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Phytochemical and Biological Properties of the Genus *Chorisia*: A Review

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Abstract

Chorisia (syn. *Ceiba*) is a genus of approximately 20 species of large, perennial, and deciduous trees within the plant family Bombacaceae, with common geographical distribution throughout the subtropical and tropical regions, especially South America. Besides their well-known ornamental and economic value, members of the genus *Chorisia* have found applications as medicinal plant species thanks to their assortments of bioactive phytoconstituents. To date, about 273 structurally varied metabolites have been described from different plant parts of *Chorisia* plants using various chromatographic and spectroscopic techniques, which mainly included flavonoids, anthocyanins, phenolic acids, quinones, terpenoids, and steroids, among others. Moreover, several organic solvent extracts and purified metabolites from *Chorisia* plants have been tested for their biological potential, such as anti-inflammatory, analgesic, antipyretic, antioxidant, hepatoprotective, antiobesity, cytotoxic, antidiabetic, hypolipidemic, antiulcerogenic, and antimicrobial properties. In of view of that, the current work provides an overview on different phytochemicals reported from the genus *Chorisia* as well as various biological and toxicological studies conducted so far on these plants, along with future research perspectives that might help expand their phytotherapeutic applications.

Keywords:

Ceiba, *Chorisia*, Bombacaceae, Phytochemical constituents, Biological activities

1.Introduction

Bombacaceae (The Bombax, Baobab or Kapok family) is a small family of flowering plants within the order Malvales and consists of 28 genera and 200 species [1]. These plants are woody, perennial, and deciduous trees that are widespread across the world's tropical and subtropical climates, especially in tropical America [2]. Besides the common use of Bombacaceae plants for ornamental purposes, several genera are economically and commercially valuable, producing timber, edible fruits, vegetable oils, and useful fibers, e.g., silk floss trees (*Chorisia* spp.) and kapok (fibers of *Ceiba* fruits) [3].

The genus *Chorisia* (syn. *Ceiba*) comprises approximately 20 species, such as *C. acuminata* S. Watson, *C. chodatti* Hassl., *C. crispiflora* Kunth., *C. insignis* H.B.K., *C. pentandra* L., *C. pubiflora* A. St. Hil., and *C. speciosa* A. St. Hil, which are found in tropical and subtropical regions, including Mexico, Central America, The Bahamas, The Caribbean, South America, West Africa and Southeast Asia [4, 5]. The genus *Chorisia* was given that name in honour of the traveller and the botanical artist, Ludwig L. Choris (1795–1828) [4]. Owing to their twisted branches, *Chorisia* plants are occasionally nicknamed as "the drunken trees" [4, 6], while as a defense mechanism against dry weather, they usually show a bottle-shaped trunk that swells in its lowest third to preserve water, and are encrusted with thick, sharp, pointed spines [5]. *Chorisia* spp. are primarily cultivated for ornamental and shade purposes thanks to their large branches and showy colored flowers that bloom during the autumn season [4, 5]. *Chorisia* species are also of economic importance, yielding flexible timber, edible and industrially useful seed oil, and versatile silky floss within their ripe fruits, thus they are also commonly named "silk floss trees". Such floss is utilized in the stuffing of cushions, pillows, and vests [4, 6]. Moreover, plants of the genus *Chorisia* are employed in folk medicine for headache, rheumatic pains, parasitic infections, GIT ulcers, and fever [7].

Over the last decade, *Chorisia* spp. have attracted the interest of many researchers to explore their phytochemicals, and accordingly numerous groups of structurally diverse metabolites have been characterized [8]. The total extracts and purified compounds of *Chorisia* plants have been also shown to exert several medicinal and therapeutic effects, e.g., anti-inflammatory, analgesic, antipyretic, antioxidant, hepatoprotective, cytotoxic, antidiabetic, and antimicrobial properties, among others [8]. Therefore, this work comprehensively reviews the reported phytochemicals and pharmacological properties of plants of the genus *Chorisia*.

2. Phytochemistry of the genus *Chorisia*

Previous phytochemical studies on *Chorisia* spp. led to the identification of a host of chemical constituents, such as flavonoids, anthocyanins, quinones, naphthoquinones, sesquiterpenes, sesquiterpene lactones, diterpenes, triterpenes, steroids, lignans, coumarins, megastigmanes, fatty acids and esters, hydrocarbons, tocopherols, amino acids, and carbohydrates. Different phytoconstitutents reported from the genus *Chorisia* are summarized in **Table 1** and portrayed in **Figures 1** and **2**.

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Table 1: A list of the reported compounds from the genus *Chorisia*

No.	Compound	Plant source	Plant Part	References
A) Flavonoids:				
1) Flavanols:				
1	(+)-Catechin	*Ceiba pentandra*	Aerial parts	[9]*
			Stem bark	[10]
2	*Epi*-catechin	*Ceiba pentandra*	Aerial parts	[9]*
2) Flavanones:				
3	Eriodictyol	*Ceiba pentandra*	Aerial parts	[9]*
4	Naringenin	*Ceiba pentandra*	Aerial parts	[9]*
5	Naringenin 7-*O*-glucopyranoside (Prunin)	*Ceiba pentandra*	Aerial parts	[9]*
3) Flavones:				
6	Apigenin	*Ceiba pentandra*	Aerial parts	[9]*
		Chorisia crispiflora	Flower	[11]
			----	[12]
7	Apigenin 7-*O*-β-glucopyran- oside (Cosmetin)	*Chorisia crispiflora*	----	[12]
			Leaf	[13]
8	Apigenin 6,8- di-*C*-β-glucopyranoside	*Chorisia crispiflora*	----	[12]
9	Apigenin 7-*O*-neohesperidoside (Rhoifolin or Rhoifoloside)	*Chorisia chodatii*	Flower	[8, 14]
			Leaf	[15]
		Chorisia crispiflora	Leaf	[13, 16]
			Flower	[11]
			----	[12]
		Chorisia insignis	Leaf	[16]
		Chorisia pubiflora	Leaf	[16]
		Chorisia speciosa	Leaf	[16, 17, 18]
			Flower	[19]
10	Apigenin 7-*O*-rhamnoside	*Chorisia crispiflora*	Leaf	[13]
11	Apigenin 7-*O*-rutinoside	*Chorisia insignis*	Leaf	[20]
12	Apigenin 4'-*O*-α-glucopyran-osyl-(6''→1''')-α-rhamnopyr-anoside	*Chorisia speciosa*	Leaf	[21]
13	3,5,4'-Trimethoxy-7-isobutyl flavone	*Chorisia insignis*	Leaf	[22]*
14	3,5,4'-Trimethoxy-7-isobutyl dihydroflavone	*Chorisia insignis*	Leaf	[22]*
15	Linarin (Acacetin 7-*O*-rutinoside)	*Ceiba pentandra*	Aerial parts	[9]*
			Leaf	[23]
16	Luteolin	*Chorisia crispiflora*	Flower	[11]
17	Luteolin 7-*O*-β-glucopyranoside (Cynaroside)	*Chorisia chodatii*	Flower	[8, 14]
		Chorisia crispiflora	Flower	[11]
		Chorisia speciosa	Leaf	[17, 18]
18	Luteolin 7-*O*-neohesperidoside	*Chorisia crispiflora*	Leaf	[11]
			Flower	
19	Luteolin 7-*O*-β-rutinoside	*Chorisia insignis*	Leaf	[20]
20	Myricitrin	*Ceiba pentandra*	Aerial parts	[9]*
21	Tricin	*Chorisia crispiflora*	Flower	[11]
22	Isovitexin	*Ceiba pentandra*	Aerial parts	[9]*
		Chorisia crispiflora	----	[12]
4) Isoflavones:				
23	5-Hydroxy-7,4',5'-trimethoxy isoflavone 3'-*O*-α-arabino-furanosyl (1→6) β-glucopyranoside	*Ceiba pentandra*	Stem Bark	[24]
24	Vavain or Pentandrin	*Ceiba pentandra*	Stem Bark	[10, 24, 25, 26*, 27*]
25	Vavain 3'-*O*-β-glucopyranoside (Pentandrin glucopyranoside)	*Ceiba pentandra*	Stem Bark	[10, 24, 25]
26	Dihydroalbigenin	*Chorisia insignis*	Leaf	[28]

No.	Compound	Plant source	Plant Part	References
5) Flavonols:				
27	5,6,7,3',4',5'-Hexahydroxy-dihydroflavonol 3-*O*-glucuronide	*Chorisia insignis*	Leaf	[22]*
28	5,6,7,3',4',5'- Hexahydroxy-dihydroflavonol 3-*O*-*β*-$\Delta^{1,3}$- octadienyl-glucuronide	*Chorisia insignis*	Leaf	[22]*
29	5,4',5'-Trihydroxy-7,3'- dimethoxy-2,3-dihydro- flavonol	*Chorisia insignis*	Leaf	[22]*
30	Kaempferol	*Ceiba pentandra*	----	[9*, 29]
		Chorisia speciosa	Bark	[30]*
31	Kaempferol 3-*O*-*β*-glucopyranoside (Astragalin)	*Ceiba pentandra*	Aerial parts	[9*, 14]
		Chorisia chodatii	Flower	[8]
		Chorisia speciosa	Leaf	[17, 18]
32	Kaempferol 3,7-di-*O*-*α*-rhamnopyranoside	*Chorisia crispiflora*	----	[12]
33	Kampferol 5,7,4'-trimethyl ether 3-*O*-*α*-rhamnosyl-(1'''→6'')-*O*-*β*-glucuronide	*Chorisia insignis*	Leaf	[22]*
34	Kampferol 5,7,4'-trimethyl ether 3-*O*-ethylene glycol	*Chorisia insignis*	Leaf	[22]*
35	Kaempferol 3-*O*-rutinoside	*Chorisia crispiflora*	Leaf	[13]
36	Quercetagetin 5,6,7,3',4'- pentamethyl ether 3-*O*-*β*-glucuronide	*Chorisia insignis*	Leaf	[22]*
37	Quercetin	*Ceiba aesculifolia*	Fruit	[31]*
		Ceiba pentandra	----	[29]
			Aerial parts	[9, 32]
		Chorisia insignis	Leaf	[22]*
		Chorisia speciosa	Bark	[30]*
			Flower	[19]
38	Quercetin 4'-methyl ether 3-*O*-*β*-*n*-hexyl-diglucuronide	*Chorisia insignis*	Leaf	[22]*
39	Quercetin 5,7,3'-trimethyl ether-3-*O*-*α*-rhamnopyranos-yl-(1'''→6'')-*O*-*β*-glucopyranoside	*Chorisia insignis*	Leaf	[22]*
40	Dihydroquercetin 5,7,3',4'-tetramethyl ether 3-*O*-glucuronide	*Chorisia insignis*	Leaf	[22]*
41	Dihydroquercetin 4'-methyl ether 3-*O*-*β*-*n*-hexyl-diglucuronide	*Chorisia insignis*	Leaf	[22]*
42	Dihydroquercetin 3-O-*α*-rhamnopyranosyl-(1'''→6'')-*O*-*β*-glucopyranososide	*Chorisia insignis*	Leaf	[22]*
43	Quercitrin	*Ceiba pentandra*	Aerial parts	[9]*
44	Rutin	*Ceiba pentandra*	Aerial parts	[9]*
		Chorisia insignis	Leaf	[20]
		Chorisia speciosa	Bark	[30]*
45	Tiliroside (Kaempferol 3-*O*-*β*-(6''-*p*-coumaroyl)-glucopyranoside	*Chorisia chodatii*	Flower	[8, 14]
		Chorisia crispiflora	Flower	[11]
		Chorisia speciosa	Flower	[19]
			Leaf	[17, 18]
6) Flavonolignans:				
46	Ceibapentain A (Ceibapentain Ia)	*Ceiba pentandra*	Aerial parts	[9, 33, 34]
47	Ceibapentain B (Ceibapentain Ib)	*Ceiba pentandra*	Aerial parts	[9, 33, 34]
48	Cinchonain Ia	*Ceiba pentandra*	Aerial parts	[9, 32, 33, 34]
49	Cinchonain IIa	*Ceiba pentandra*	Aerial parts	[9]*
50	Cinchonain IIa isomer	*Ceiba pentandra*	Aerial parts	[9]*
51	Cinchonain Ib	*Ceiba pentandra*	Aerial parts	[9, 32, 33, 34]
52	Cinchonain Ic	*Ceiba pentandra*	Aerial parts	[9]*
53	Cinchonain Id	*Ceiba pentandra*	Aerial parts	[9]*
54	Cinchonain I methyl ether	*Ceiba pentandra*	Aerial parts	[9]*

No.	Compound	Plant source	Plant Part	References
55	Corbulain Ib [2-(4-Hydroxy phenyl)-3,4,9,10-tetrahydro- 3, 5-dihydroxy-10-(3,4-dihydroxyphenyl)-(2*R*,3*R*, 10*S*)2*H*,8*H*-benzo[1,2-b:3,4-b']dipyran-8-one]	*Ceiba pentandra*	Aerial parts	[9]*
B) Anthocyanins:				
56	Cyanidin 3-glucopyranoside	*Ceiba acuminata*	Flower	[35]
		Chorisia speciosa	Flower	[35]
57	Cyanidin 3,5-diglucopyranoside	*Chorisia speciosa*	Flower	[35]
C) Quinones and naphthoquinones:				
58	Bombaxquinone B (Isohemigossypolone-2-methyl ether) or (8-Formyl-7-hydroxy-5-isopropyl-2-methoxy-3-methyl-1,4-naphthoquinone)	*Ceiba pentandra*	Heart wood Root bark Stem bark	[36] [37] [26]*
59	Isohemigossypolone (2,7-Dihydroxy-8-formyl-5-isopropyl-3-methyl-1,4-naphthoquinone)	*Ceiba pentandra*	Heart wood	[36]
D) Sesquiterpenes and bis-norsesquiterpenoids:				
60	Bicycloelemene	*Chorisia speciosa*	Leaf	[17]**
61	Hydroxydehydrochamazulene	*Chorisia insignis*	Leaf	[28]**
62	8-(Formyloxy)-8a-hydroxy-4a methyldecahydro-2-naphthalene carboxylic acid	*Ceiba pentandra*	Stem bark	[27]*
63	7-Hydroxycadalene (5-Isopropyl-3,8-dimethyl-2-naphthol)	*Ceiba pentandra*	Root bark	[37]
64	Farnesol	*Ceiba pentandra*	Aerial parts	[38]**
65	Dehydrofarnesol	*Chorisia insignis*	Leaf	[28]**
66	6,10,14-Trimethyl-2-pentadecanone	*Ceiba pentandra*	Aerial parts	[38]**
		Chorisia insignis	Leaf	[28]**
E) Sesquiterpene lactones:				
67	Hemigossylic acid lactone-2-hydroxy-7-methyl ether (Isohemigossylic acid lactone-7-methyl ether)	*Ceiba pentandra*	Root bark	[37]
68	Isohemigossylic acid lactone-2-methyl ether	*Ceiba pentandra*	Root bark	[37]
69	5-Isopropyl-3-methyl-2,7-dimethoxy-8,1-naphthalene carbolactone	*Ceiba pentandra*	Root bark	[37]
F) Diterpenes:				
70	Phytol	*Ceiba pentandra*	Aerial parts	[34, 38]**
		Chorisia insignis	Leaf	[28]**
		Chorisia speciosa	Leaf	[17]**
71	Isophytol	*Chorisia insignis*	Leaf	[28]**
72	Phytane	*Ceiba pentandra*	Aerial parts	[38]**
G) Triterpenes:				
73	*β*-Amyrin	*Ceiba pentandra*	Aerial parts	[34, 38**]
		Chorisia speciosa	Leaf	[17, 18]
74	*β*-Amyrone	*Chorisia crispiflora*	Leaf	[11]
75	Friedelin	*Chorisia crispiflora*	Leaf	[11]
76	3*β*-Friedelinol	*Chorisia crispiflora*	Leaf	[11]
77	*trans*-Squalene	*Ceiba pentandra*	Aerial parts	[34, 38]
		Chorisia insignis	Leaf	[28]**
		Chorisia speciosa	Leaf	[17]**
78	10-Demethyl squalene	*Chorisia insignis*	Leaf	[28]**
79	3*β*-Taraxerol	*Ceiba pentandra*	Aerial parts	[34, 38]
80	3*β*-Taraxerol acetate	*Ceiba pentandra*	Aerial parts	[34, 38]
H) Steroids:				
81	3*β*-Hydroxyandrost-5-ene-17-one	*Ceiba pentandra*	Aerial parts	[38]**
82	*δ*-5-Avenasterol	*Ceiba pentandra*	Seed	[39]**
83	*δ*-7-Avenasterol	*Ceiba pentandra*	Seed	[39]**
84	Brassicasterol	*Chorisia insignis*	Seed	[40]
		Chorisia speciosa	Seed	[40]
85	Campesterol (24-Methyl cholesterol)	*Ceiba aesculifolia*	Fruit	[31]
		Ceiba pentandra	Seed	[39]**
		Chorisia insignis	Seed	[40]
		Chorisia speciosa	Seed	[40]

No.	Compound	Plant source	Plant Part	References
86	Cholesterol	*Ceiba pentandra* *Chorisia insignis* *Chorisia speciosa*	Seed Seed Seed	[39]** [40] [40]
87	24-Ethylcholesta-1,3,5-triene	*Chorisia insignis* *Chorisia speciosa*	Seed Seed	[40] [40]
88	*β*-Sitosterol (21-Ethyl-cholesterol)	*Ceiba pentandra* *Chorisia chodatii* *Chorisia crispiflora* *Chorisia insignis* *Chorisia speciosa*	Aerial parts Seed Stem bark Flower Leaf Seed Seed	[34, 38] [39]** [25] [8, 14] [11, 41] [40] [40]
89	*β*-Sitosterol 3-*O*-*β*-glucopyranoside (Daucosterol)	*Ceiba pentandra* *Chorisia chodatii* *Chorisia crispiflora* *Chorisia speciosa*	Stem bark Aerial parts Flower Leaf Leaf	[25] [9*, 34*, 38] [8, 14] [11, 41] [17, 18, 21]
90	*γ*-Sitosterol	*Ceiba aesculifolia* *Chorisia speciosa*	Fruit Leaf	[31]* [17]**
91	5-Dehydroepisterol	*Chorisia speciosa*	Leaf	[17]**
92	Taraxasterol	*Chorisia speciosa*	Leaf	[17]**
93	Stigmasterol (24-Ethyl-5,22-cholestadien-3*β*-ol)	*Ceiba aesculifolia* *Ceiba pentandra* *Chorisia insignis* *Chorisia speciosa*	Fruit Seed Stem bark Leaf Seed Leaf Seed	[31] [39]** [27]* [28]** [40] [17, 18] [40]
94	5-*α*-Stigmastane-3,6-dione	*Chorisia speciosa*	Leaf	[17]**
95	Stigmast-3,5-dien-7-one	*Chorisia insignis* *Chorisia speciosa*	Seed Seed	[40] [40]
96	Stigmast-4-ene-3-one	*Chorisia insignis* *Chorisia speciosa*	Seed Seed	[40] [40]
97	Stigmast-4,6-dien-3-one	*Chorisia insignis* *Chorisia speciosa*	Seed Seed	[40] [40]
98	Stigmast-4-ene-3,6-dione	*Chorisia insignis* *Chorisia speciosa*	Seed Seed	[40] [40]
99	Stigmasterol 3-O-β-glucopyranoside	*Chorisia crispiflora*	Leaf	[41]
100	ε-7-Stigmastenol	*Ceiba pentandra*	Seed	[39]**
101	5,6-Dihydrositosterol (Stigmastanol)	*Chorisia insignis*	Leaf	[28]**
102	3-Methoxy-5,6-dihydrostigmasterol	*Chorisia insignis*	Leaf	[28]**
103	Ergost-5-en-3-ol	*Ceiba aesculifolia*	Fruit	[31]*
104	5,6-Dihydroergosterol	*Chorisia insignis*	Leaf	[28]**
105	4-Methylcholesterol	*Chorisia insignis*	Leaf	[28]**
106	Cholestanol	*Chorisia insignis*	Leaf	[28]**
107	Multiflorenol	*Chorisia insignis*	Leaf	[28]**
108	Cholest-5-en-3-one	*Chorisia insignis*	Leaf	[28]**
109	Cholest-6-one	*Chorisia insignis*	Leaf	[28]**
I) Lignans and neolignans:				
110	Dehyrodiconiferyl alcohol 9'-*O*-*β*-glucopyranoside	*Ceiba pentandra*	Aerial parts	[32, 34]
J) Coumarins:				
111	Aesculetin	*Ceiba pentandra* *Chorisia chodatii*	Aerial parts Flower	[9] [8, 14]
112	Aesculin	*Ceiba pentandra*	Aerial parts	[9]*
113	Coumarin	*Ceiba pentandra*	Aerial parts	[9]*

No.	Compound	Plant source	Plant Part	References
114	*Epi*-phyllocoumarin	*Ceiba pentandra*	Aerial parts	[9]*
115	Scopoletin	*Chorisia chodatii*	Flower	[8, 14]
116	Umbelliferone	*Ceiba pentandra*	Aerial parts	[9]*
K) Tannins:				
117	Condensed tannins	*Chorisia speciosa*	----	[42]
118	*Epi*-catechin-(4*β*→8) *epi*-afzelechin	*Ceiba pentandra*	Aerial parts	[9]*
119	*Epi*-catechin-(4*β*→8)-*epi*- catechin (Procyanidin B2)	*Ceiba pentandra*	Aerial parts	[9]*
120	Gallic acid	*Chorisia crispiflora* *Chorisia speciosa*	---- Bark	[12] [30]*
L) Alcohols, Phenols, Aldehydes and Ketones:				
121	5,8,5'-Trihydroxy-6,7,3',4'-tetramethoxy-3-*O*-glucuronyl dulcitol	*Chorisia insignis*	Leaf	[22]*
122	5-Hydroxymethyl furfural	*Chorisia chodatii*	Flower	[8, 14]
123	7-Butyryl-4,6-dihydroxy-3-methylbenzo[b]furan	*Chorisia speciosa*	Leaf	[17]**
124	Linalool tetrahydride	*Chorisia insignis*	Leaf	[28]**
125	Yomogi alcohol (2,5,5-Trimethyl-3,6-heptadien-2-ol)	*Chorisia insignis*	Leaf	[28]**
126	Stearyl alcohol	*Ceiba pentandra*	Aerial parts	[38]**
127	1-Hexacosanol (Ceryl alcohol)	*Ceiba pentandra*	Aerial parts	[34, 38]
128	Triacontanol	*Chorisia crispiflora*	Leaf	[11]
129	3,4,5-Trihydroxycyclohexan-1-ol (1'→1)-rhamnoside	*Chorisia insignis*	Leaf	[22]
130	Methyl bulnesol	*Chorisia insignis*	Leaf	[28]**
131	*Cis*-*p*-Menth-2-en-1-ol	*Chorisia insignis*	Leaf	[28]**
132	2,4,6-Trimethoxyphenol	*Ceiba pentandra*	Stem bark	[26, 27]*
133	*m*-*tert*-Butylphenol	*Chorisia speciosa*	Leaf	[17]**
134	Butylated hydroxytoluene	*Chorisia insignis*	Leaf	[28]**
135	Verbascoside (Acteoside)	*Chorisia speciosa*	Leaf	[17, 18]
136	Cyclohexanone	*Chorisia insignis*	Leaf	[28]**
137	Nopinone	*Chorisia insignis*	Leaf	[28]**
138	4-Hydroxy-4-methyl-2-pentanone	*Chorisia insignis*	Leaf	[28]**
139	2-Methyl cyclopentanone	*Chorisia insignis*	Leaf	[28]**
140	1-Methyl-6-acetyl-3-oxo-4-(1-methylethylene) bicyclo [4.3.0] nonane	*Chorisia speciosa*	Leaf	[17]**
141	Cyclohexadecanolide	*Chorisia insignis*	Leaf	[28]**
M) Lactones:				
142	Argentilactone I	*Chorisia crispiflora*	----	[43]
143	Argentilactone II	*Chorisia crispiflora*	----	[43]
144	Loliolide	*Ceiba pentandra*	Aerial parts	[9]*
145	(*R*)-6-[(*Z*)-1-Heptenyl)]-5,6-dihydro-2H-pyran-2-one	*Chorisia crispiflora*	----	[43]
146	(3*R*,4*R*,5*S*)-3,4-Dihydroxy-5-methyldihydrofuran-2-one	*Chorisia chodatii*	Flower	[8, 14]
N) Acids and Esters:				
147	Abscisic acid	*Ceiba pentandra*	Aerial parts	[9]*
148	Caffeic acid	*Ceiba pentandra* *Chorisia speciosa*	---- Aerial parts Bark	[29] [9] [30]*
149	Chlorogenic acid	*Chorisia speciosa*	Bark	[30]*
150	Dihydro *p*-coumaric acid	*Ceiba pentandra*	Aerial parts	[9]*
151	Ellagic acid	*Chorisia crispiflora* *Chorisia speciosa*	---- Bark	[12] [30]*
152	*trans*-Ferulic Acid	*Ceiba pentandra*	Aerial parts	[9]
153	Vanillic acid	*Chorisia chodatii*	Flower	[8, 14]

No.	Compound	Plant source	Plant Part	References
154	Ethyl vanillate	*Chorisia chodatii*	Flower	[8, 14]
155	Protocatechuic acid	*Ceiba pentandra*	Aerial parts	[9]*
			Leaf	[23, 44]
		Chorisia crispiflora	Leaf	[13]
156	Protocatechuic acid ethyl ester	*Chorisia chodatii*	Flower	[8, 14]
157	Hexanoic anhydride (Hexanoic acid anhydride)	*Chorisia insignis*	Leaf	[28]**
158	Heptanoic anhydride (Heptanoic acid anhydride)	*Chorisia insignis*	Leaf	[28]**
159	Succinic acid	*Chorisia chodatii*	Flower	[8, 14]
		Chorisia speciosa	Leaf	[17, 18]
160	Mono-octylphthalate	*Chorisia chodatii*	Flower	[8, 14]
161	Di-*n*-octylphthalate	*Ceiba pentandra*	Leaf	[45]
		Chorisia speciosa	Leaf	[17]
162	3,5-Dimethyl gallic acid phenyl ester	*Chorisia insignis*	Leaf	[22]
163	*p*-Hydroxybenzoic acid	*Chorisia chodatii*	Flower	[8, 14]
		Chorisia speciosa	Leaf	[17, 18]
164	Quinic acid ester of rhamnose	*Chorisia insignis*	Leaf	[28]
165	Methyl-2-(3',3'-dimethyl-1'-butyn-1'-yl)-1-cyclohexene carboxylate	*Chorisia insignis*	Leaf	[28]**
O) Megastigmanes:				
166	Chodatiionoside A	*Chorisia chodatii*	Leaf	[15]
167	Chodatiionoside B	*Chorisia chodatii*	Leaf	[15]
168	(6*S*,7*E*,9*R*)-6,9-Dihydroxy-4,7-megastigmadien-3-one 9-*O*-[*α*-arabinopyranosyl-(1 →6)-*β*-glucopyranoside]	*Chorisia chodatii*	Leaf	[15]
169	(3S,5R,6R,7E,9S)-Megastigman-7-ene-3,5,6,9-tetrol 3-O-β-glucopyranoside	*Chorisia chodatii*	Leaf	[15]
170	Cucumegastigmane II	*Chorisia chodatii*	Leaf	[15]
171	β-Ionone	*Chorisia insignis*	Leaf	[28]**
172	β-iso-Methyl ionone	*Chorisia speciosa*	Leaf	[17]**
173	Propyl homologue of β-ionone	*Chorisia insignis*	Leaf	[28]**
P) Fatty acids and esters:				
174	9-Decadienoic acid, 2-nitro-ethyl ester	*Chorisia speciosa*	Leaf	[17]**
175	Myristic acid (Tetradecanoic acid) $C_{14:0}$	*Ceiba pentandra*	Aerial parts	[34, 38]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[47]
176	Methyl tetradecanoate	*Chorisia insignis*	Leaf	[17]**
177	Methyl pentadecanoate	*Chorisia insignis*	Leaf	[28]**
178	Methyl 14-methyl pentadecanoate	*Chorisia insignis*	Leaf	[28]**
179	Palmitic acid (Hexadecanoic acid) $C_{16:0}$	*Ceiba aesculifolia*	Fruit	[31]*
		Ceiba pentandra	----	[29]
			Aerial parts	[34, 38]**
			Seed	[39]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[47]
		Chorisia speciosa	Seed	[48]**
180	Palmitoleic acid $C_{16:1}$	*Ceiba speciosa*	Seed	[46]**
		Chorisia speciosa	Seed	[48]**
181	Methyl hexadecanoate (Methyl palmitate)	*Chorisia insignis*	Leaf	[28]**
		Chorisia speciosa	Leaf	[17]**
182	Methyl 14-methyl hexadecanoate	*Chorisia insignis*	Leaf	[28]**

No.	Compound	Plant source	Plant Part	References
183	Methyl isohexadecanoate	*Ceiba aesculifolia*	Fruit	[31]*
184	Methyl 16,22-hexacosa-dienoate	*Chorisia insignis*	Leaf	[28]**
185	Heptadecanoic acid (Margaric acid) $C_{17:0}$	*Ceiba speciosa*	Seed	[48]**
		Chorisia speciosa	Seed	[46]**
186	Heptadecenoic acid $C_{17:1}$	*Chorisia speciosa*	Seed	[48]**
187	Methyl heptadecanoate	*Chorisia insignis*	Leaf	[17]**
188	Stearic acid $C_{18:0}$	*Ceiba pentandra*	Aerial parts	[34, 38]**
			Seed	[39]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[47]
		Chorisia speciosa	Seed	[48]**
189	Methyl stearate	*Chorisia insignis*	Leaf	[17, 28]**
190	Oleic acid $C_{18:1\ \omega 9}$	*Ceiba pentandra*	----	[29]
			Aerial parts	[34, 38]
			Seed	[39]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[47]
		Chorisia speciosa	Seed	[48]**
191	Methyl oleate	*Ceiba aesculifolia*	Fruit	[31]*
		Chorisia insignis	Leaf	[28]**
192	α-Linolenic acid $C_{18:3}$	*Ceiba pentandra*	Aerial parts	[34, 38]**
193	Linoleic acid $C_{18:2\ \omega 6}$	*Ceiba pentandra*	----	[29]
			Aerial parts	[34]**
			Seed	[39]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[47]
		Chorisia speciosa	Seed	[48]**
194	Vernolic acid (Linoleic acid 12:13-oxide)	*Chorisia speciosa*	Seed	[48]**
195	Methyl linoleate (Methyl 9,12-octadecadienoate)	*Ceiba aesculifolia*	Fruit	[31]*
		Chorisia insignis	Leaf	[28]**
		Chorisia speciosa	Leaf	[17]**
196	Triglycerides with linoleic acid	*Chorisia speciosa*	Seed	[49]
197	Malvalic acid (8,9-Methylene heptadec-8-enoic acid)	*Ceiba acuminata*	Seed	[29]
		Ceiba pentandra	----	[29]
			Seed	[39]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[50]
		Chorisia speciosa	Seed	[49, 50]
198	Dihydromalvalic acid	*Ceiba pentandra*	Seed	[51]
199	Methyl 4-hydroxy-9-octadecenoate	*Chorisia insignis*	Leaf	[28]**
200	Sterculic acid (9,10-methylene-octadec-9-enoic acid)	*Ceiba acuminata*	Seed	[29]
		Ceiba pentandra	----	[29]
			Seed	[39]**
		Ceiba speciosa	Seed	[46]**
		Chorisia insignis	Seed	[50]
		Chorisia speciosa	Seed	[49, 50]
201	2-Hydroxysterculic acid	*Ceiba pentandra*	Aerial parts	[9]*
202	Dihydrosterculic acid	*Ceiba speciosa*	Seed	[46]**
203	9,12,15-Octadecatrienoic acid methyl ester	*Chorisia speciosa*	Leaf	[17]*
204	(9Z,12Z,15Z)-17-Methyl octadeca-9,12,15-trienoic acid	*Ceiba pentandra*	Stem bark	[27]*
205	Methyl 3-methyl-8-nonadecenoate	*Chorisia insignis*	Leaf	[28]**
206	C20 Monoethylenic acid	*Chorisia insignis*	Seed	[47]
207	Arachidic acid C20:0	*Ceiba speciosa*	Seed	[46]**
		Chorisia insignis	Seed	[47]
		Chorisia speciosa	Seed	[48]**

No.	Compound	Plant source	Plant Part	References
208	Eicosenoic acid (Gadoleic acid or Gondoic acid) $C_{20:1}$	*Ceiba speciosa*	Seed	[46]**
		Chorisia speciosa	Seed	[48]**
209	Methyl 19,19-dimethyl eicosanoate	*Chorisia insignis*	Leaf	[28]**
210	Methyl arachidate	*Chorisia insignis*	Leaf	[28]**
211	Methyl 11-heneicosenoate	*Chorisia insignis*	Leaf	[28]**
212	Behenic acid $C_{22:0}$	*Ceiba speciosa*	Seed	[46]**
		Ceiba pentandra	Seed	[39]**
		Chorisia insignis	Seed	[47]
213	Methyl docosanoate (Methyl behenate)	*Chorisia insignis*	Leaf	[17, 28]**
214	Methyl 19,21-dimethyl-15,19-docosadienoate	*Chorisia insignis*	Leaf	[28]**
215	Lignoceric acid (Tetracosanoic acid) $C_{24:0}$	*Ceiba speciosa*	Seed	[46]**
216	Methyl 22-tetracosenoate	*Chorisia insignis*	Leaf	[28]**
217	Methyl 17,23-tetracosadienoate	*Chorisia insignis*	Leaf	[28]**
218	Methyl heptacosanoate	*Chorisia insignis*	Leaf	[28]
Q) Hydrocarbons and Tocopherols:				
219	2,8-Dimethyl nonane	*Chorisia insignis*	Leaf	[28]**
220	1-Isobutyladamantane	*Chorisia speciosa*	Leaf	[17]**
221	*n*-Undecane	*Chorisia insignis*	Leaf	[28]**
222	9-Dodecyltetradecahydro-anthracene	*Chorisia speciosa*	Leaf	[17]**
223	1-Hexadecene	*Ceiba pentandra*	Aerial parts	[38]**
224	2-Methyl-7-nonadecene	*Ceiba pentandra*	Aerial parts	[38]**
225	Cycloeicosane	*Ceiba pentandra*	Aerial parts	[38]**
226	5-Eicosene	*Ceiba pentandra*	Aerial parts	[38]**
227	1,19-Eicosadiene	*Ceiba pentandra*	Aerial parts	[38]**
228	*n*-Docosane	*Ceiba pentandra*	Aerial parts	[34, 38]**
229	9-Tricosene	*Ceiba pentandra*	Aerial parts	[38]**
230	*n*-Tetracosane	*Ceiba pentandra*	Aerial parts	[38]**
231	3-Ethyltetracosane	*Ceiba pentandra*	Aerial parts	[34, 38]**
232	*n*-Pentacosane	*Ceiba pentandra*	Aerial parts	[34, 38]**
233	*n*-Nonacosane	*Ceiba pentandra*	Aerial parts	[34, 38]**
234	*n*-Tririacontane	*Chorisia insignis*	Leaf	[28]**
235	*n*-Hentriacontane	*Ceiba aesculifolia*	Fruit	[28**, 31*]
		Chorisia insignis	Leaf	
236	11-Methyl-$\Delta^{5,7,9,15,17,23}$-triacont-hexene	*Chorisia insignis*	Leaf	[28]**
237	17-Pentatriacontene	*Ceiba pentandra*	Aerial parts	[38]*
238	*n*-Hexatriacontane	*Ceiba aesculifolia*	Fruit	[31]*
239	*n*-Tetratetracontane	*Ceiba aesculifolia*	Fruit	[31]*
240	α-Tocopherol	*Ceiba pentandra*	Seed	[39]*
241	γ-Tocopherol	*Ceiba pentandra*	Seed	[39]*
242	σ-Tocopherol	*Ceiba pentandra*	Seed	[39]*
R) Amino acids and amides:				
243	Valine	*Ceiba pentandra*	Aerial parts	[9]*
244	Leucine	*Ceiba pentandra*	Aerial parts	[9]*
245	Isoleucine	*Ceiba pentandra*	Aerial parts	[9]*
246	*p*-Coumaroyl tyrosine	*Ceiba pentandra*	Aerial parts	[9]*
247	Ficusoside	*Ceiba pentandra*	Aerial parts	[34]
248	Ceibamide-A	*Ceiba pentandra*	Aerial parts	[9]
249	Ceibamide-B	*Ceiba pentandra*	Aerial parts	[9]

No.	Compound	Plant source	Plant Part	References
250	*N*-(3,4-Dihydroxy-*cis*-cinnamoyl)-3-(3',4'-dihydroxyphenyl) alanine (*cis*-Clovamide)	*Ceiba pentandra*	Aerial parts	[9*, 32, 34]
251	*cis*-Clovamide methyl ester	*Ceiba pentandra*	Aerial parts	[9]*
252	*cis*-Clovamide ethyl ester	*Ceiba pentandra*	Aerial parts	[9]*
253	*cis*-Clovamide butyl ester	*Ceiba pentandra*	Aerial parts	[9]*
254	*N*-(3,4-Dihydroxy-*trans*-cinnamoyl)-3-(3',4'-dihydroxyphenyl) alanine (*trans*-Clovamide)	*Ceiba pentandra*	Aerial parts	[9*, 32, 34]
255	*trans*-Clovamide methyl ester (*N*-*trans*-Caffeoyl-DOPA-methyl ester)	*Ceiba pentandra*	Leaf Aerial parts	[9] [23]
256	*trans*-Clovamide ethyl ester	*Ceiba pentandra*	Aerial parts	[9] *
257	*trans*-Clovamide butyl ester	*Ceiba pentandra*	Aerial parts	[9] *
258	Betaine	*Ceiba pentandra*	Aerial parts	[9] *
259	1,3-Dihydro-3,3-dimethyl-5-methoxy-2*H*-indol-2-one	*Chorisia speciosa*	Leaf	[17]**
S) Lipids:				
260	Dehydrophytosphingosine	*Ceiba pentandra*	Aerial parts	[9] *
T) Carbohydrates:				
1) Monosaccharides:				
261	Arabinose	*Chorisia speciosa*	Fruit Gum	[52] [53]
262	Galactose	*Chorisia speciosa*	Fruit Gum Seed	[52] [53] [54]
263	Glucose	*Chorisia speciosa*	Fruit	[52]
264	Mannose	*Chorisia speciosa*	Fruit Gum	[52] [53]
265	Rhamnose	*Chorisia speciosa*	Fruit Gum Seed	[52] [53] [54]
266	Xylose	*Chorisia speciosa*	Fruit Gum	[52] [53]
2) Polysaccharides:				
267	Polysaccharide consists of: rhamnose, arabinose, galactose and uronic acid	*Chorisia speciosa*	Silk floss	[55]*
268	Polysaccharide contains: fucose, xylose, arabinose, glucose, galactose, glucuronic acid and 4-O-methyl-D-glucuronic acid	*Ceiba pentandra*	Stem bark	[56]*
3) Derived carbohydrates and uronic acids:				
269	Glucuronic acid	*Chorisia speciosa*	Fruit Seed Gum	[52] [54] [53]
270	Mucilage contains: galactose, rhamnose, xylose, mannose, arabinose, and glucuronic acid	*Chorisia speciosa*§	Flower	[19]
271	Mucilage contains: glucuronic acid, galact-uronic acid, rhamnose, galactose, glucose, arabinose, xylose, mannose, and ribose.	*Chorisia speciosa*§	Leaf	[57]
U) Vitamins:				
272	Niacinamide or Vitamin B3	*Ceiba pentandra*	Aerial parts	[9]*
V) Miscellaneous compounds:				
273	1,1,3,3-Tetramethyl-1,3-disilaindan	*Chorisia speciosa*	Leaf	[17]**

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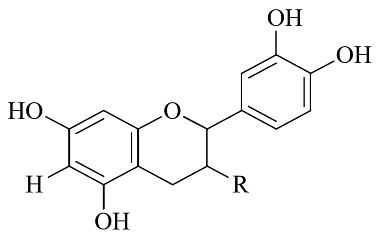
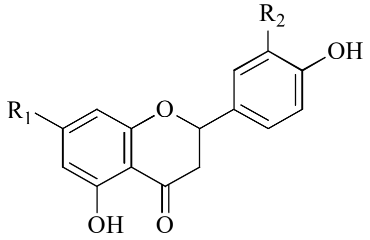
* Identification of these compounds was based on LC/MS analysis.

** Identification of these compounds was based on GC/MS analysis.

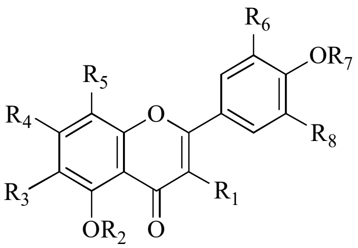
§ Mucilage of *C. speciosa* leaves contains ribose and mannose, while that of *C. crispiflora* and *C. pubiflora* leaves contains ribose but no mannose. Mucilage of *C. insignis* leaves, on the other hand, contains no mannose or ribose



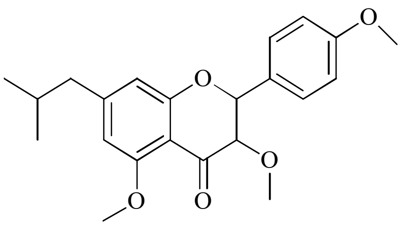
	R
(1)	βOH
(2)	αOH



	R_1	R_2
(3)	OH	OH
(4)	OH	H
(5)	Glc.	H



	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
(6)	H	H	H	OH	H	H	H	H
(7)	H	H	H	O-Glc.	H	H	H	H
(8)	H	H	C-Glc.	OH	C-Glc.	H	H	H
(9)	H	H	H	O-Glc.(2→1)Rha.	H	H	H	H
(10)	H	H	H	O-Rha.	H	H	H	H
(11)	H	H	H	O-Glc.(6→1)Rha.	H	H	H	H
(12)	H	H	H	OH	H	H	Glc.(6→1)Rha.	H
(13)	OMe	Me	H	CH_2-CH-$(CH_3)_2$	H	H	Me	H
(15)	H	H	H	O-Glc.(6→1)Rha.	H	H	Me	H
(16)	H	H	H	OH	H	OH	H	H
(17)	H	H	H	O-Glc.	H	OH	H	H
(18)	H	H	H	O-Glc.(2→1)Rha.	H	OH	H	H
(19)	H	H	H	O-Glc.(6→1)Rha.	H	OH	H	H
(20)	ORha.	H	H	OH	H	OH	H	OH
(21)	H	H	H	OH	H	OMe	H	OMe
(22)	H	H	C-Glc.	OH	H	H	H	H



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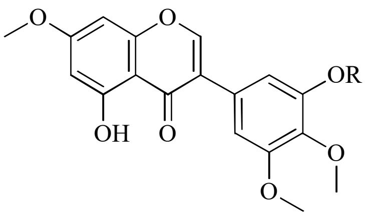
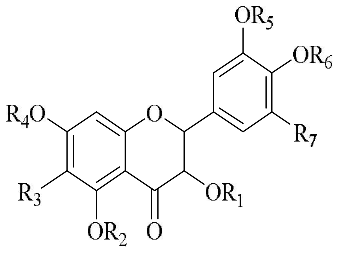
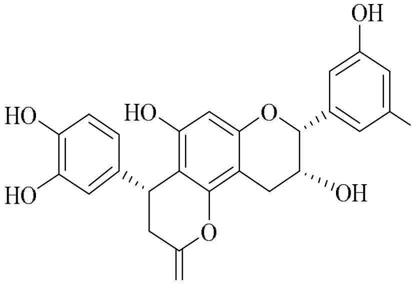


	R
(23)	Glc.(6→1)Ara.(f)
(24)	H
(25)	Glc.

Figure 1: Chemical structures of the reported compounds from the genus *Chorisia*.



	R_1	R_2	R_3	R_4	R_5	R_6	R_7
(27)	CO-$(CHOH)_4$-CH_2OH	H	OH	H	H	H	OH
(28)	(6''-$\Delta^{1,3}$-octadienyl)Gluc.	H	OH	H	H	H	OH
(40)	CO-$(CHOH)_4$-CH_2OH	Me	H	Me	Me	Me	H
(41)	Gluc.(6''→1''')6'''-n-hexyl-Gluc.	H	H	H	H	Me	H
(42)	Glc.(6→1)Rha.	H	H	H	H	H	H



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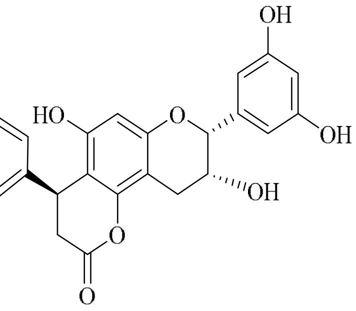

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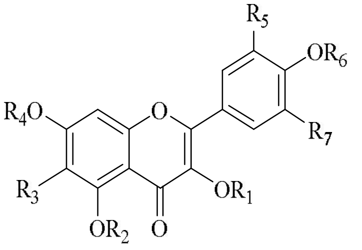
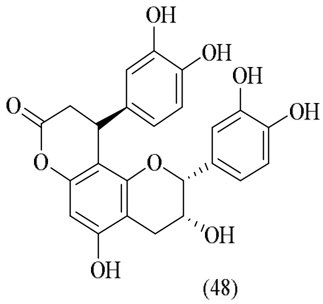


	R_1	R_2	R_3	R_4	R_5	R_6	R_7
(29)	H	H	H	Me	OMe	H	OH
(30)	H	H	H	H	H	H	H
(31)	H	H	H	H	OH	H	H
(32)	Rha.	H	H	Rha.	H	H	H
(33)	Gluc.(6→1)Rha.	Me	H	Me	H	Me	H
(34)	CHOH-CH_2OH	Me	H	Me	H	Me	H
(35)	Glc.(6→1)Rha.	H	H	H	H	H	H
(36)	Gluc.	Me	OMe	Me	OMe	Me	H
(37)	H	H	H	H	OH	H	H
(38)	diGluc.-n-hexyl	H	H	H	OH	Me	H
(39)	Glc.(6→1)Rha.	Me	H	Me	OMe	H	H
(43)	Rha.	H	H	H	OH	H	H
(44)	Glc.(6→1)Rha.	H	H	H	OH	H	H
(45)	Glc.-(6″-*p*-coumaroyl)	H	H	H	H	H	H

Figure 1: (cont.).



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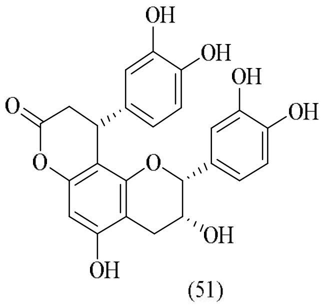

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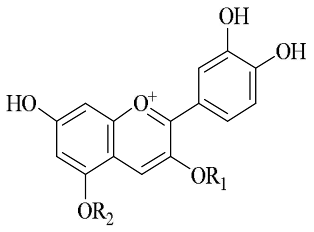
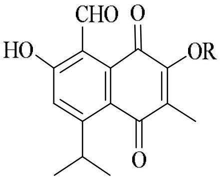
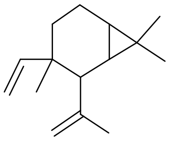


	R_1	R_2
(56)	Glc.	H
(57)	Glc.	Glc.



	R
(58)	Me
(59)	H



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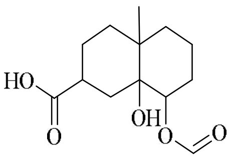

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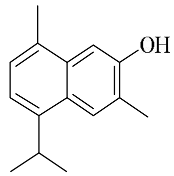

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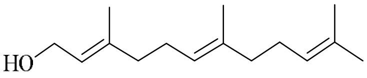

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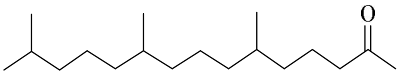

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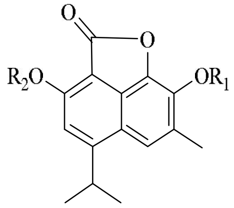
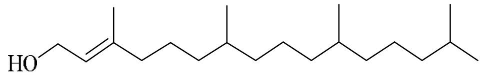


	R_1	R_2
(67)	H	Me
(68)	Me	H
(69)	Me	Me



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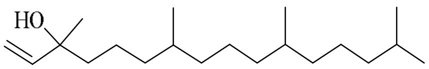
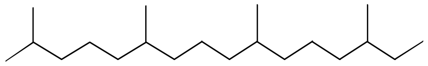
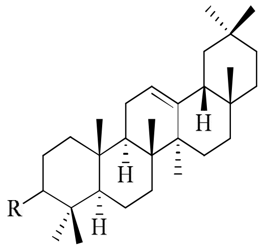


(71)

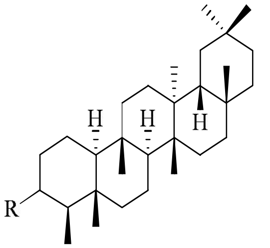
Figure 1: (cont.).



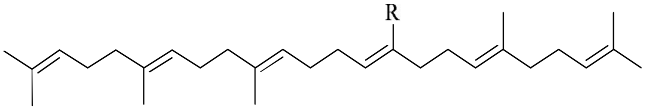
(72)



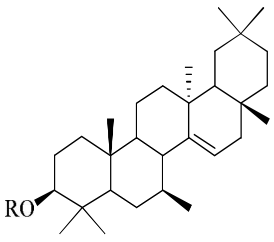
R
(73) βOH
(74) =O



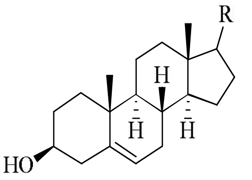
R
(75) =O
(76) βOH



R
(77) Me
(78) H

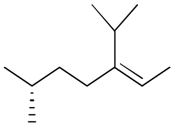


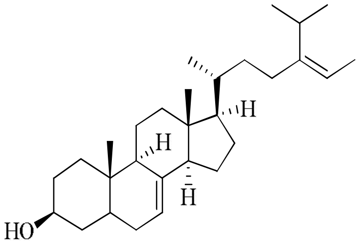
R
(79) H
(80) COMe



R
(81) =O

(82)





(83)

Figure 1: (cont.).

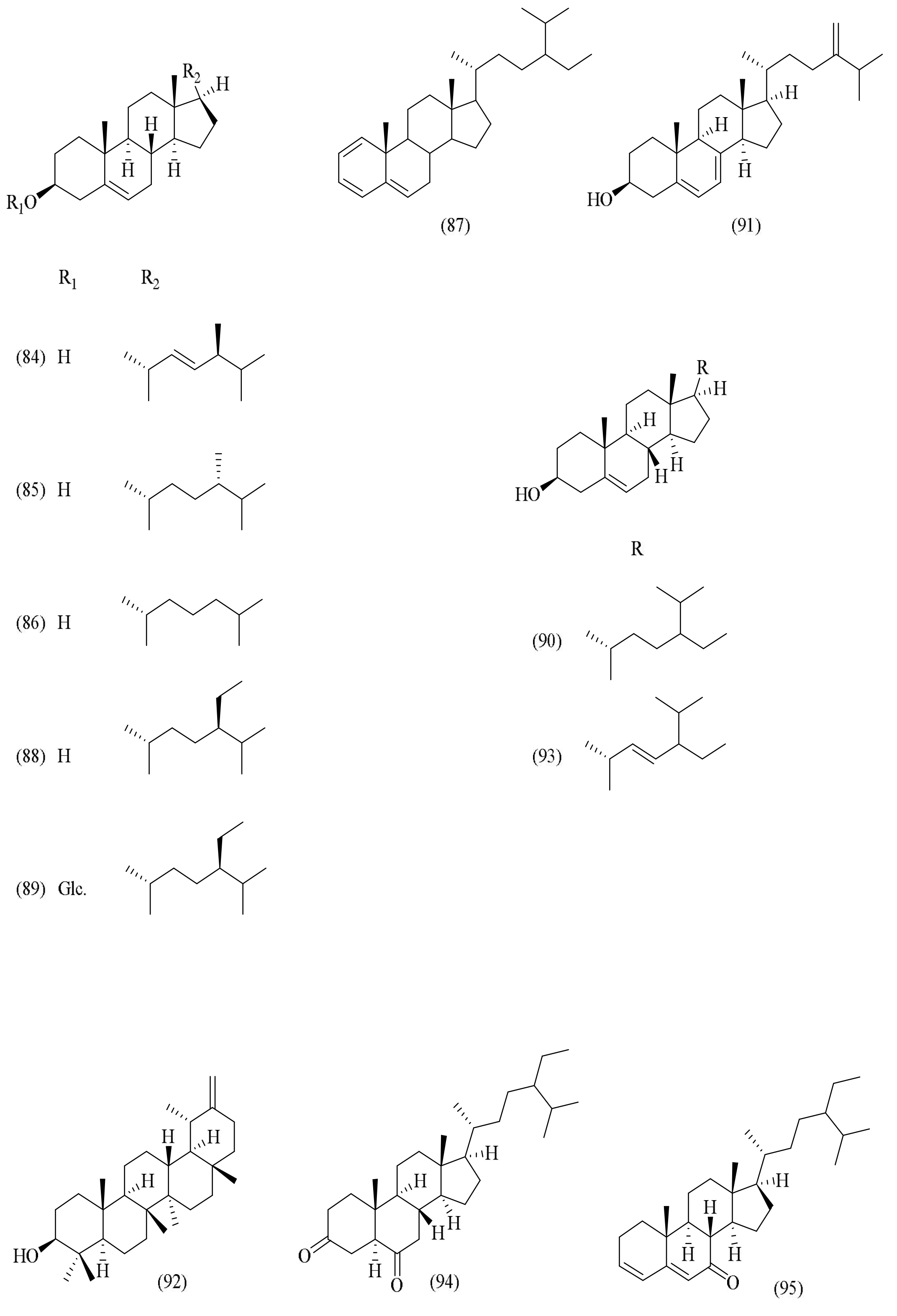
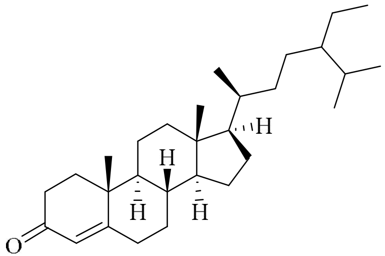
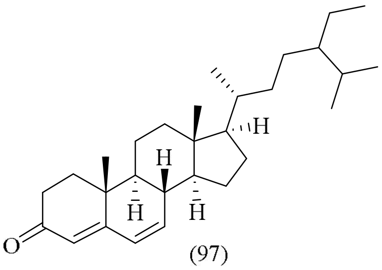


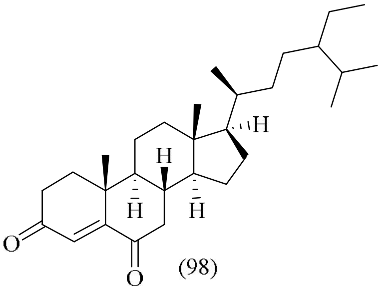
Figure 1: (cont.).



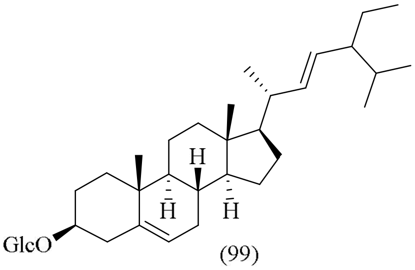
(96)



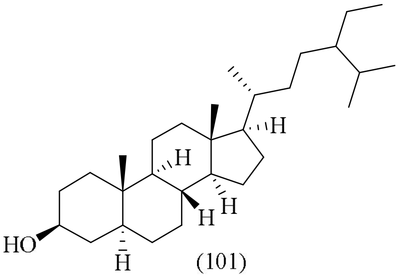
(97)



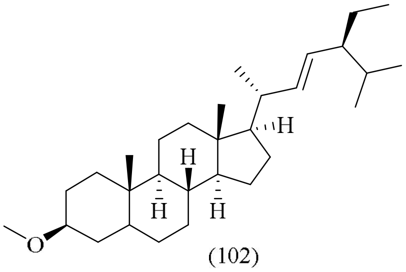
(98)



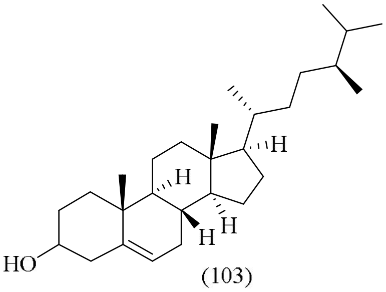
(99)



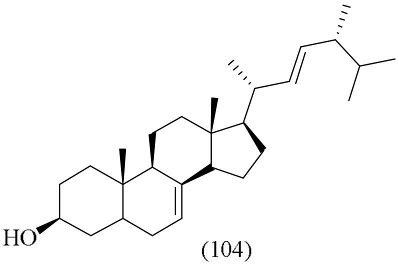
(101)



(102)

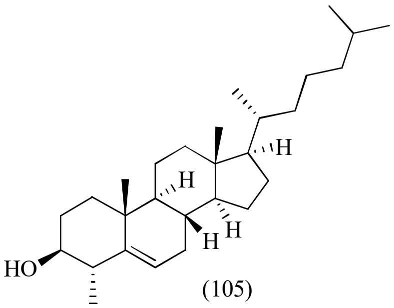


(103)

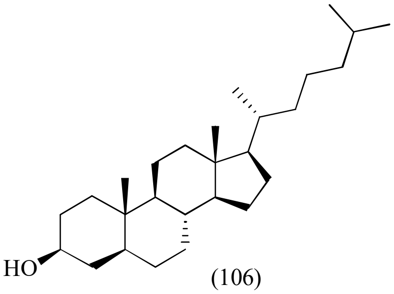


(104)

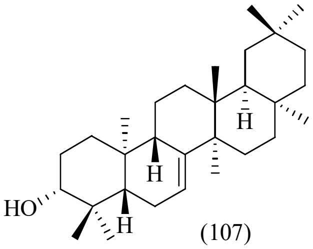
Figure 1: (cont.).



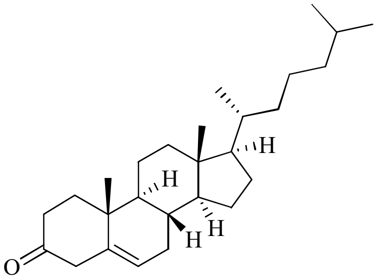
(105)



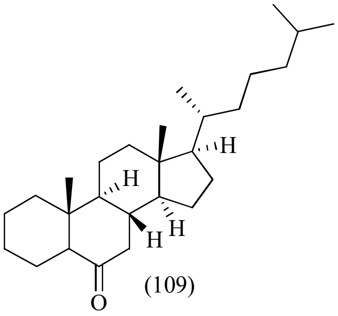
(106)



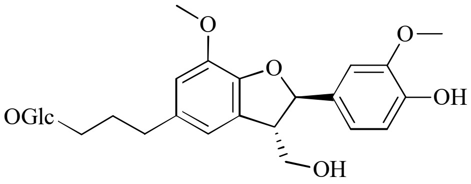
(107)



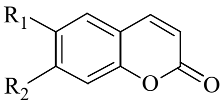
(108)



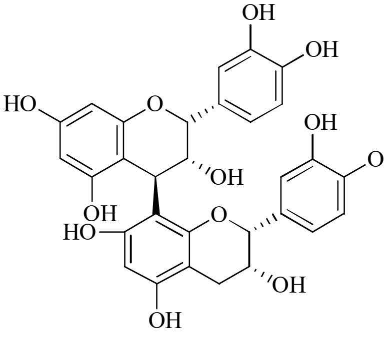
(109)



(110)

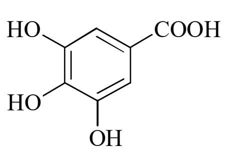


	R_1	R_2
(111)	OH	OH
(112)	OGlc.	OH
(113)	H	H
(115)	OMe	OH
(116)	H	OH

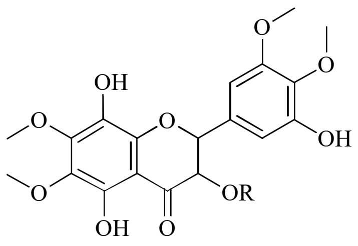


(119)

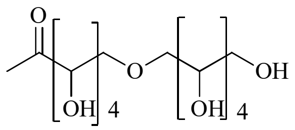
Figure 1: (cont.).

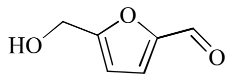


(120)

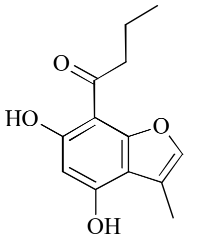


(121) R=

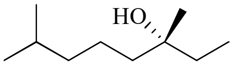




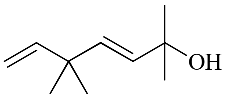
(122)



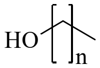
(123)



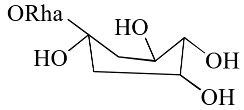
(124)



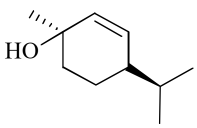
(125)



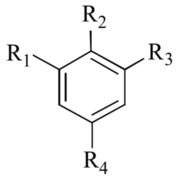
(126) n=17
(127) n=25
(128) n=29



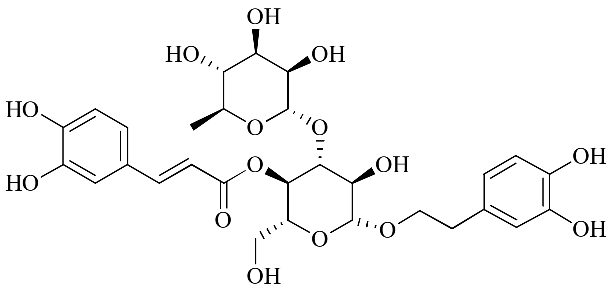
(129)



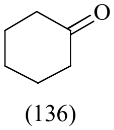
(131)



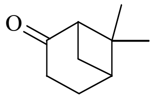
	R_1	R_2	R_3	R_4
(132)	OMe	OH	OMe	OMe
(133)	*t*-butyl	H	OH	H
(134)	*t*-butyl	OH	*t*-butyl	Me



(135)

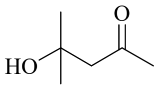


(136)

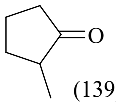


(137)

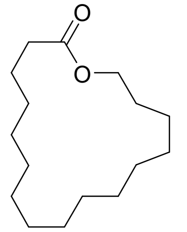
Figure 1: (cont.).



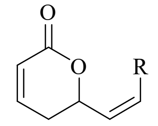
(138)

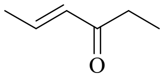
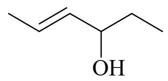
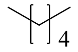


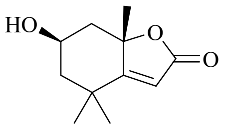
(139)



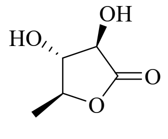
(141)



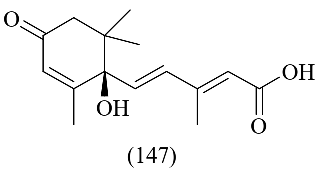
	R
(142)	
(143)	
(145)	



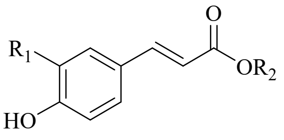
(144)

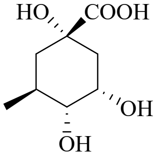


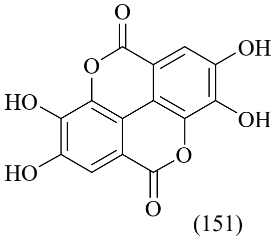
(146)



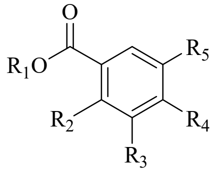
(147)



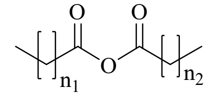
	R_1	R_2
(148)	OH	H
(149)	OH	
(150)	H	H
(152)	OMe	H



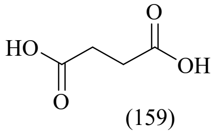
(151)



	R_1	R_2	R_3	R_4	R_5
(153)	H	H	OMe	OH	H
(154)	CH_2CH_3	H	OMe	OH	H
(155)	H	H	OH	OH	H
(156)	CH_2CH_3	H	OH	OH	H
(160)	H	$COO(CH_2)_7CH_3$	H	H	H
(161)	$(CH_2)_7CH_3$	$COO(CH_2)_7CH_3$	H	H	H
(162)	phenyl	H	OMe	OH	OMe
(163)	H	H	H	OH	H

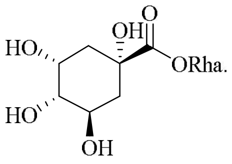


(157) n_1=4; n_2=4
(158) n_1=5; n_2=5

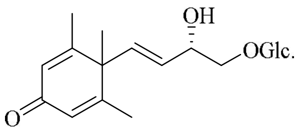


(159)

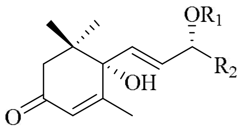
Figure 1: (cont.).



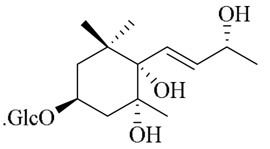
(164)



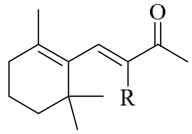
(166)



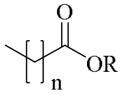
	R_1	R_2
(167)	H	CH_2-OGlc.(6→1)Ara.
(168)	Glc.(6→1)Ara.	Me
(170)	H	CH_2-OGlc.



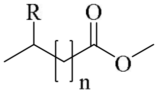
(169)



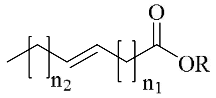
	R
(171)	H
(172)	Me



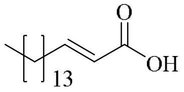
(175) n=12; R=H
(176) n=12; R=Me
(177) n=13; R=Me
(179) n=14; R=H
(181) n=14; R=Me
(185) n=15; R=H
(187) n=15; R=Me
(188) n=16; R=H
(189) n=16; R=Me
(207) n=18; R=H
(210) n=18; R=Me
(212) n=20; R=H
(213) n=20; R=Me
(215) n=22; R=H
(218) n=25; R=Me



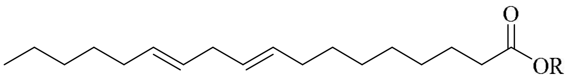
(178) n=12; R=Me
(182) n=12; R=CH_2-CH_3



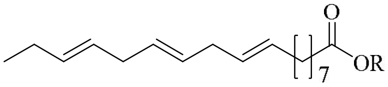
(180) n_1=7; n_2=5; R=H
(190) n_1=7; n_2=7; R=H
(191) n_1=7; n_2=7; R=Me
(208) n_1=9; n_2=7; R=H



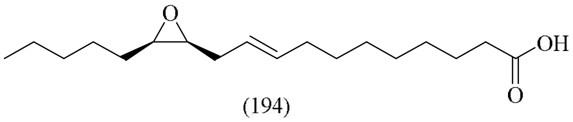
(186)



	R
(193)	H
(195)	Me



	R
(192)	H
(203)	Me



(194)

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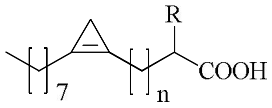
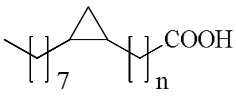
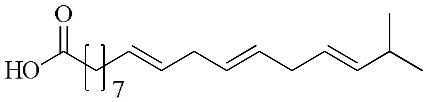


(197) n=5; R=H
(200) n=6; R=H
(201) n=6; R=OH



(198) n=6
(202) n=7



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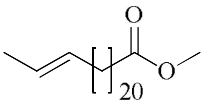

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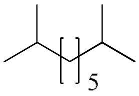

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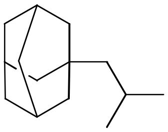

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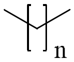
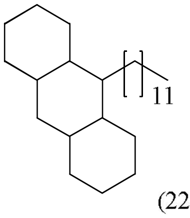


(221) n=9
(228) n=20
(230) n=22
(232) n=23
(233) n=27
(235) n=29
(238) n=34
(239) n=42



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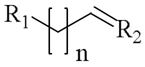
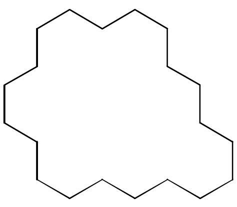


(223) R_1=Me; R_2=CH_2; n=13
(224) R_1=Me; R_2=CH-Isoheptyl; n=10
(227) R_1=Vinyl; R_2=CH_2; n=16



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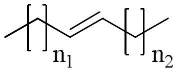
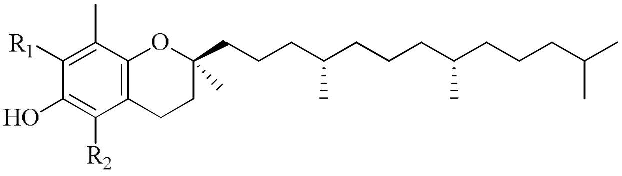
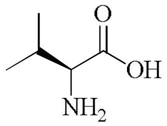


(226) n_1=13; n_2=3
(229) n_1=12; n_2=7
(237) n_1=16; n_2=15



	R_1	R_2
(240)	Me	Me
(241)	Me	H
(242)	H	H

Figure 1: (cont.).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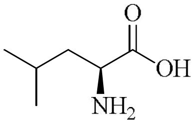
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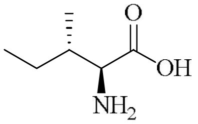
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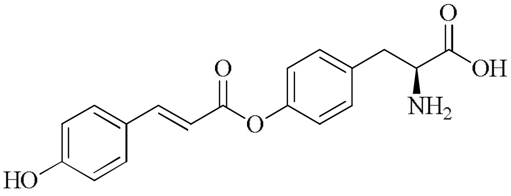
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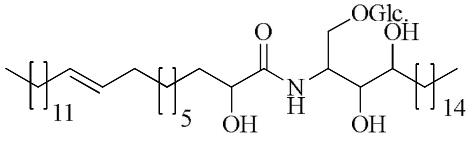
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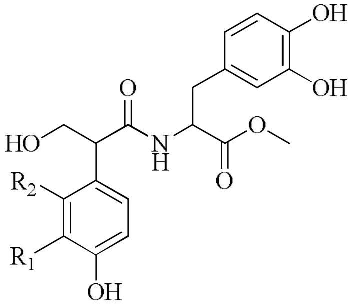
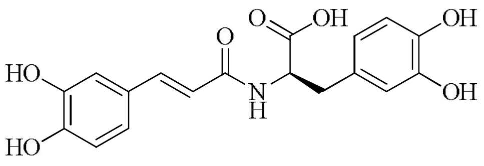


	R_1	R_2
(248)	OH	H
(249)	H	OH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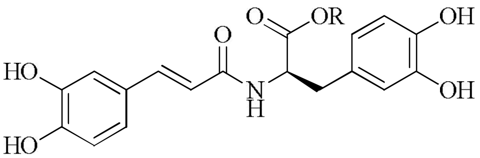
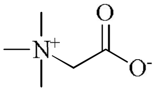


	R
(254)	H
(255)	Me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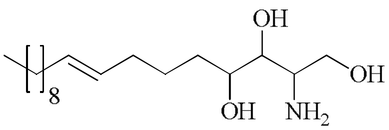
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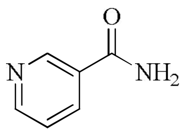
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Figure 1: (cont.).

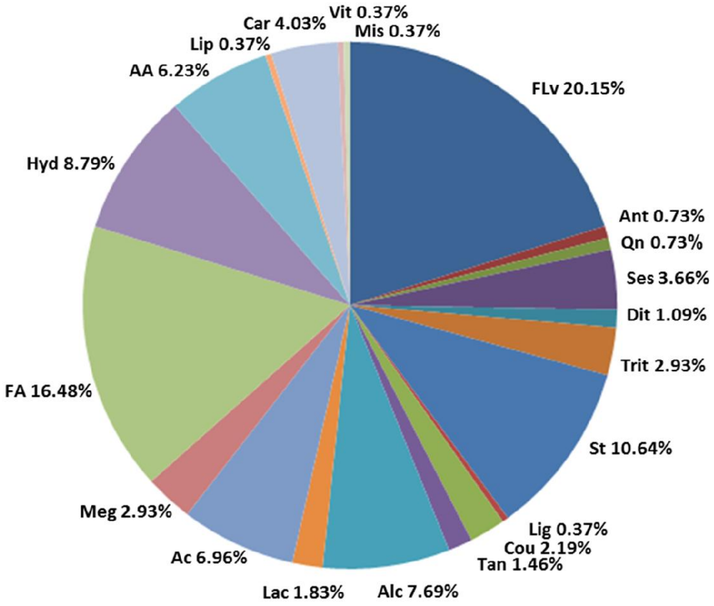

Figure 2: Different classes of compounds in plants of the genus *Chorisia*.

[**Flv:** Flavonoids; **Ant:** Anthocyanins; **Qn:** Quinones; **Ses:** Sesquiterpenoids; **Dit:** Diterpenoids; **Trit:** Triterpenoids; **St:** Steroids; **Lig:** Lignans and neolignans; **Cou:** Coumarins; **Tan:** Tannins: **Alc:** Alcohols, phenols, aldehydes, and ketones: **Lac:** lactones; **Ac:** Acids and esters; **Meg:** Megastigmanes; **FA:** Fatty acids and esters; **Hyd:** Hydrocarbons and tocopherols; **AA:** Amino acids and amides; **Lip:** Lipids: **Car:** Carbohydrates; **Vit:** Vitamins; **Mis:** Miscellaneous compounds].

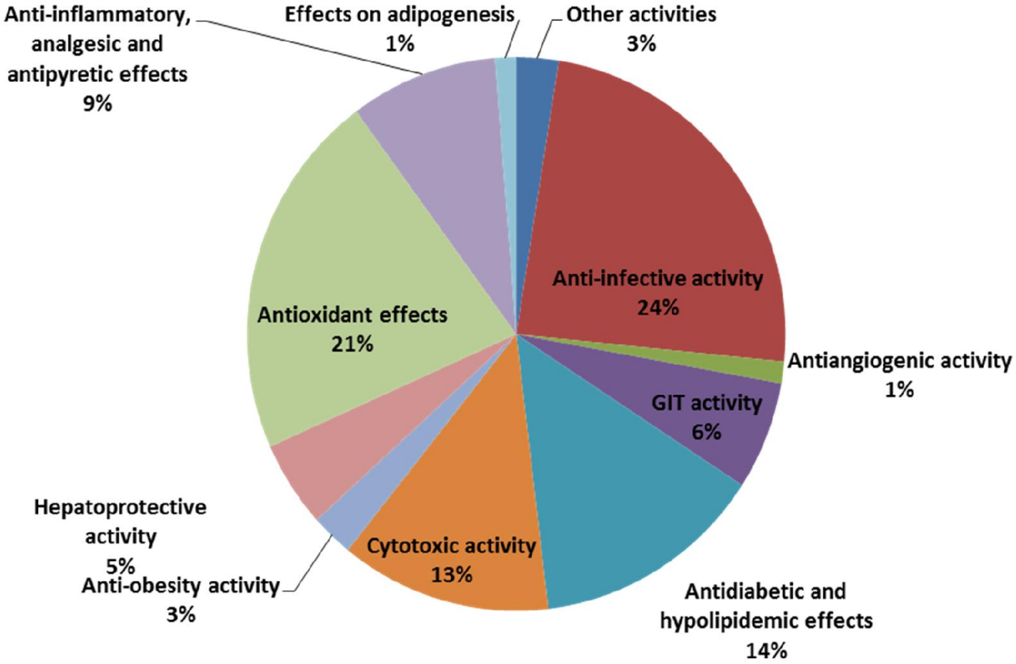

Figure 3: Different biological activities of plants of the genus *Chorisia*.

3. Biological activities of the genus *Chorisia*

Literature survey on the genus *Chorisia* showed that different extracts and isolated compounds from various plant parts of *Chorisia* plants exhibited a wide range of biological properties, which are described in **Table 2** and summarized in **Figure 3.**

Table 2: A list of various biological activities of the genus *Chorisia*

Plant name (Plant part)	Extract, fraction or compound	Bioactivity	References
A) Effects on adipogenesis:			
Chorisia chodatii and *Chorisia speciosa* (Leaves, flowers, fruits, and seeds)	Total ethanol extracts and their derived fractions (petroleum ether, chloroform, ethyl acetate, and aqueous fractions) of different plant parts.	They were examined for their impact on lipogenesis in 3T3-L1 adipocytes at concentrations of 5, 10, 50, and 100 µg/ml. The highest stimulatory effects on adipogenesis were shown by the ethyl acetate, aqueous and chloroform fractions of various organs at varied concentrations, but the petroleum ether fractions significantly increased lipogenesis only at 50 and 100 µg/ml.	[14, 58]
B) Anti-inflammatory, analgesic and antipyretic effects:			
Chorisia insignis (Leaves)	Total 70% ethanol extract and its successive fractions (petroleum ether, diethyl ether, chloroform, ethyl acetate and *n*-butanol fractions) in addition to the aqueous extract.	They demonstrated strong anti-inflammatory activity at 100 mg/kg, p.o against carrageenan-induced paw edema in mice. Compared to indomethacin (20 mg/kg), the total ethanol and aqueous extracts as well as the ethyl acetate fraction were the most effective samples.	[20]
Ceiba pentandra (Seeds)	Petroleum ether and ethanol extracts	As compared to aspirin (300 mg/kg), these extracts considerably reduced the carrageenan-induced paw edema in rats when they were administered at 200 and 400 mg/kg.	[59]
Chorisia speciosa (Leaves)	*n*-Hexane, chloroform, and methanol extracts	Similar to diclofenac sodium (10 mg/kg), the three extracts significantly reduced inflammation. After two hours of administration, the chloroform extract's impact was more noticeable at 400 mg/kg, exhibiting a considerable decrease in the inflammation caused by carrageenan. On the other hand, it was revealed that the chloroform and methanol extracts were more efficient than the hexane extract, with a maximum percentage of inhibition similar to that of paracetamol, indicating their potential as an antipyretic.	[60]
Chorisia speciosa (Leaves, stem and fruits)	- Total ethanol extract of the leaves and stem and its derived fractions (*n*-hexane, *n*-butanol, chloroform, ethyl acetate and aqueous fractions) -Rhiofolin	In the rat hind paw edema model caused by carrageenan, they showed anti-inflammatory efficacy. The chloroform and ethyl acetate extracts of the leaves and the total ethanolic extract of the stem displayed an increasing percentage of anti-inflammatory activity even after five hours. Moreover, rhiofolin showed potent anti-inflammatory and antipyretic properties. With the exception of the *n*-hexane and *n*-butanol fractions of the stem, the effect maximized around the 3rd hour and lasted until the 5th hour for all fractions. The considerable analgesic effect against heat stimuli displayed by the studied extracts varied significantly, as demonstrated by the increase in the latency time in minutes. The chloroform and n-butanol fractions of the leaf demonstrated the lowest percentage of protection, followed by the ethyl acetate fraction, and the total ethanolic extract of the stem.	[17]
Ceiba pentandra (Stem bark)	Methanol extract	It revealed a considerable decrease in the acetic acid-induced vascular permeability as well as a significant suppression of xylene-induced ear edema and egg albumin-induced paw edema. Also, in a dose-dependent pattern, it markedly decreased the number of writhes in the acetic acid-induced writhing test and provided good protection against heat-induced pain in the tail flick latency test.	[61]

Plant name (Plant part)	**Extract, fraction or compound**	**Bioactivity**	**References**
Ceiba pentandra (Aerial parts)	Ethyl acetate extract.	It exhibited a considerable improvement in the blood levels of TNF-*α* and CRP as well as a notable reduction in the expression of the IL-18 gene in the rat model of methotrexate-induced nephrotoxicity. In comparison with silymarin, the extract had a little better impact.	[32]
Ceiba speciosa (Stem bark)	Ethanol extract.	The extract inhibited the activity of p38α (1.66 µg/ml), JAK3 (5.25 µg/ml), and JNK3 (8.34 µg/ml) and decreased the production of TNF-α in human blood. Moreover, it decreased the recruitment of leukocytes to the pouch exudate and the development of edema, reversing the inflammatory effects brought on by carrageenan.	[62]
C) Antioxidant effects:			
Chorisia insignis (Leaves)	70% Ethanol and aqueous extracts in addition to the ethyl acetate fraction and *n*-butanol fractions.	- The 70% ethanol extract, followed by the ethyl acetate fraction, the aqueous extract, and the *n*-butanol fraction, at 100 mg/kg each, exhibited a strong *in vivo* antioxidant activity compared to vitamin E (7.5 mg/kg). The rise in blood glutathione levels in alloxan-induced diabetic rats was indicative for the activity of these effects. - Both the 70% ethanol and aqueous extracts showed significant *in vitro* DPPH radical scavenging activities compared to vitamin C.	[20]
Ceiba pentandra (Roots)	50% Ethanol extract.	Using the FRAP and ORAC tests, it demonstrated notable antioxidant effects with values of 0.14 ± 0.01 µmol Fe II /g dry weight and 917 ± 139 µmol trolox /g dry weight, respectively. In addition, it demonstrated DPPH radical scavenging properties, with an IC50 of 51 ± 0.7 µg/ml vs. 1.25 ± 0.07 µg/ml for ascorbic acid.	[63]
Ceiba pentandra (Spikes and fruits)	n-Hexane, chloroform, ethyl acetate, aqueous and methanol extracts.	Using several test models, the methanol and the aqueous extracts showed strong radical scavenging abilities. Among the tested samples, the methanol extract showed considerable anti-hemolytic properties and lower levels of malondialdehyde.	[64]
Ceiba pentandra (Seeds)	Seed oil.	The oil at 100 mg/ml revealed 47.56% inhibition/50 µl and 39.69% inhibition/0.1 ml, respectively, in the DPPH and hydroxyl radicals scavenging tests in comparison with rutin (1 mg/ml (45% and 75%)) and BHT (1 mg/ml (76%/ and 75.6%)) as positive controls,. Moreover, the measured FRAP capacity at 100 mg/ml was 309 FRAP units, whereas the reducing activity of the oil was 20.52 µg ascorbic acid equivalents/ml.	[65]
Ceiba pentandra (Leaves)	Ethyl acetate fraction.	Some antioxidant compounds in the ethyl acetate fraction showed considerable free radical scavenging capacity in a qualitative screening test (DPPH assay) on TLC plates.	[23]
Plant name (Plant part)	Extract, fraction or compound	Bioactivity	
Ceiba pentandra (Seeds)	Ethanol and water extracts.	The ethanol seed extract revealed significant DPPH radical scavenging activity in a concentration-dependent manner, with an IC50 value of 50.33 ± 5.29 µg/ml compared to ascorbic acid (IC50= 44.39 ± 2.92 µg/ml).	[66]
Ceiba pentandra (Seeds)	Seed oil.	Total phenolics in seed oil showed significant DPPH radical scavenging activity in a concentration-dependent manner, with an IC50 of 11.52 ± 0.90 mg/ml at 2.5 mg/100 g in line with sesame and Moringa oleifera seed oils.	[39]
Ceiba pentandra (Stem bark)	Aqueous and methanol extracts.	Both the aqueous decoction, the aqueous macerate and the methanol extract exhibited significant radical scavenging abilities against DPPH with respective EC50 values of 87.84, 54.77, and 6.15 µg/ml compared to vitamin C (EC50= 2.24 µg/ml). The methanol extract's antioxidant activity was comparable to that of vitamin C, and both of them almost had their maximum impact at 10 µg/ml. The anti-hemolytic action of the aqueous decoction was the strongest, reaching a maximum inhibition of 77.57% at 100 µg/ml.	[67]

Plant name (Plant part)	**Extract, fraction or compound**	**Bioactivity**	**References**
Chorisia chodatii and Chorisia speciosa (Leaves, flowers, fruits and seeds)	Total ethanol extracts and their derived fractions (petroleum ether, chloroform, ethyl acetate and aqueous fractions) of different plant parts.	Except the petroleum ether fractions, different extracts and fractions of both species displayed concentration-dependent scavenging abilities of the DPPH radical. The greatest activity was demonstrated by the ethyl acetate, aqueous, and chloroform fractions, respectively. The total ethanol seed extracts of both species showed lower scavenging capacities than those of the other plant parts.	[14, 58]
Chorisia speciosa (Leaves, stem and fruits)	-Total ethanol extract of the leaves and stem and its derived fractions (*n*-hexane, *n*-butanol, chloroform, ethyl acetate and aqueous fractions) -Total ethanol extract of the fruits.	All the tested extracts showed a significant DPPH free radical scavenging activity, especially the ethyl acetate and *n*-butanol fractions of the leaves, the ethyl acetate fraction of the stem and the total ethanolic extract of the fruits due to the presence of phenolic compounds.	[17]
Ceiba pentandra (Aerial parts)	Methanol extract and different fractions (*n*-hexane, methylene chloride, ethyl acetate and *n*-butanol).	The total methanol extract and ethyl acetate fraction exhibited powerful antioxidant activity in comparison with ascorbic acid, BHA and BHT using two cancerous cell lines (HepG2 and MCF-7).	[34]
Ceiba speciosa (Bark)	Lyophilized aqueous extract.	It showed a scavenging effect of the DPPH radical in a concentration-dependent manner, being 49.12%, 27.52%, and 13.32% at 10, 5, and 2 µg/ml, respectively, in the comet assay.	[30]
Ceiba pentandra (Aerial parts)	Ethyl acetate extract.	It showed powerful in vitro DPPH radical scavenging potential (IC50= 0.0716 mg/ml) comparable to the standard agents (ascorbic acid, IC50= 0.045 mg/ml) and BHA (IC50= 0.056 mg/ml). Moreover, it decreased the oxidative stress caused by methotrexate and increased kidney antioxidant capacity.	[32]
Ceiba speciosa (Seed Oil)	Fixed oil.	It exerted a promising ABTS radical scavenging activity, with an IC50 value of 10.21 µg/ml, whereas it had an IC50 of 77.44 µg/ml against the DPPH radical. A lower effect was recorded in the FRAP test, in which the FRAP value was 3-times less than that of BHT.	[46]
Ceiba pentandra (Stem bark)	Methanol and aqueous extracts.	Methanol and aqueous extracts showed significant and concentration-dependent radical scavenging activities of the superoxide anion with IC50 values of 51.81 and 34.26 µg/ml, respectively, compared to gallic acid (IC50= 55.66 µg/ml). On the other hand, only ascorbic acid and the methanol extract were capable of scavenging the hydrogen peroxide radical, with IC50 values of 13.84 and 44.84 µg/ml, respectively, but the aqueous extract was a poor hydrogen peroxide scavenger.	[27]
Ceiba speciosa (Leaves)	Petroleum ether, dicholoromethane, ethyl acetate, n-butanol, methanol and water extracts.	They demonstrated considerable DPPH free radical scavenging activity, and the results (ranked by their IC50 values (µg/ml)) were as follows: dicholoromethane extract (12.37 ± 4.52), methanol extract (15.48 ± 3.80), ethyl acetate extract (27.07 ± 1.72), n-butanol extract (59.68 ± 4.46), petroleum ether extract (60.97 ± 2.29), and water extract (78.76 ± 2.26) compared to ascorbic acid (7.60 ± 0.85 µg/ml).	[68]
Ceiba speciosa (Stem bark)	Ethanol extract.	It demonstrated considerable DPPH free radical scavenging activity in a concentration-dependent manner, with an IC50 value of 19.83 ± 0.34 µg/ml in comparison with gallic acid.	[62]
D) Hepatoprotective activity:			
Chorisia crispiflora (Leaves)	Rhoifolin.	It showed 80.3% protection against CCl_4-induced hepatotoxicity in mice at 20 mg/kg. The architecture of the livers was normal and the levels of serum ALT and AST were preserved within normal limits.	[11]
Chorisia insignis (Leaves)	70% Ethanol and aqueous extracts as well as the ethyl acetate fraction.	In CCl_4 (5 ml/kg, i.p.) liver model, a significant decrease in the elevated AST, ALT and ALP levels was observed after treatment of rats for one month with 100 mg/kg of the extracts as compared to silymarin (25 mg/kg).	[20]

Plant name (Plant part)	**Extract, fraction or compound**	**Bioactivity**	**References**
Ceiba pentandra (Stem bark)	Ethyl acetate fraction of the methanol extract.	At 400 mg/kg (p.o.), it demonstrated hepatoprotective activity against the liver damage caused by paracetamol (3 g/kg) in rats, with a substantial decrease in blood ALT, AST, ALP levels and total bilirubin contents.	[69]
Ceiba pentandra (Roots)	Methanol extract.	In comparison with silymarin (50 mg/kg, p.o.), the treatment of thioacetamide-intoxicated rats with the methanol extract (200 and 400 mg/kg) considerably reduced the phase-I and phase II enzyme levels and boosted antioxidant levels to close to the normal values. The activities of cytochrome P450, NADPH cytochrome C reductase and glutathione-*S*-transferase were also shown to have significantly increased.	[70]
E) Anti-obesity activity:			
Ceiba pentandra (Leaves)	Ethanol extract.	It prevented the increase in body weight in cafeteria diet-treated albino rats and also caused a significant reduction of body weight in cafeteria diet-treated obese rats. Rat liver and fat pad weights were similarly reduced. Estimated serum biochemical parameters of *C. pentandra*-treated animals showed no reduction in total cholesterol, serum triglycerides, LDL and VLDL, and no increase in HDL levels, suggesting that *C. pentandra* may lower fat absorption by stopping the breakdown of dietary fats in GIT without influencing their hepatic metabolism.	[71]
Ceiba speciosa (Seeds oil)	Fixed oil.	It showed significant anti-obesity effects, with IC50 values of 135.69 ± 2.68 and 158.22 ± 2.89 µg/ml were recorded against α-glucosidase and α-amylase, respectively, whereas an IC50 value of 127.57 ± 2.98 µg/ml was found against the lipase enzyme using acarbose as a positive control in both α-amylase (IC50= 50.01 ± 0.92 µg/ml) and α-glucosidase (IC50= 35.52 ± 1.23 µg/ml) tests and orlistat (IC50= 37.63 ± 1.01) as a positive control in the lipase test.	[46]
F) Cytotoxic activity:			
Chorisia crispiflora	Argentilactone I, II, and (*R*)-6-[(*Z*)-1-heptenyl)]-5,6-dihydro-2*H*-pyran-2-one.	They exhibited varied cytotoxic activities against some tumor cells.	[43]
Chorisia crispiflora (Leaves)	Ethyl acetate extract.	The extract demonstrated substantial anticancer activity against Ehrlich Ascites carcinoma. The observed alterations in the haematological parameters in Swiss albino mice were also reversed.	[11]
Ceiba pentandra (Roots)	50% Ethanol extract.	It showed extremely low toxicity on human fibroblast primary culture using the Resazurin reduction test for in vitro cytotoxicity assessment.	[63]
Chorisia insignis (Leaves)	70% Ethanol extract and its successive fractions.	The 70% ethanol extract showed a significant activity (IC50= 2.21 µg) against the larynx cell line HEP2. It also displayed slight effects towards the breast cell line MCF7 (surviving fraction= 0.753), the liver cell line HEPG2 (surviving fraction= 0.770), the brain cell line U251 (surviving fraction= 0.8), the colon cell line HCT116 (surviving fraction= 0.79) and the cervix cell line HELA (surviving fraction= 0.826). Moreover, all the successive fractions except for the chloroform (IC50 > 10 µg) exerted significant cytotoxic activities against the larynx cell line HEP2. Among them, the petroleum ether extract showed the highest activity (IC50= 5.12 µg), followed by the n-butanol (IC50= 6.58 µg), aqueous (IC50= 7.11 µg) and ethyl acetate fractions (IC50= 8.61 µg), in comparison with cisplatin (IC50= 0.66 µg), doxorubicin (IC50= 0.74 µg) and 5-fluorouracil (IC50= 2.2 µg). The least cytotoxic effects were exhibited by the diethyl ether fraction (IC_{50}= 9.06 µg).	[22]

Plant name (Plant part)	**Extract, fraction or compound**	**Bioactivity**	**References**
Chorisia crispiflora (Leaves)	*n*-Hexane and ethyl acetate extracts.	They had strong *in vitro* cytotoxic effects on MCF-7 breast cancer cell line due to downregulation of NF-κB in time- and concentration-dependent manners.	[13, 41]
Chorisia crispiflora (Leaves)	Rhoifolin.	It exhibited powerful *in vitro* cytotoxicity with great selectivity against human epidermoid larynex (Hep 2) (IC_{50}= 5.9 µg/ml) and human cervical (HeLa) carcinoma cell lines (IC_{50}= 6.2 µg/ml). Similar promising activities were also observed against hepatocellular (Hep G2) (IC_{50}= 22.6 µg/ml), colon (HCT-116) (IC_{50}= 34.8 µg/ml) and fetal human lung fibroblast (MRC-5) (IC_{50}= 44.6 µg/mL) carcinoma cell lines. The observed antitumor influences were comparable and nearly similar to those of vinblastine. Results also showed no cytotoxic activity against healthy normal mammalian cells (Vero cells), indicating its good selectivity.	[72]
Ceiba pentandra (Aerial parts)	Methylene chloride fraction.	This fraction demonstrated prominent cytotoxic effect against the cancer cell lines, HepG2 (IC_{50}= 14.895 µg/ml) and MCF-7 (IC_{50} = 18.859 µg/ml).	[38]
Ceiba pentandra (Aerial parts)	Methanol extract, methylene chloride, ethyl acetate and *n*-butanol fractions.	They showed varied cytotoxic activities in the *in vitro* MTT bioassay against C32, MCF-7, MCF-10A and BJ cancer cell lines, with the ethyl acetate fraction revealed the most effective actions against MCF-7 and C32 cell lines, exhibiting strong selectivity for tumor cells.	[9]
Ceiba pentandra (Aerial parts)	Ethyl acetate fraction.	It showed intense antitumor effects against melanoma cells by using flow cytometric cell cycle analysis. The cyclin dependent kinases that control cell cycle were thought to be responsible for the noticed cytotoxic potential, leading to cell cycle arrest in the G2/M phase.	[9]
Ceiba speciosa (Leaves)	Petroleum ether, dicholoromethane, ethyl acetate, *n*-butanol, methanol and water extracts.	They showed moderate to weak cytotoxic effects against HepG2 cells with the following IC_{50} values: petroleum ether (74.35 µg/ml), dicholoromethane (57.3 µg/ml), ethyl acetate (79.73 µg/ml), *n*-butanol (446.11 µg/ml) and methanol (410.37 µg/ml). The water extract was inactive (IC_{50}= 954.99 µg/ml).	[68]
G) Antidiabetic and hypolipidemic effects:			
Chorisia insignis (Leaves)	70% Ethanol and aqueous extracts along with the ethyl acetate fraction.	In comparison to metformin, they demonstrated significant anti-hyperglycemic actions in male albino rats with alloxan-induced diabetes.	[20]
Ceiba pentandra (Stem bark)	Aqueous extract.	Oral administration of the aqueous extract for four weeks at increasing doses (250–1500 mg/kg) produced a statistically significant drop in plasma glucose levels in streptozotocin-induced diabetic rats.	[73]
Ceiba pentandra (Root bark)	Methylene chloride/methanol (1:1) extract.	It exhibited important antidiabetic activity in streptozotocin-induced type-2 diabetic rats by consuming less food and water intake and lowering the levels of blood glucose, serum cholesterol, triglyceride, creatinine and urea when compared to diabetic controls. The anti-hyperglycemic effect was more notable when compared to glibenclamide, with the added benefit of considerably reducing serum cholesterol and triglyceride levels.	[74, 75]
Ceiba pentandra (Root bark)	Methanol extract.	After seven weeks of oral treatment with 150 mg/kg of the extract, both the normal and alloxan-induced diabetic rats exhibited hypoglycemic effects.	[76, 77]

Plant name (Plant part)	**Extract, fraction or compound**	**Bioactivity**	**References**
Ceiba pentandra (Leaves)	Dry powdered leaves.	In alloxan-induced diabetic rats, they had both hypoglycemic as well as hypolipidemic effects. They significantly lowered plasma glucose, LDL, VLDL and triglyceride levels, while HDL, total proteins and albumin levels were significantly enhanced.	[77, 78]
Ceiba pentandra L. (Leaves)	Ethanol extract.	In the oral glucose tolerance test in rats, it displayed noticeable hypoglycemic effects. Compared to the alloxan-treated rats, those administered the extract at 300 mg/kg, p.o. showed considerably lower blood glucose levels and significantly higher insulin levels than normal animals.	[79]
Ceiba pentandra (Roots)	50% Ethanol extract.	It showed significant and dose-dependent α-glucosidase inhibitory activity (IC_{50}= 51 ± 0.7 µg/ml) that was superior to that of acarbose (IC_{50}= 726 ± 15 µg/ml).	[63]
Ceiba pentandra (Stem bark)	Aqueous (either prepared by decoction or maceration) and methanol extracts.	The aqueous decoction was able to significantly increase glucose uptake by liver and skeletal muscles similar to insulin. Both the decoction and insulin greatly increased glucose consumption in the liver by 56.57% and 127.28%, respectively. Glucose uptake in skeletal muscles was also raised by 94.19% in the presence of the decoction and by 135.11% with insulin. On the other hand, neither the aqueous macerate nor the methanol extract showed significant impact on both tissues.	[67]
Ceiba pentandra (Stem bark)	Aqueous extract (prepared by decoction).	Oral administration of the aqueous decoction considerably decreased the hyperglycemia caused by dexamethasone in a dose-dependent manner, with the maximal effect of 33% was obtained at 150 mg/kg/day. Metformin, the positive control used reduced hyperglycemia by 26% in comparison to the dexamethasone group. The decoction also reduced total plasma cholesterol, triglycerides, catalase, glutathione and NO levels impaired by dexamethasone without any impact on superoxide dismutase and malondialdehyde in rats suffering from insulin resistance caused by dexamethasone.	[26]
Ceiba pentandra (Stem bark)	Aqueous and methanol extracts.	They displayed strong antidiabetic properties in type-2 diabetic rats induced by the combination of a high-fat diet and a single dose of streptozotocin (40 mg/kg, i.p.). The aqueous extract significantly decreased the hyperglycemia by up to 29% and 56.9%, whereas the methanol extract exhibited 53.4% and 62.4% reduction at 75 and 150 mg/kg, respectively, compared to metformin, which showed a reduction of 71.2% at 40 mg/kg.	[80]
Ceiba pentandra (Stem bark)	Aqueous and methanol extracts.	The methanol and aqueous extracts inhibited α-amylase and α-glucosidase with IC_{50} values of (6.15 and 76.61 µg/ml) and (54.52 and 86.49 µg/ml), respectively. The aqueous extract showed a mixed non-competitive inhibition of both enzymes, whereas the methanol extract exhibited a competitive inhibition of α-amylase and a pure non-competitive inhibition of α-glucosidase.	[27]
H) GIT activity:			
Ceiba pentandra (Stem bark)	Aqueous extract.	It demonstrated anti-ulcerogenic properties against rats' stomach ulcers brought about by indomethacin. In compareison with ranitidine (50 mg/kg), the extract at 400 mg/kg, p.o. considerably decreased the pH decline and lesion development.	[81]
Ceiba pentandra (Stem bark)	Methanol extract.	At 1000 mg/kg, it significantly prevented castor oil-induced diarrhea in mice, but no appreciable delay in intestinal transit time was seen. This effect was comparable to loperamide (5 mg/kg).	[82]

Plant name (Plant part)	Extract, fraction or compound	Bioactivity	References
Ceiba pentandra (Roots)	Methanol extract.	It demonstrated significant and dose-dependent antiulcer benefits against ulcers in rats caused by ethanol and pylorus ligation using ranitidine (50 mg/kg, p.o.) as a standard drug. Oral treatment of the extract at 200 and 400 mg/kg effectively reduced the index of gastric lesions in both ulcer models.	[83]
Ceiba pentandra (Stem bark)	Methanol extract.	At 100, 200 and 400 mg/kg, it displayed great and dose-dependent anti-ulcer activity in both indomethacin (50 mg/kg) and ethanol-induced gastric ulcers in albino rats, which at high doses, was comparable to ranitidine (100 mg/kg) and omeprazole (100 mg/kg), respectively.	[84]
Ceiba speciosa (Stem bark)	Ethanol extract.	It showed significant protection of ulcer formation compared to omeprazole. It also displayed no cytotoxicity, but markedly affected some enzymes involved in inflammatory processes, indicating its potential against gastric ulcers. *In vivo* studies also showed that the gastric mucosa of rats treated with the extract was similar to that of normal animals.	[62]
I) Antiangiogenic activity:			
Ceiba pentandra (Leaves and Stem)	Methanol extract.	It dramatically reduced the tube-like formation induced by human umbilical venous endothelial cells in an *in vitro* assay. The methanol stem extract exhibited a strong action with an inhibition percentage of 87.5% at 100 µg/ml.	[85]
J) Anti-infective activity:			
1) Antibacterial effects:			
Chorisia speciosa (Flowers)	-Ethyl acetate extract. -Tiliroside.	The ethyl acetate extract was reported to have antibacterial potential. The flavonoidal glycoside, tiliroside exhibited substantial antibacterial properties with minimum inhibitory concentration of 1.96 µg/ml against *Bacillus subtilis*.	[19]
Ceiba pentandra (Stem bark)	Aqueous and ethanol extracts.	They had inhibitory effects on *Staphylococcus aureus*, *Pseudomonas aeroginosa*, *Escherichia coli* and *Shigella dysentriae* with the ethanol extract being more effective. The minimal inhibitory and minimal bactericidal concentrations ranged between 6.25−50 mg/ml.	[86]
Ceiba pentandra (Leaves and Stem bark)	Ethanol extract.	It demonstrated strong *in vitro* antibacterial activity against human pathogens such *Klebsiella pneumonia, P. aeruginosa, S. aureus* and *E. coli.*	[87]
Ceiba pentandra (Stem bark)	n-Hexane, acetone and ethanol extracts.	They were examined against S. aureus, K. pneumoniae and P. aeruginosa using ampicillin as a standard. The maximum activity was observed for the acetone extract at 300 mg/ml, while the ethanol extract showed the lowest activity at 100 mg/ml. In contrast, the n-hexane extract was inactive.	[88]
Chorisia insignis (Leaves)	Petroleum ether, diethyl ether and ethyl acetate fractions.	They have strong antibacterial action against B. subtilis and Bacillus cereus.	[28]
Chorisia speciosa (Leaves)	Methanol, chloroform and n-hexane extracts.	The methanol and chloroform extracts were active against B. cereus, with inhibition zones of 16 and 11 mm, respectively. A moderate activity was shown against P. aeruginosa, K. pneumonia and S. aureus, with inhibition zones ≥10 mm, whereas no activity was found against E. coli and Salmonella enterica.	[60]
Chorisia speciosa (Leaves, stem and fruits)	-Total ethanol extract of the fruits. -Total ethanol extract of the leaves and stems and their derived fractions (n-hexane, chloroform,	The total ethanolic extract, ethyl acetate fraction and n-butanol fraction of the leaves were considerably active against B. cereus, Micrococcus luteus, S. aureus, Serratia marcenscens, E. coli and P. aeruginosa with inhibition zones ranged from 8 to 12 mm.	[17]

Plant name (Plant part)	**Extract, fraction or compound**	**Bioactivity**	**References**
	ethyl acetate and aqueous fractions)	The chloroform and *n*-butanol fractions of the stem showed moderate activity, while the other samples were inactive against the tested bacterial strains.	
Ceiba aesculifolia (Fruits)	Methanol extract.	It exhibited antibacterial activity against two Gram-positive bacteria (*Enterococcus faecalis* and *S. aureus*) and one Gram-negative bacterium (*Vibrio cholerae*) with inhibition zones of 10.4 ± 0.2, 9.0 ± 1.2 and 10.0 ± 1.0 mm, respectively.	[31]
Ceiba pentandra (Aerial parts)	Methanol extract and different fractions (*n*-hexane, methylene chloride, ethyl acetate and *n*-butanol).	The ethyl acetate fraction was the most active against all the tested organisms, including *Micrococcus roseus, M. luteus, Proteus vulgaris,* and *B. cereus* except for *S. marcenscens*, which was more susceptible for the *n*-butanol fraction. The other fractions showed relatively little antibacterial activity against both the tested Gram-positive and Gram-negative bacteria, the *n*-hexane fraction exclusively showed antibacterial activity against Gram-negative bacteria.	[34]
Ceiba pentandra (Seeds)	Aqueous, methanol, ethanol and acetone extracts.	The maximum inhibitory impact of the aqueous extract was shown only against *Staphylococcus epidermidis* and *S. aureus*. It also exerted moderate antibacterial effects against E. coli, P. aeruginosa, Enterobacter aerogenes, and minimal inhibition of Salmonella typhi, Salmonella typhimurium and P. vulgaris. Methanol and ethanol extracts showed powerful antibacterial effects against S. epidermidis, S. aureus and moderate inhibition of P. vulgaris, E. coli, E. aerogenes, S. typhi and S. typhimurium, but mild effect on P. aeruginosa. The acetone extract had the most inhibitory impact on S. aureus, P. vulgaris, S. epidermidis, P. aeruginosa, S. typhi and S. typhimurium, but moderate inhibition of E. coli and E. aerogenes.	[89]
Chorisia speciosa (Leaves)	Essential oil.	It exhibited different inhibitory effects against some microbes, where the strongest activity was noticed against S. aureus (25 mm). Moderate activity (15 mm) was also observed against E. coli, but no activity against S. typhi (9 mm) at 3.64 mg.	[90]
Ceiba speciosa (Leaves)	Petroleum ether, dicholoromethane, ethyl acetate, n-butanol, methanol and water extracts.	The dichloromethane extract showed powerful antimicrobial action against S. aureus (inhibition zone= 23 mm), while the methanol, petroleum ether and ethyl acetate extracts showed moderate activity with inhibition zones of 16, 16, and 17 mm) respectively. On the other hand, the n-butanol extract had weak activity with an inhibition zone of 12 mm, while the water extract had no activity against S. aureus. On the other hand, the petroleum ether and dichloromethane extracts displayed potent activity against P. aeruginosa with inhibition zones of 19 and 22 mm, respectively, while the methanol and ethyl acetate extracts showed moderate activity with similar inhibition zones of 18 mm. In contrast, both the n-butanol and water extracts showed no activity against P. aeruginosa.	[68]
2) Antifungal effects:			
Chorisia crispiflora (Leaves)	*n*-Hexane, ethyl acetate, *n*-butanol and methanol extracts.	They displayed antifungal activities at 3000 µg/ml against three plant pathogenic fungi: *Alternaria solani, Botrytis* and *Fusarium oxysporum*, of which the latter was the least responsive to various extracts.	[11]
Ceiba pentandra	Alcohol and water extracts.	Compared to ketoconazole (1 mg/ml), the extracts reduced the growth of *Epidermophyton flocosum*, *Microsporum canis*, *Trichopyton rubrum* and *Candida albicans* utilizing disc diffusion and agar	[91]

Plant name (Plant part)	Extract, fraction or compound	Bioactivity	References
		dilution procedures. Both extracts had minimum inhibitory concentrations between 50 and 100 mg/ml, with the alcoholic extract had higher potency.	
Ceiba pentandra (Stem bark)	Aqueous and ethanol extracts.	They had inhibitory effects on *C. albicans* and *Aspergillus flavus*, with the ethanol extract having the most efficacy. The minimum fungicidal concentrations varied from 50 to 100 mg/ml.	[86]
Chorisia speciosa (Leaves)	*n*-Hexane, chloroform and methanol extracts.	All extracts showed moderate antifungal activity against *C. albicans* with inhibition zones of 8, 10 and 9 mm, respectively.	[60]
Ceiba speciosa (Leaves)	Petroleum ether, dicholoromethane, *n*-butanol, ethyl acetate, methanol and water extracts.	Only the petroleum ether, dicholoromethane and methanol extracts showed potent activity against *C. albicans,* with inhibition zones of 20, 19 and 21 mm, respectively. The dichloromethane extract showed higher activity with an inhibition zone of 21 mm, while the methanol, petroleum ether and water extracts showed moderate activity with inhibition zones of 15, 18, and 15 mm, respectively. On the other hand, both the ethyl acetate and *n*-butanol extracts had moderate activities against *A. niger* with inhibition zones of 14 and 13 mm, respectively.	[68]
3) Antiparasitic effects:			
Ceiba pentandra	90% Ethanol extract.	It revealed potential anthelmintic activity in the larvicidal test against *Haemonchus contortus*.	[77, 92]
Ceiba pentandra L. (Stem bark)	Aqueous extract.	It was reported to reduce the parasitaemia of trypanosomiasis-infected mice at 150 mg/kg body weight (p.o., 2 times daily for 3 days). It also demonstrated an IC_{50} value of 10 µg/ml in the low inoculation long incubation test against *Trypanosoma brucei brucei* STIB 345.	[93]
K) Other activities and pharmaceutical uses:			
Ceiba pentandra L. (Leaves)	Di-*n*-octyl phthalate	It was reported to have anti-venom effects against *Echis ocellatus*. It showed dose-dependent inhibitory effects against phospholipase A2 of the venom.	[45]
Ceiba pentandra (Aerial parts)	Cinchonain Ia	It exhibited 91% inhibition of A*β* aggregation, which was higher than that of the standard agent, curcumin (70%), indicating its probable development as an anti-Alzheimer's agent.	[33]
L) Toxicological studies:			
Chorisia insignis (Leaves)	Petroleum ether, diethyl ether, chloroform, ethyl acetate, n-butanol, 70% ethanol and aqueous extracts.	They exhibited LD_{50} values of 6.3, 6.7, 5.4, 7.1, 6.5, 7.8 and 7.5 g/kg in male albino mice, respectively, revealing the low toxicity of this species.	[20]
Ceiba pentandra (Stem bark)	Methanol extract.	The LD50 was shown to be higher than 5000 mg/kg in mice.	[82, 84]
Ceiba pentandra (Stem bark)	Aqueous extract.	Up to 3200 mg/kg p.o., it was well tolerated by rats and no mortality was noted.	[81]
Ceiba pentandra (Seeds)	Petroleum ether and ethanol extracts.	Even at 2000 mg/kg p.o., they showed no acute toxic symptoms or death in female Wistar albino rats.	[59]
Ceiba pentandra (Leaves)	40% Methanol extract.	The per-oral LD50 in adult albino mice was determined to be greater than 5000 mg/kg. AST, ALT and ALP concentrations were significantly elevated, whereas creatinine and total protein levels was decreased.	[94]
Ceiba pentandra (Roots)	Methanol extract.	It was evaluated using adult Wistar albino rats and no signs of toxicity were demonstrated after oral administration of the extract at 50, 500, 1000 and 2000 mg/kg. The subacute toxicity was also studied by daily oral doses of 100, 400 and 750 mg/kg for 28 days and the results revealed no abnormalities in treated groups compared to the controls.	[95]

Plant name (Plant part)	Extract, fraction or compound	Bioactivity	References
Chorisia speciosa (Leaves, stem and fruits)	*n*-Hexane, chloroform, ethyl acetate, *n*-butanol fractions and total ethanolic extract.	The *n*-hexane, chloroform, ethyl acetate, *n*-butanol fractions and the total ethanolic extract of the leaves, stems and fruits had i.p. LD_{50} values of 1.75, 1.75, 2.75, 1.75, 2.25, 1.25, 1.75, 0.95, 1.25, 1.75 and 2.75 g/kg, respectively.	[17]
Ceiba pentandra (Aerial parts)	Methanol extract and its ethyl acetate fraction.	The total methanolic extract and its ethyl acetate fraction were shown to be safe when administered orally to rats at doses up to 5 g/kg body weight. Such safety was also substantiated by biochemical, molecular, and histological evidence.	[34]

4. Conclusion and future perspective

Literature data survey on plants of the genus Chorisia highlighted them as prolific natural sources of several metabolites, especially phenolics, with varied biological properties. While some species have been phytochemically and biologically investigated, e.g., C. crispiflora, C. chodatti, C. insignis, C. speciosa, and C. pentandra, many others still remain untouched; a fact that emphasizes the necessity for further detailed investigation of different Chorisia species in future in order to complement our phytopharmacological and chemotaxonomic knowledge on these plants. Future research studies should also be focused on exploring the molecular mechanisms of the reported biological effects of Chorisia plants and their bioactive phytocompounds in an effort to set a basis for their traditional medical uses and to expand their possible phytotherapeutic and pharmaceutical applications.

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