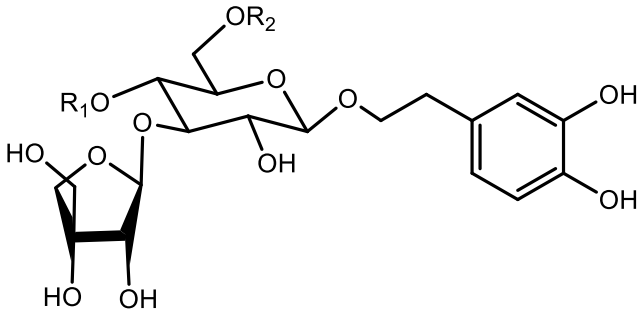


184 R=OH
185 R=OC_2H_5

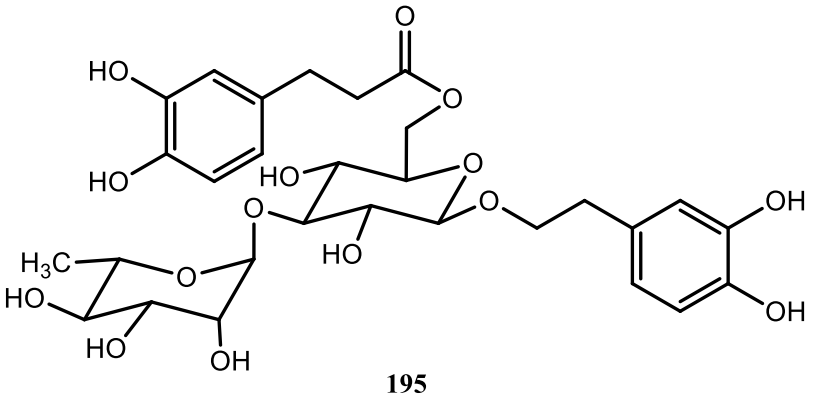


186 R_1=R_3=R_4=OH; R_2=R_6=H; R_5=OCH_3
187 R_1=R_5=OCH_3; R_2=R_6=H; R_3=R_4=OH
188 R_1=CH_3; R_2=R_6=H; R_3=R_5=OCH_3; R_4=OH
189 R_1=OH; R_2=R_4=R_5=H; R_3=R_6=OCH_3
190 R_1=O-β-D-Glu-(1–2)-β-D-Glu; R_2=R_4=R_5=H; R_3=R_6=OCH_3
191 R_1=R_5=OCH_3; R_2=R_4=R_6=H; R_3=O-β-D-Glu
192 R_1=O-β-D-Glu; R_2=R_4=H; R_3=R_6=OCH_3; R_5=OH

Figure 2: Structures of flavonoids from *Lantana camara*



193R_1=Caffeoyl; R_2=H
194R_1=H; R_2=Caffeoyl



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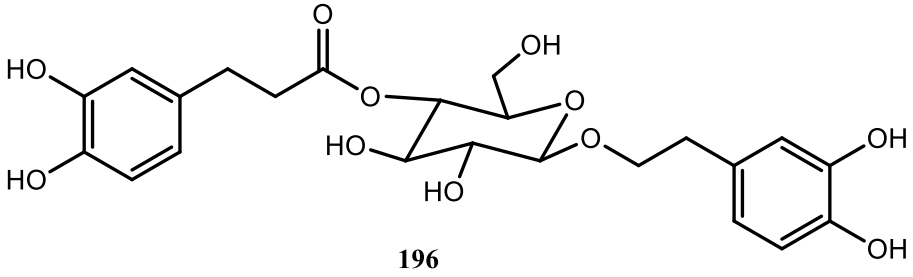

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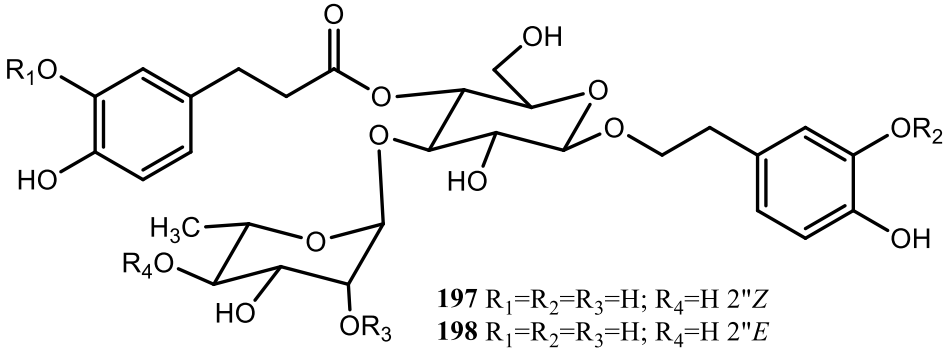
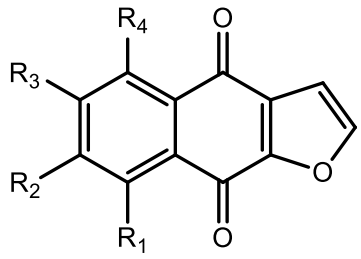


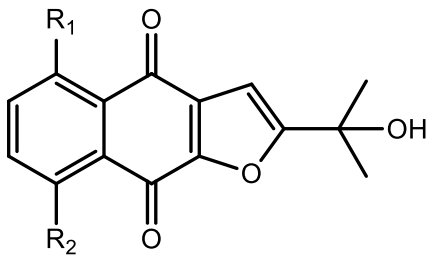
197 R_1=R_2=R_3=H; R_4=H 2"*Z*
198 R_1=R_2=R_3=H; R_4=H 2"*E*
199 R_1=R_2=CH_3; R_3=H; R_4=H 2"*E*

Figure 3: Structures of Phenylethanoid glycosides from *Lantana camara*



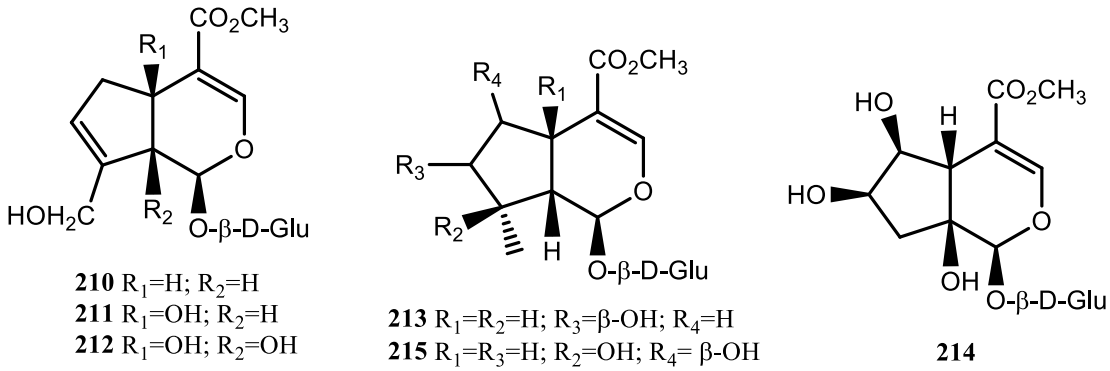
200 R_1=R_3=R_4=H; R_2=OCH_3
201R_1=R_3=H; R_2=OCH_3; R_4=OH
202 R_1=R_2=R_4=H; R_3=OCH_3
203 R_1=OH; R_2=R_4=H; R_3=OCH_3
204 R_1=R_2=H; R_3=OCH_3; R_4=OH
205 R_1=OH; R_2=OCH_3; R_3=R_4=H

208 R_1=OH; R_2=R_3=R_4=H
209 R_1=R_2=R_3=H; R_4=OH



206 R_1=OH; R_2=H
207 R_1=H; R_2=OH

Figure 4: Structures of Furanonaphthoquinones from *Lantana camara*

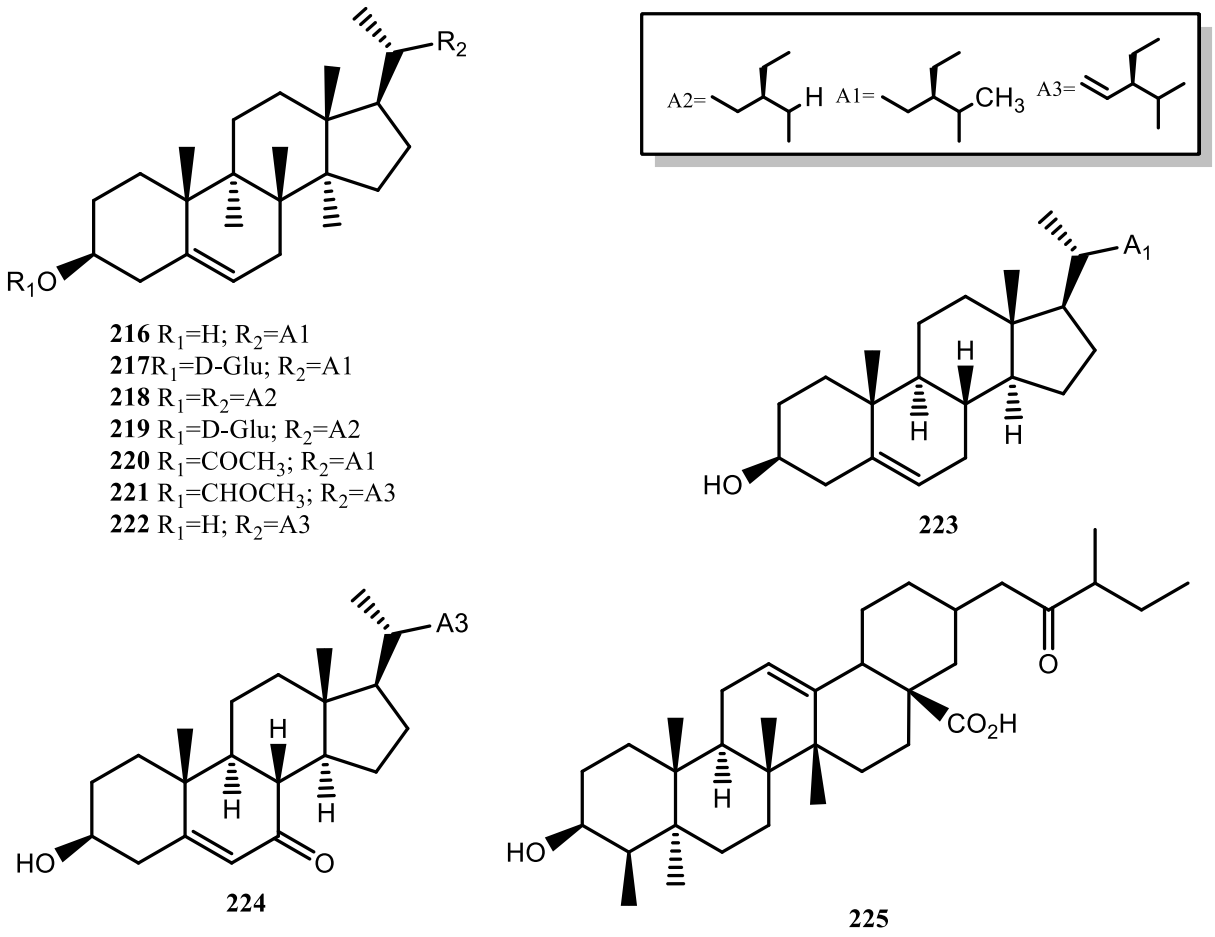


210 R_1=H; R_2=H
211 R_1=OH; R_2=H
212 R_1=OH; R_2=OH

213 R_1=R_2=H; R_3=β-OH; R_4=H
215 R_1=R_3=H; R_2=OH; R_4= β-OH

214

Figure 5: Structures of iridoid glycosides from *L. camara*



216 R_1=H; R_2=A1
217R_1=D-Glu; R_2=A1
218 R_1=R_2=A2
219 R_1=D-Glu; R_2=A2
220 R_1=$COCH_3$; R_2=A1
221 R_1=$CHOCH_3$; R_2=A3
222 R_1=H; R_2=A3

223

224

225

Figure 6: Structures of Steroids from *Lantana camara*

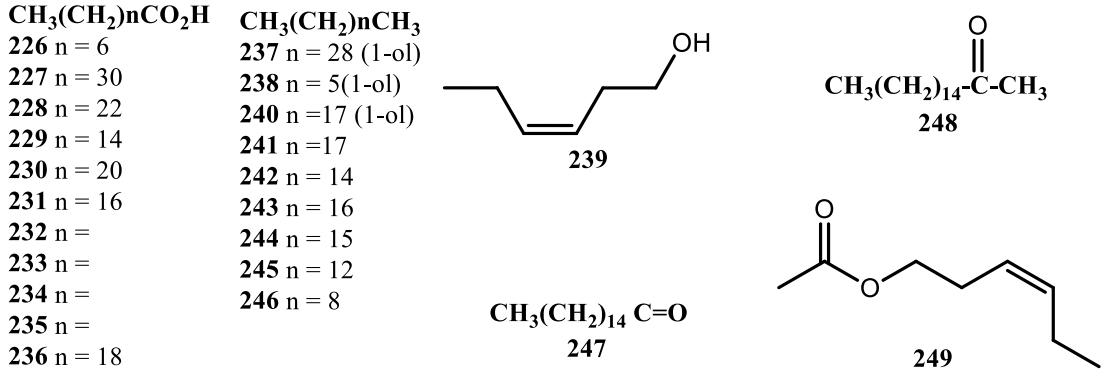


Figure 7: Structures of aliphatic compound from *L. camara*

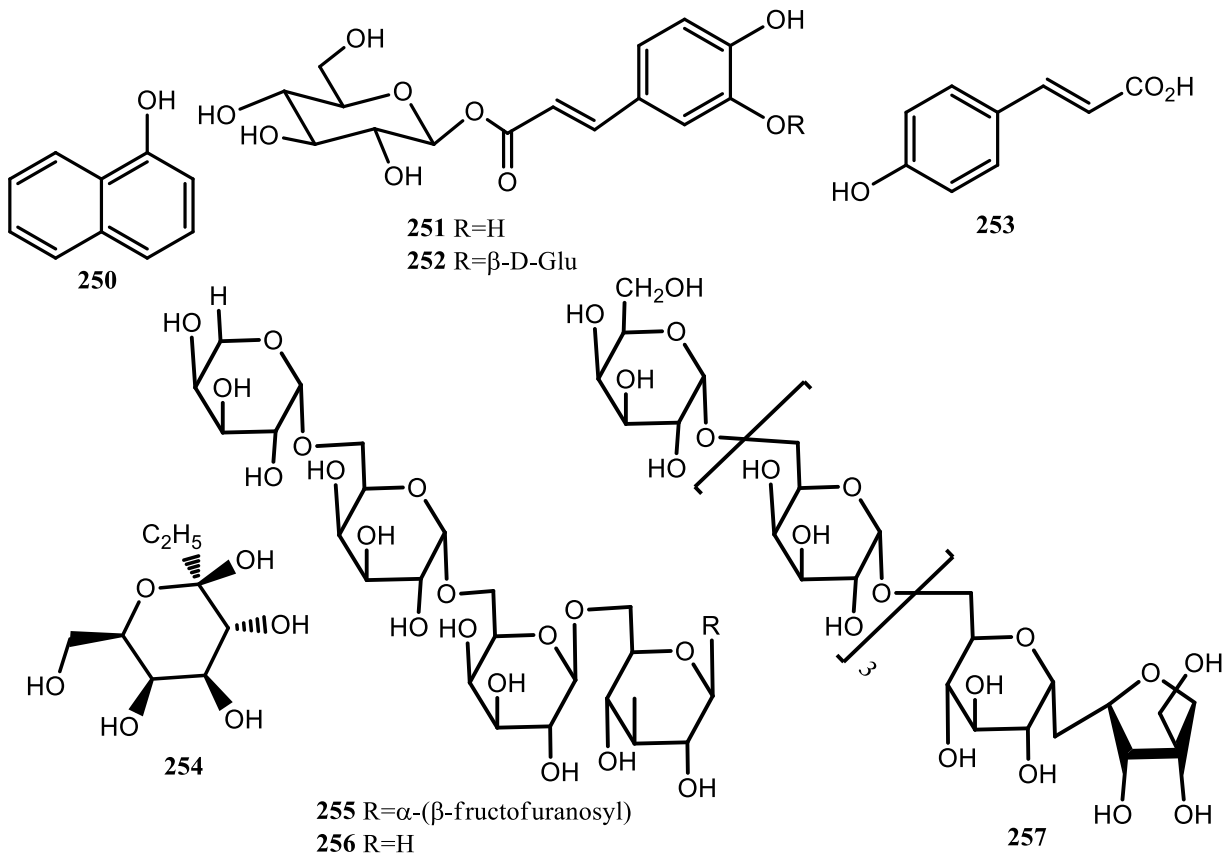
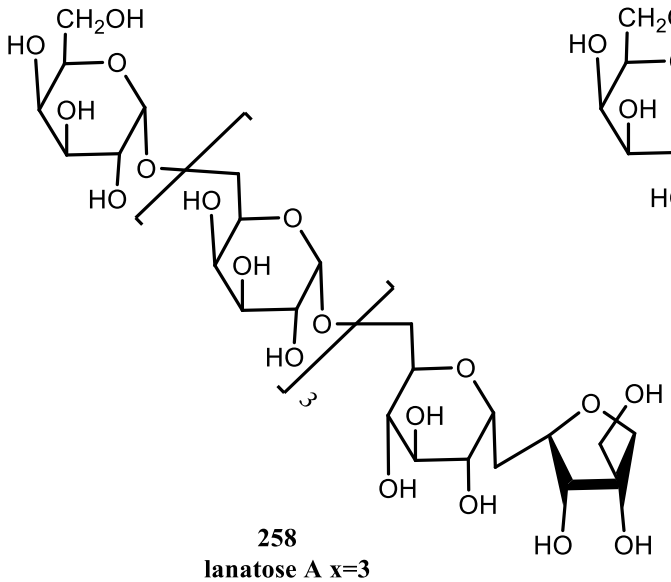
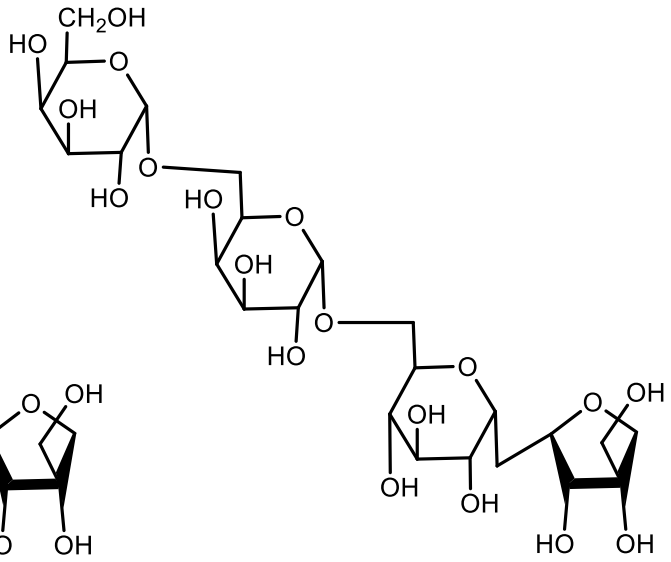


Figure 8: Structures of miscellaneous compounds from *L. camara*



258
lanatose A x=3
lanatose B x=4



259

Biological activity

Anthelminthic activity

Begum et al. (2008b) isolated seven compounds from the aerial parts of *L. camara* L., and tested them for nematicidal activity against the root-knot nematode *Meloidogyne incognita*. The lantanolic acid (**28**), pomolic acid (**46**), and lantoic acid (**54**) showed 100% mortality at 1.0% concentration after 24 h, while camarin (**23**), camarinin (**37**), lantacin (**45**) and ursolic acid (**47**) exhibited 100% mortality at 1.0% concentration after 48 h [43]. Lantanoside (**75**), linaroside (**76**) and camaric acid (**29**) isolated from the aerial parts of *L. camara* L. showed 90, 85 and 100% mortality, respectively, at 1.0% concentration [57]. All results were comparable with the conventional nematicide furadan (100% mortality at 1.0% concentration after 24 h).

In another study, extracts of stems and isolated compounds from seedlings of *L. camara*. were assessed for anti-filarial activity *in vitro* and *in vivo* [33]. The crude extract at 1 g/kg for five days, administered orally, killed 43.05% of the adult *Brugia malayi* parasites and sterilized 76% of surviving female worms in the rodent model *Mastomys coucha.* A 34.5% adulticidal activity along with sterilization of 66% of female worms could be demonstrated using the chloroform fraction. In the same study, the extract was also found to be effective against a subcutaneous rodent filariid *Acanthocheilonema viteae* maintained in *M. coucha*, where it exerted strong microfilaricidal (95.04%) and sterilization (60.66%) efficacy with mild macrofilaricidal action. Two compounds, oleanonic acid (**8**) and oleanolic acid (**9**), isolated from the hexane and chloroform fractions showed LC_{100} of 31.25 and 62.5 µg/mL, respectively, against *B. malayi in vitro.*

Extracts of *L. camara* L. with organic solvents were found to cause significant mortality *in vitro* of *Meloidogyne javanica* in mungbean, while aqueous and methanolic extracts demonstrated greater inhibition compared to ethyl acetate or hexane extracts, indicating that active principles were polar in nature [68].

Anti-protozoal activity

The dichloromethane extract leaf from *L. camara* L. (pink flower) was analyzed in one study and showed very promising activity when tested *in vitro* against cultures of chloroquine-sensitive (3D7) and chloroquineresistant (W2) strains of *P. falciparum* (IC_{50} 8.7±1.0 µg/ mL and 5.7±1.6 µg/mL, respectively) [69]. The dichloromethane extract from *L. camara* (orange flower) also exhibited promising activity (IC_{50}14.1±8.4 µg/mL and 12.2±2.9 µg/mL, respectively). In the same study, the dichloromethane extract (50 mg/kg) was investigated *in vivo* against *Plasmodium berghei* infected mice, and exhibited only 5% inhibition. Another *in vivo* study reported 8% inhibition of the parasite [70]. On the other hand, the aqueous extract of at doses of 250 and 500 mg/kg/day were tested *in vivo* in rats infected with *P. berghei*; the extract showed partial antimalarial activity at the doses tested, reducing parasite load by 25 and 49%, respectively [71].

Clarkson et al. (2004) reported that an extract of *L. camara* L. leaves demonstrated *in vitro* anti-plasmodial activity against a chloroquine-sensitive strain (D10) with an IC_{50} value of 11 µg/mL [72]. The non-polar extract of root-bark also displayed high anti-malarial activity against the multidrug resistant K1 strain [73].

***In vitro* toxicity**

One study reported that essential oils from the leaves of *L. camara* L. and *Lantana* sp. were evaluated for toxicity \ using *Artemia salina* larvae. The oils exhibited significant activities with LC_{50} of 14 µg/mL for *L. camara* and 24 µg/mL for *Lantana* sp. [74]. In other study, the essential oil of *L. camara* L. leaves showed an LC_{50} value of 10 µg/mL [75]. Fatore et al. (2002) studied the extracts of leaves, twigs, stems and roots of *L. camara* L., which were partitioned and analyzed for activity in the brine-shrimp lethality test. The active fractions yielded lantadene A (**1**), oleanonic acid (**8**), and oleanolic acid, which were very toxic to brine shrimp larvae. The three compounds were not lethal to *Spodoptera littoralis* Biosduval (Lepidoptera: Noctuidae), *Clavigralla tomentosicollis* Stal. (Hemiptera: Coreidae) and Aphis craccivora Koch (Homoptera: Aphididae) when tested at 5000 µg/mL. Lantadene A, however, suppressed the fecundity of *C. tomentosicollis* at this concentration [76].

Insecticidal activity

A recent study investigated the insecticidal activity of essential oil from the leaves of *L. camara* against mosquito vectors [77]. LD_{50} values of the oil were 0.06, 0.05, 0.05, 0.05 and 0.06 mg/cm^2 while LD_{90} values were 0.10, 0.10, 0.09, 0.09 and 0.10 mg/cm^2 against *Aedes aegypti, Culex quinquefasciatus, Anopheles culicifacies, A. fluvialitis* and *A. Stephensi*, respectively. KDT_{50} of the oil were 20, 18, 15, 12, and 14 min, and KDT_{90} values were 35, 28 25, 18, 23 min against *Ae. aegypti*, quinquefasciatus, *An. culicifacies, An. fluviatilis* and *An. stephensi*, respectively, on 0.208 mg/cm^2 impregnated paper. [78] showed that 200 ppm oil of *L. camara* L. produced 100% mortality in *C. quinquefasciarus* larvae in 15 min.

The essential oils from leaves of *L. camara* was tested for larvicidal activity against *A. aegypti* larvae at the third developmental stage [79]. The results showed that it has larvicidal potential with LC_{50} of 42.3±0.85 µg/mL. The essential oil also showed insecticidal activity against adults of *Sitophilus oryzae* L. (LC_{50} 0.22 mg/cm^2) and *Tribolium castaneum* (LC_{50} 0.22 mg/cm2), and revealed low fumigant toxicity against *S. oryzae* (LC_{50} 29.47 µL/L) and against *T. castaneum* (LC_{50} 47.68 µL/L) [80].

Kumar and Maneemegalai (2008) investigated the methanol and ethanol extracts of leaves and flowers of *L. camara* L. which showed mosquito larvicidal activity against 3rd and 4th instar larvae of the mosquito species *A. aegypti* and *C. quinquefasciatus*. Extracts at 1.0 mg/mL caused maximal mortality in *A. aegypti* exposed for 24 h. In the case of *C. quinquefasciatus*, maximal mortality was seen when the concentration was increased to 3.0 mg/mL [81]. Repellent properties of different fractions obtained from *L. camara* L. flowers have been evaluated against *Aedes* mosquitoes (*A. albopictus, A. vittatus* and *Ae. aegypti*) [82]. The results showed that one application of the chloroform fraction gave 100% protection for 2 h and up to 75.8% protection at 7 h against *A. mosquito* bites.

A methanolic extract of *L. camara* L. was tested on larval weight, pupation and adult emergence of cabbage butterfly [83]. *L. camara* resulted in significantly lower effect on reduction in weight (1.25%). Pupal formation increased significantly (0.0-43.1%) with a decrease in concentration from 5.0 to 1.25%. A similar trend was observed with respect to adult emergence of *Plasmodiophora brassicae* [84]. On the other hand, the methanolic extract of *L. camara* caused a significant reduction in aphid establishment (less than 50 %) at 5.0%.

Extracts of *L. camara* var. aculeata leaves were studied for their termiticidal effects against adult termite workers [85]. Only 5% chloroform extract exhibited excellent termite mortality. With respect to LC_{50}, the effect of 5% chloroform extract against *Microcerotermes beesoni* termites was the most interesting, compared to 0.5% chlorpyrifos.

Iannacone and Lamas (2003) studied the effects of extracts of *L. camara* on eggs, first instar larvae and adults of *Phthorimaea operculella* in bioassays of insecticidal effectiveness. The results showed that hatched eggs were affected by the hexane extract, and that first instar larva mortality was affected by hexane, acetone and water extracts at 10% concentrations [86].

The petroleum ether and methanol extracts of the aerial part of *L. camara* L. have been reported to be toxic to *Callosobruchus chinensis* [87]. The extracts showed 10-43% mortality at 5% concentrations, with fecundity loss at higher doses, and the antioviposition values were 30 mg/100 g for the petroleum ether extract and 40 mg/100 g of seed for the methanol extract. In other studies, the essential oils of leaves and flowers of *L. camara* L. revealed insecticidal activity against 3rd instar larvae of *Musca domestica*, demonstrating mortality rates of 80 and 100%, respectively [88], and the oil of leaves was effective against adults of *Sitophilus zeamais* (LC_{50} 0.16% at 24 h)

[89]. Essential oil of *L. camara* L. leaves also showed insecticidal properties against 3rd instar larvae of *Helicoverpa armigera*, causing 56% inhibition [90], and activity against fresh 5th instar nymphs of *Dysdercus similies* [91].

Antioxidant activity

Bhakta and Ganjewala (2009) showed that premature leaves of *L. camara* on twigs are very active in the biosynthesis and accumulation of secondary metabolites and, hence, exhibit greater antioxidant activity (DPPH scavenging activity, 62%). It was also found that older leaves had less antioxidant activity (55%), indicating loss of secondary metabolites as result of leaf senescence. In another study, *L. camara* essential oil exhibited high antioxidant activity as determined by the Trolox equivalent antioxidant capacity assay (TEAC) with a level of 29.0 mmol Trolox/kg [92].

Antifeedant activity

The chloroform, petroleum ether and methanol extracts of *L. camara* exhibited antifeedant activity against the tea mosquito bug (*Helopeltis theivora* Waterhouse), and among all the extracts, the chloroform extract showed the highest antifeedant effect [93]. An aqueous extract of leaves was tested for its antifeedant effects on *Plutella xylostella* [94]. The results showed that cabbage plants sprayed weekly with the extract protected the cabbage from *P. xylostella* to varying degrees. An antifeedant effect of crude lantadene from *L. camara* L. on *P. xylostella* and *Spodoptera litura* larvae has also been reported [95].

Phytotoxic activity

Previous evaluations of *L. camara* L. growing in Spain showed that an aqueous extract was not as effective against germination or seedling growth of *Amaranthus hybridus* and *Portulaca oleracea* as its essential oil [96]. The results suggest that its essential oil could be used as a potential allelopathic substance. Zhang et al. (2009) reported the allelopathic effect of aqueous extracts of leaf and reproductive organs (flower and fruit) of *L. camara* L. on seed germination, seedling growth and dry matter production of radish and lettuce. The results showed that fruit extracts were more stimulatory, while flower and leaf extracts had similar stimulatory/inhibitory effects. *L. camara* reproductive organs exerted stronger allelopathic effects compared to vegetative organs. Thus, the allelopathic effect of its reproductive organs makes it more competitive and invasive [97].

Sousa et al. (2009) investigated for the first time the cytotoxic and genotoxic effects of aqueous extracts of *L. camara* L. leaves on *Lactuca sativa* (lettuce) root tip meristem cells using a cytogenetic approach. The results showed that the highest concentration (30 g/L) of aqueous extracts decreased the mitotic index, seed germination and root development of lettuce. The extracts also induced chromosome aberrations and cell death in root cells of *L. sativa* [98].

The extracts of *L. camara* leaves and their fractions were shown to reduce the biomass of *Eichhornia crassipes* and *Microcystis aeruginosa* within 7 days under laboratory conditions [23]. Two fractions with highly inhibitory activity were isolated from the extract and subsequently identified as lantadene A (**1**) and lantadene B (**2**). Both compounds significantly inhibited *E. crassipes* and *M. aeruginosa* growth, even at a low concentration.

Antibacterial, antifungal activity

An investigation of acetone extracts of leaves of *L. camara* L. showed growth inhibitory effects against two Gram-negative (*E. coli* and *Pseudomonas aeruginosa*) and two Gram-positive (*Enterococcus faecalis* and *S. aureus*) bacteria, with MIC varying from 0.39 mg/mL to 6.3 mg/mL [99].

The essential oil of the leaves of *L. camar*a L. has been examined for antibacterial activity by the microdilution test [100]. The results showed an inhibitory activity against the multiresistant strains *E. coli* (MIC 512 µg/mL) and *S. aureus* (MIC 256 µg/mL). The compounds lantanoside (**75**), linaroside (**76**) and isolated from *L. camara* L. were also effective against strains of *M. tuberculosis*, both with a MIC of 6.25 µg/mL [57].

The antibacterial activity of lantic acid (**57**) isolated from *L. camara* leaves was studied in Gram-positive and Gram-negative bacteria using bioautography assays [46]. Lantic acid was found to possess strong antibacterial activity against *E. coli* and *Bacillus cereus*, in which 0.08 and 0.1 µg were the minimum inhibitory doses, respectively, compared to 0.05 and 0.005 µg for chloramphenicol, respectively.

Camarinic acid (**55**) isolated from *L. camar*a L. leaves was found to be active (30 mg/disk) against *S. aureus* and *Salmonella typhi* with an average antibacterial index of 0.95 and 0.55, respectively. By comparison, chloramphenicol against *S. aureus* and tetracycline against *S. typhi* had an index of respectively 1.6 and 0.8 at the same concentration [45]. In Tanzania the root bark extract of *L. camara* showed an *in vitro* antimalarial test with *Plasmodium falciparum* [73]. The essential oil containing β-caryophyllene, geranyl acetate, terpinyl acetate,

bornylacetate and limonene remarkably inhibited the growth of many fungi [19].

Essential oil of *L. camara* exhibited pronounced antifungal activity against the growth of *Aspergillus flavus (La3228)* and *A. parasiticus* (*Ab2242*). MIC of essential oil was found to be 2.5 µL /mL and 3.0 µl/ml respectively against toxigenic strains of *Aspergillus flavus (La3228)* and *Aspergillus parasiticus* (*Ab2242*).The essential oil exhibited pronounced antifungal activity against the toxigenic strain *Aspergillus parasiticus* (*Ab2242*) at 3.0 µl/ml and 3.5 µl/ml. At lower concentrations, such as 1.5 µL/mL, 2.0 µL/mL and 2.5 µL/mL, antifungal activity is less important with percentage of Inhibition of 18.66 %, 46.77%, and 80.77%, respectively [101].The essential oil of the leaves of *L. camar*a L. has been examined for antibacterial activity by the microdilution test. The results showed weak antibacterial activity against *S. aureus* ATCC (25923) and *E. faecalis* ATCC (29212) with MIC of 400 and 350 µg/mL, respectively [102]. The essential oil volatile constituents inhibited the growth of *Staphylococcus aureus* and *Pseudomonas aeruginosa* with MIC of 1 and > 1 mg/L, respectively. The activity of the antibiotic amikacin was increased by 65% against *S. aureus* and *P. aeruginosa* after contact with the volatile components [103].

Antifungal activity of essential oil from leaves of *L. camara* in comparison with some standard antifungals shown in Table 2 [104].

Anti-inflammatory, analgesic, sedative and antipyretic activity

Anti-inflammatory activity of oleanonic acid (**8**) isolated from *L. camara* L. was investigated by using the carrageenan-induced rat paw edema model. Oleanonic acid caused a reduction in edema, which validated its *in vivo* anti-inflammatory effect [34]. Another study reported that *L. camara* essential oil showed a relatively low anti-inflammatory activity due to its weak ability to inhibit lipooxygenase (IC_{50} 81.5 mg/mL) [105].

Whole plant and ethanolic extracts of fresh leaves of *L. camara* L. were investigated for their anti-inflammatory properties using the cotton pellet anti-inflammatory bioassay technique [106]. The treatments of the inflamed rats with the extracts resulted in the inactivation of phosphatase and transaminase activities and the stimulation of adenosine triphosphatase activity in plasma and exudates.

Antiproliferative and cytotoxic activities

Oleanolic acid (**9**), isolated from the roots of *L. camara* L., was converted into six semi-synthetic ester and seven amide derivatives. The ester derivatives showed 3-6 times more selective activity than did oleanolic acid against the human ovarian cancer cell line IGR-OV-1, while amide derivatives showed 16-53 times more selective activity against the human lung cancer cell line HOP-62 [39].

A crude extract of *L. camara* leaves had a cytotoxic effect on HeLa cells at 36 h (at 100 µg/ mL) to 72 h (at 25 µg/mL), by employing the 3-(4,5dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) cell viability assay [107]. The results showed that an increase in the concentration or duration of the extract treatment was effective in killing cancer cells.

Lantadenes A (**1**), B (**2**), C (**3**) and 22 β-dimethylacryloyloxy-24-hydroxy-3-oxo-olean12-en-28-oic acid (**17**), isolated from leaves of *L. camara* L., displayed weak to moderate cytotoxic activities against four cancer cell lines: human oral epidermoid carcinoma (KB), human colon cancer (HCT-116), human breast cancer (MCF-7), and mouse lymphocytic leukemia (L1210) (IC_{50} values of 4.7-44.7 µM) [24].

The compounds icterogenin (**16)** and 22β-dimethylacryloyloxy-24hydroxy-3-oxo-olean-12-en-28-oic acid (**17**), isolated from leaves of *L. camara* are evaluated for their interaction with the antiapoptotic protein Bcl-xL/Bak association. The two compounds exhibited binding activity with *Ki* values between 7.6 and 5.3 µM, indicating that they both act as antagonists of the Bcl-xL/Bak association [24].

Sharma et al. (2008) studied methyl ester derivatives of lantadene obtained from the lantadene fraction of leaves of *L. camara* L. and showed cytotoxicity against four human cancer cell lines (HL-60, HeLa, colon 502713, and lung A-549). Cytotoxicity increased as the length of the side chain increased from acetoxy to propoxy. There was a significant decrease in cytotoxicity with branching of the side chain. The C-17 methyl esters were all more cytotoxic, with 22 showing the best activity (IC_{50} 19.3-22.4 µg/mL). In the same study, lantadene A (**1**) and four methyl ester derivatives of lantadene exhibited tumor inhibitory activity on two-stage squamous cell carcinogenesis in Swiss albino mice, induced by DMBA and promoted by TPA. Lantadene A showed an 18.1% incidence of tumors and a delay of three weeks, while animals in the group treated with a derivate compound showed a significant decrease in the incidence of cancer (17.2 % vs 100%) at the end of twenty weeks [108].

Dichloromethane extracts of leaves from *L. camara* (colors of flowers: pink and orange) were tested for *in vitro* cytotoxicity against human WI-38 fibroblasts. The dichloromethane extracts showed IC_{50} values of 69.5±12.1 and 97.2±2.4 µg/mL for *L. camara* with pink and orange flowers, respectively [69].

In addition, the methanolic extracts of *L. camara* L. leaves was very effective in inhibiting tumor cell growth, where 50% growth inhibition (GI_{50}) was seen at concentrations of 12.5 µg/mL in MK-1 and 25 µg/mL in HeLa and B16F10. The inhibitory activity was found to be localized in the nonglycoside fraction that contains several flavonoids.

Another study found that the leaf extract of *L. camara* L., administered at dose of 400 mg/kg, showed a chemopreventive effect against DMBA-induced squamous cell carcinogenesis in Swiss albino mice (Sharma et al., 2007a). It was also found that lantadene A (**1**) induces apoptosis in human leukemia HL-60 cells by activating the caspase-3 pathway and through down- and upregulation of Bcl-2 and Bax expression, respectively (IC_{50} value of 19.8±0.10 µg/mL following 48 h incubation) (Sharma et al., 2007b).

Verbascoside (**113**) isolated from *L. camara* was shown to be an inhibitor of protein kinase C (PKC) from rat brain. The study reported that half-maximal inhibition of the kinase occurs at 25 µM. Verbascoside interacts with the catalytic domain of PKC and is a competitive inhibitor with respect to ATP (*Ki* 22 µM) and a non-competitive inhibitor with respect to the phosphate acceptor (histone IIIS). The antitumor activity of verbascoside measured *in vitro* may be due at least in part to the inhibition of PKC [60].In another study found a high toxicity level of essential oils from leaves and stems of *L. camara* showed against *A. salina* larve with a lethal concentration LC_{50} 0.234 µg/mL, when compared to values for the controls beberine chloride (LC_{50} of 22.5 µg/mL) and strychnine sulfate (LC_{50} of 77.2 µg/mL) [104].

Antiulcerogenic activity

Sathisha et al. (2011) studied the antiulcerogenic effect of a methanolic extract of *L. camara* L. in aspirin-induced gastric ulcerogenesis in pylorus-ligated rats and ethanol-induced gastric ulcer, and cysteamine-induced duodenal ulcer models. The extract was administered orally at two different doses, 250 and 500 mg/kg. The results showed that the extract significantly reduced the ulcer index and total acidity and significantly increased gastric pH of aspirin- and pylorus ligation-induced ulcerogenesis and ethanol-induced intestinal ulcer model. The extract also significantly reduced the ulcer index of cysteamine induced duodenal ulcer [109].

Anti-motility activity

L. camara L. var. *acuelata* leaf powder, methanolic extract, lantadene A (**1**), neostigmine alone and neostigmine with methanolic extract were evaluated for antimotility activity in the intestine of treated mice [110]. Neostigmine was used as a promotility agent and the intestinal motility was assessed by the charcoal meal test. It was observed that the percent intestinal transit significantly increased with neostigmine, but significantly decreased by all concentrations of methanolic extract and lantadene A. In the same study, an anti-diarrheal effect of the methanolic extract was studied in the castor oil-induced diarrhea model in mice. When the plant extract at 125 and 250 mg/kg doses was administered intraperitoneally, there was a significant reduction in fecal output compared with castor oil-treated mice. At higher doses (500 and 1000 mg/ kg), fecal output was almost completely stopped.

Anti-fertility activity

Mello et al. (2005) investigated the effects of the hydroalcoholic extract of the leaves of *L. camara* var. *aculeate* on reproduction. Three doses were tested in pregnant rats, 1, 3 and 7 g equivalent of plant material/kg body weight. The extract decreased the frequency of fetal skeleton anomalies in females and induced embryo toxicity as indicated by post-implantation loss, without any signs of maternal toxicity [111]. In another study, the hydro-alcoholic extract of *L. camara* leaves on fertility did not interfere with overall weight or internal organ weights of male rats, but interfered with sperm count, daily sperm production and sperm morphology in a dose-dependent manner [112].

Anticoagulant activity

Methanolic extracts prepared from the leaves of *L. camara* were found to inhibit human R-thrombin [56]. The activity was shown to be associated with the euphane lactone triterpenes (**70-74**). The mechanism of the inhibition of the blood-clotting cascade was shown to involve acylation of the active-site Ser 195 residue of thrombin. This acylating activity is generic towards other serine proteases. Weir et al. (1998) showed that the inhibitors bind to the active site of human R-thrombin and R-chymotrypsin Tight-binding reversible competitive inhibition was shown by euphane lactone B (**70-71**). Protease inhibition involves the opening of the lactone ring and acylation of the active-site serine 195. The IC_{50} with α-thrombin, α-chymotrypsin and trypsin was respectively

0.004, 0.07 and 0.07 for euphane lactone B (**70**) and 0.004, 0.01, 0.12 mM for euphane lactone C (**72**) [113].

***In vivo* Toxicity**

Tokarnia et al. (1999) diagnosed an outbreak of poisoning by *L. camara* var. *aculeata* in cattle in Quatis County, state of Rio of Janeiro. The results showed that the plant caused lethal poisoning when given as a single dose of 40 g/kg; 20 g/kg caused severe poisoning, 10 g/kg slight or no poisoning and 5 g/kg failed to provoke symptoms [114]. Another study showed that ingestion of 340-453 g of leaves of the *L. camara* causes liver and kidney damage, photosensitization, intestinal hemorrhage, paralysis of the gall bladder, and death in 1-4 days in horses, cattle and sheep (not goats) [115].

Lantadene C (**3**) isolated from *L. camara* var. *aculeata* leaves was shown to elicit a strong hepatotoxic response in guinea pigs associated with decrease in fecal output, feed intake, hepatomegaly, hepatic injury at the cellular and subcellular level, and increase in plasma bilirubin and acid phosphatase activity [28].

Sharma et al. (1989) had also reported that the oral administration (125 mg/kg) of a toxin fraction obtained from *L. camara* leaves, whose main constituents were lantadene A (**1**) and lantadene B (**2**), in male and female guinea pigs, caused icterus and photosensitization within 48 h [116]. A single dose of the lantadene A at 1-3 mg/kg injected intravenously in sheep was found to cause mild hepatocellular injury characterized by transient rises in serum enzymes, with or without hyperbilirubinemia, where higher doses resulted in hepatic necrosis [117].

In other studies, a partially purified fraction obtained from *L. camara* leaves containing seven chemicals was investigated. Lantadene A and lantadene B were the major compounds and nontoxic to guinea pigs [17]. 22□-hydroxyoleanonic acid (**7**) was isolated from the lantadene fraction of *L. camara* and was studied for hepatotoxicity using lantadene A (**1**) as standard and found to be nontoxic [31].

Antimutagenic activity

A study of the compounds lantanilic acid (**27**) and camarinic acid (**55**), which were isolated from *L. camara* showed high antimutagenic activity in the mouse; at 6.75 mg/kg, they reduced the number of micronucleated polychromatic erythrocytes induced by mitomycin C by 76.7% and 60%, respectively [45].

Wound healing activity

Lantana camara extract treated animals showed a significant reduction in wound area and period of epithelisation. The ethanolic and ethyl acetate extracts treated animals showed faster epithelisation of wound (10.34±0.11 and 11.86±0.17) than the control. The period of epithelisation was 9.14±0.21 in case of standard drug 5% Intadine ointment [118] (**Table 3**)

Table 2: Antifungal activity of essential oil from leaves of *L. camara*

Essential oil inhibition (oil concentration 100 mg/mL,50, 25 and 12.5 mg/mL)					Anfotericine	Fluconazole	Itraconazole	Terbinafine
Strains	Zone of inhibition in mm				Zone of inhibition in mm			
C. krusei	14	12	12	10	29	resistance	21	Resistance
C. albicans	13	11	11	11	19	29	19	Resistance

Table 3: Effect of topical application of 2% w/w ointment of ethanolic and ethyl acetate extract of *L. camara* on wound healing

Groups	Wound Closure (mm)^2			Epithelisation period (Days)
	3rd day	6th day	9th day	
Control(Untreated)	103.93±6.80	173.67±5.00	217.58±5.64	13.23±0.57
Standard(Intadine treated)	193.99±6.96	298.06±4.03*	314.46±0.31*	9.14±0.21*
Ethanolicextract of *Lantanacamara*	166.53±3.34*	262.21±1.37*	312.74±0.20*	10.34±0.11*
Ethyl acetate extract of *Lantana camara*	146.53±3.34*	232.21±1.37*	310.74±0.20*	11.86±0.17*

Values are mean ± SEM from a group of four animals. *p<0.01 when all treatment groups compared to control group

Conclusion

In the present review, we compiled ethnopharmacological, phytochemical, pharmacological and toxicological information on *Lantana camara*. The plant is a rich source of pharmacologically important molecules and deserves further research endeavors.

Conflict of interest

Authors declare that there is no conflict of interest to reveal.

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