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Phytochemical Constituents of *Combretum* Loefl. (Combretaceae)

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Abstract: *Combretum* is the largest and most widespread genus of Combretaceae. The genus comprises approximately 250 species distributed throughout the tropical regions mainly in Africa and Asia. With increasing chemical and pharmacological investigations, *Combretum* has shown its potential as a source of various secondary metabolites. *Combretum* extracts or isolates have shown *in vitro* bioactivitities such as antibacterial, antifungal, antihyperglycemic, cytotoxicity against various human tumor cell lines, anti-inflammatory, anti-snake, antimalarial and antioxidant effects. *In vivo* studies through various animal models have also shown promising results. However, chemical constituents and bioactivities of most species of this highly diversified genus have not been investigated. The molecular mechanism of bioactivities of *Combretum* isolates remains elusive. This review focuses on the chemistry of 261 compounds isolated and identified from 31 species of *Combretum*. The phytochemicals of interest are non-essential oil compounds belonging to the various structural groups such as terpenoids, flavonoids, phenanthrenes and stilbenoids.

Keywords: *Combretum*, phytochemistry, pharmacology, terpenoids, polyphenolic compounds, antibacterial activity, antifungal activity.

INTRODUCTION

The Combretaceae family consists of as many as 600 species of trees, shrubs and lianas in about 18-20 genera. Plants belonging to this family are found in tropical and subtropical regions, mostly in Africa and India [1]. Five genera are commonly found in southern and western Africa, of which four are tree species including the largest two genera, *Combretum* Loefl. and *Terminalia* L. [2].

Combretum comprise of about 250 species and distributed throughout the tropics and subtropics. *Combretum* is absent from Australia and the Pacific Islands. Three subgenera are recognized by Excell and Stace; they are *Combretum*, *Cacoucia* (Aubl.) Excell & Stace and the monotypic Asian subgenus, *Apetalantum* Excell & Stace. On the worldwide scale the subgenera *Combretum* and *Cacoucia* are separable with certainty only on the character of the presence of either scale (subgen. *Combretum*) or microscopic stalked glandular hairs (subgen. *Cacoucia*) [3]. The species of *Combretum* (Fig. **1**) are trees, shrubs, shrublets or woody climbers, very rarely subherbaceous. Scales (subgen. *Combretum*) or microscopic (sometimes macroscopic) stalked glands (subgen. *Cacoucia*) are present. The subgenus *Combretum* is sometimes, in addition, divided into eleven sections, based on the floral, scale and fruit anatomy [3]. In the genus *Combretum* the leaves are opposite, verticillate or rarely alternate, usually petiolate, almost always with entire margins. The petiole is sometimes persistant, and especially in climbers it forms a hooked wooded spine when the leaf abscises. The flowers are hermaphroditic, regular or slightly zygomorphic, 4-5-merous and they are borne in elongated or subcapitate axillary or extra-axillary spikes or racemes or in terminal or terminal and axillary, often leafy panicles. The receptacle is usually clearly divided into a lower part (lower receptacle) surrounding and adnate to the ovary, and an upper receptacle which sometimes is differentiated into a lower part containing the disk and an often more expanded upper part. Sepals are 4-5 (rarely more), deltate to subulate or filiform, sometimes scarcely developed. Petals are 4-5, small and inconspicuous or showy (white, purple, red) and exceeding the sepals. Stamens are twice as many as the petals, inserted in 1 or 2 series inside the upper receptacle. The disk of the receptacle is glabrous or hairy, with or without a free margin, sometimes inconspicuous and absent. The fruit is 4-5 winged and ridged or angled, sessile or stipitate, indehiscent or rarely dehiscent; the pericarp is usually thin and papery, sometimes leathery, more rarely fleshy. Even if the fruits are often used as a good species identification characters, species identification is not always easy at the fruiting stage [3].

At least twenty four species of *Combretum* are well known in African traditional medicine, and used for the treatment of a variety of ailments and diseases, ranging from scorpion and snake bites, mental problems, heart and worm remedies to fever and microbial infections [4]. All parts of the *Combretum* species, in some cases even the fruits are used for medicinal purposes [5]. The fruits and seeds are, although, in general considered poisonous by traditional healers in various African countries and have been reported to give toxic effects on humans [6]. *Combretum* species are

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prepared for herbal remedies as hot water decoctions, cold water extracts or mixed with food, such as maize porridge. Sometimes fresh leaf sap is used as such. The remedies made from *Combretum* species are used both internally and externally. Sometimes the curing compounds of the plants are inhaled through fumes of steam baths of hot water extracts or from the smoke of burnt plant material. Dressings and ointments of different plant parts are used mainly for the treatment of wounds and infections on the skin. It is very common to mix different species of *Combretum* or to mix *Combretum* spp. with other medicinal plants for herbal remedies [3].

Several plants of the genus *Combretum* have been reported for their biological activities. Antibacterial activity of different extracts (ethanol, chloroform, methanol or water) of *C. micranthum* was noted against *Pseudomonas aeruginosa, Staphylococcus aureus, Salmonella* species, *Streptococcus* species, *Proteus vulgaris*, *Klebsiella* species, *Sarcina lutea*, *Micrococcus luteus* and *Bacillus subtilis* [7]. Antifungal activity against *Candida albicans*, antiviral activity against *Herpes simplex 1* and *Herpes simplex 2*, antimalarial activity against *Plasmodium falciparum* and antidiabetic activity was also reported [8-11]. *C. molle* has also demonstrated antibacterial, antifungal, anthelmintic, antiasthmatic and antitussive activities [12-14]. Extracts of *C. erythrophyllum* obtained with different solvents (acetone, hexane, chloroform, carbon tetrachloride and butanol) have shown antibacterial activity at different doses against *Escherichia coli*, *P. aeruginosa*, *S. aureus* and *Enterococcus faecalis* [15, 16]. Moreover, in studies evaluating antifungal activity, extracts obtained with different solvents (acetone, hexane, dichloromethane and methanol) was active against the following species: *C. albicans*, *C. neoformans*, *A. fumigatus*, *S. schenckii* and *M. canis* [8].

As referenced above, there are several studies describing the bioactivities of extracts and isolated compounds from the species of the genus *Combretum*. Although many species of *Combretum* have not been extensively investigated for their chemical constituents, various classes of secondary metabolites including terpenoids, flavonoids, stilbenoids and phenanthenes have been reported. Existing phytochemical investigations indicated the presence of triterpenoids from *C. molle*, *C. nigricans* Lepr., *C. quadrangulare*, *C. petrophilum* Retief, *C. edwardsii* Exell, *C. elaeagnoides* Klotzsch., *C. nelsonii* Dümmer, *C. bracteatum* (Laws.) Engl. et Diels, *C. laxum* Jacq., *C. micranthum*, *C. imberbe*, *C. padoides* Engl. & Diels, *C. leprosum* Mart., *C. sundaicum* Miquel, *C. oliviforme* Chao, *C. Zeyheri* Sond., *C. vendee* A.E.van Wyk., *C. erythrophyllum*, *C. coccineum* (Sonn.) Lam. and *C. rotundifolium* Rich. [17-49]. Other classes of compounds isolated from *Combretum* include, flavonoids from *C. quadrangulare*, *C. micranthum, C. erythrophyllum*, *C. apiculatum* Sond., *C. yannanense* Exell, *C. lanceolatum* Pohl., *and C. leprosum* [23-38, 44, 51-54], diarylpropanes, phenanthrenes and stilbenoids from *C. yannanense*, *C. griffithii* Van Heurck & Müll. Arg., *C. molle*, *C. apiculatum* Sond., *C. psidioides* Welw., *C. Hereroense* Schinz, *C. cafrum* (Eckl. & Zeyh.) Kuntze and *C. woodii* Duemmer [39, 45-54]; galic acid derivatives from *C. quadrangulare*, *C. yannanense* and *C. Krausii*; ellagitannins from *C. molle* and *C. glutinosum* Perr. ex DC.; and, cyclobutanes from *C. albopunctatum* Suesseng [28, 32, 49, 65-69].

This review focuses on the chemistry and pharmacological activities of 261 non-essential oil compounds isolated from 31 species of the genus *Combretum*. All of the isolated compounds with their source and references are listed in (Table **1**) while their chemistry under each chemical class, such as terpenoids, flavonoids and stilbenoids, is presented separately.

Fig. (1). *Combretum fragrans* (photo by Dawe Amadou).

PHYTOCHEMISTRY

Of 250 species of the genus *Combretum*, only 31 species (Table **1**) have been more or less investigated for their phytochemistry. To date, at least 261 compounds, primarily terpenoids (mainly triterpenes) and phenolic compounds (flavonoids, stilbenoids, phenanthrenes) have been isolated and identified from these species.

Triterpenoids

Simple triterpenoids and triterpenoids glycosides are known to be the major constituents of the genus *Combretum*. To date, 135 compounds belonging to the cycloratane, ursanes, oleananes and dammarane triterpene and their glycosides structural groups have been isolated from the genus. Combretene A and B (**1-2**) were isolated from the aerial part of *C. molle* together with 2α,3β,6β-trihydroxy-23-galloylolean-12-en-28-oate (**3**) [17, 18]. Combregenin (**4**), arjungenin (**5**), arjunglucoside I (**6**), combreglucoside (**7**) and sericoside (**8**); mollic acid (**9**) and its glycosides [mollic acid 3*β*-*O*-glucoside (**10**), mollic acid 3*β*-*O*-arabinoside (**11**), mollic acid 3*β*-*O*-xyloside (**12**)] were also reported from the stem bark of *C. molle* [18, 21].

Other chemical investigations led to the isolation of 73 oleananes, lupanes, cycloartanes and triterpenes glycosides types from seeds, leaves, stem bark and roots of eastern Asia C quadrangulare named, 1*α*,3*β*-dihydroxy-cycloart-24-ene-30-carboxylic acid (**13**), 1*α*,3*β*-dihydroxy-cycloart-24-ene-30-carboxylic acid methyl ester (**14**), (20*ξ*)-1*α*, 3*β*,25-trihydroxy-cycloart-21-al-23-ene-30-carboxylic acid

Table 1. Major Non-Essential Oil Compounds Isolated and Identified from *Combretum*

No	Compound Name	Botanical Source	Reference
	Triterpenoids		
1	combretene A	*C. molle*	[17]
2	combretene B	*C. molle*	[17]
3	2*α*,3*β*,6*β*-trihydroxy-23-galloylolean-12-en-28-oate	*C. molle*	[18,54]
4	combregenin	*C. molle* *C. nigricans* *C. yannanense*	[18,19]
5	arjungenin	*C. molle* *C. nigricans* *C. quadrangulare* *C. yannanense*	[18,19,31,54]
6	arjunglucoside I	*C. molle* *C. nigricans* *C. quadrangulare* *C. yannanense*	[18,19,31,54]
7	combreglucoside	*C. molle* *C. nigricans* *C. yannanense*	[18,19,31]
8	sericoside	*C. molle*	[20]
9	mollic acid	*C. molle* *C. nigricans* *C. petrophilum*	[21,22,36,39]
10	mollic acid 3*β*-*O*-glucoside	*C. molle* *C. petrophilum*	[21,22]
11	mollic acid 3*β*-*O*-arabinoside	*C. molle* *C. petrophilu* *C. edwardsii*	[21,22, 23]
12	mollic acid 3*β*-*O*-xyloside	*C. molle* *C. petrophilum*	[21,22]
13	1*α*,3*β*-dihydroxy-cycloart-24-ene-30-carboxylic acid	*C. quadrangulare*	[24]
14	1*α*,3*β*-dihydroxy-cycloart-24-ene-30-carboxylic acid methyl ester	*C. quadrangulare*	[24]
15	(20ξ)-1*α*,3*β*,25-trihydroxy-cycloart-21-al-23-ene-30-carboxylic acid methyl ester	*C. quadrangulare*	[24]
16	quadrangularic acid F	*C. quadrangulare*	[25]
17	quadrangularic acid J	*C. quadrangulare*	[25]
18	quadrangularic acid G	*C. quadrangulare*	[25]
19	methyl quadrangularate I	*C. quadrangulare*	[25]
20	24-epiquadrangularic acid M	*C. quadrangulare*	[25]
21	24-epiquadrangularic acid G	*C. quadrangulare*	[25]
22	quadrangularic acid M	*C. quadrangulare*	[25]
23	quadrangularic acid H	*C. quadrangulare*	[25]
24	quadrangularic cid K	*C. quadrangulare*	[25]
25	quadrangularic acid L	*C. quadrangulare*	[25]
26	24-epiquadrangularic acid L	*C. quadrangulare*	[25]

(Table 1) contd….

No	Compound Name	Botanical Source	Reference
27	7-hydroxy-23-deoxojessic acid	*C. quadrangulare*	[25]
28	norquadrangularic acid A	*C. quadrangulare*	[25]
29	methyl quadrangularate A	*C. quadrangulare*	[26]
30	methyl quadrangularate B	*C. quadrangulare*	[26]
31	methyl quadrangularate C	*C. quadrangulare*	[26]
32	methyl 24-epiquadrangularate C	*C. quadrangulare*	[26]
33	methyl quadrangularate O	*C. quadrangulare*	[26]
34	methyl quadrangularate D	*C. quadrangulare*	[26]
35	quadragularol A	*C. quadrangulare*	[26]
36	methyl quadrangularate N	*C. quadrangulare*	[26]
37	quadragularol B	*C. quadrangulare*	[26]
38	quadrangularic acid E	*C. quadrangulare*	[26]
39	23-deoxojessic acid	*C. quadrangulare*	[26]
40	1-*O*-acetyl-23-deoxojessic acid	*C. quadrangulare*	[26]
41	4*β*,14*α*-dimethyl-5*α*-ergosta-9*β*,19-cyclo-24(31)-en-3*β*-hydroxy-4*α*-carboxylic acid	*C. quadrangulare*	[26]
42	methyl 23-deoxojessoate	*C. quadrangulare*	[26]
43	jessic acid	*C. elaeagnoides*	[27]
44	methyl quadrangularate P	*C. quadrangulare*	[26]
45	norquadrangularic acid B	*C. quadrangulare*	[26]
46	norquadrangularic acid C	*C. quadrangulare*	[26]
47	betulinic acid	*C. quadrangulare* *C. yannanense*	[26,54]
48	2*α*,6*β*-dihydroxybetulinic acid	*C. quadrangulare*	[28]
49	6*β*-hydroxyhovenic acid	*C. quadrangulare*	[28]
50	quadranoside II	*C. quadrangulare*	[28,29]
51	6*β*-hydroxyarjunic acid	*C. quadrangulare*	[28]
52	arjunic acid	*C. quadrangulare,* *C. yannanense*	[28,54]
53	arjunolic acid	*C. quadrangulare* *C. nelsonii*	[28,30,33,39]
54	arjunglucoside II	*C. molle* *C. quadrangulare*	[20, 28,33]
55	19*α*-hydroxyasiatic acid	*C. quadrangulare*	[28,29]
56	nigaichigoside F1	*C.quadrangulare* *C. bracteatum*	[28,29,32]
57	quadranoside IV	*C. quadrangulare*	[28,29,33]
58	2 *α*,3*β*,23-trihydroxyurs-12,18-dien-oic acid	*C. quadrangulare*	[28]
59	glucosyl 2*α*,3*β*,23-trihydroxyurs-12,18-dien-28-oate	*C. quadrangulare*	[28]
60	glucosyl 2*α*,3*β*,23-trihydroxyurs-12,19(20)-dien-28-oate	*C. quadrangulare*	[28]

(Table 1) contd….

No	Compound Name	Botanical Source	Reference
61	quadranoside I	*C. quadrangulare*	[29]
62	quadranoside III	*C. quadrangulare*	[29]
63	quadranoside V	*C. quadrangulare*	[29]
64	2*α*,3*β*,23-trihydroxyurs-12,19-dien-28-oic acid *β-D*-glucopyranosyl	*C. quadrangulare*	[29]
65	pinfaensin	*C. quadrangulare*	[29]
66	quadranoside VI	*C. quadrangulare*	[31]
67	quadranoside VII	*C. quadrangulare*	[31]
68	quadranoside VIII	*C. quadrangulare*	[31]
69	quadranoside IX	*C. quadrangulare*	[31]
70	rosamutin	*C. quadrangulare*	[31]
71	28-*O*-*β*-D-glucopyranosyl-6*β*,23-dihydroxytormentic acid	*C. quadrangulare*	[31]
72	quadranoside X	*C. quadrangulare*	[31]
73	quadranoside XI	*C. quadrangulare*	[31]
74	arjunetin	*C. quadrangulare* *C. yannanense*	[31,54]
75	chebuloside II	*C. quadrangulare* *C. bracteatum*	[31,32]
76	*β*-D-glucopyranosyl 3*β*,19*α*-dihydroxy-2-oxo-urs-12-en-28-oate	*C. bracteatum*	[32]
77	*β*-D-glucopyranosyl 2*α*,3*β*,24-trihydroxyolean-12-en-28-oate	*C. laxum*	[33]
78	bellericoside	*C. laxum*	[33]
79	*β*-D-glucopyranosyl 2*α*,3*β*,6*β*-trihydroxyolean-12-en-28-oate	*C. quadrangulare* *C. bracteatum* *C. laxum*	[31,32,33]
80	asiatic acid	*C. nelsonii* *C. laxum* *C. yannanense*	[30,33,54]
81	*β*-D-glucopyranosyl 2*α*,3*β*,23,24-tetrahydroxyurs-12-en-28-oate	*C. laxum*	[33]
82	α-amyrin	*C. micranthum*	[34]
83	lupeol	*C. micranthum*	[34]
84	1α,3β-dihydroxy-12-oleanen-29-oic (imberic acid)	*C. micranthum* *C. imberbe*	[34,35,36, 37]
85	1-hydroxyolean-12-en-30-oic acid	*C. imberbe*	[36]
86	3,30-dihydroxyolean-12-en-29-one	*C. imberbe*	[36]
87	1,3,24-trihydroxyolean-12-en-29-oic acid	*C. imberbe*	[36]
88	1,23-dihydroxyolean-12-en-29-oic acid-3*β*-*O*-2,4-diacetyl-1-rhamnopyranoside	*C. imberbe*	[36]
89	1*α*,3*β*-dihydroxyolean-12-en-29-oic acid 23-*O*-*α*-L-(4-acetylrhamnopyranoside)	*C. imberbe*	[37]
90	1*α*,3*β*,23-trihydroxyolean-12-en-29-oate 23-*O*-*α*-(3,4-diacetylrhamnopyranoside)	*C. imberbe*	[37]
91	1*α*,3*β*,23-trihydroxyolean-12-en-29-oate 23-*O*-*α*-(3,4-diacetylrhamnopyranosyl)-29-*O*-*α*-rhamnopyranoside	*C. imberbe*	[37]
92	1*α*,3*β*,23-trihydroxyolean-12-en-29-oate 23-*O*-*α*-(4-acetoxyrhamnopyranosyl)-29-*α*-rhamnopyranoside	*C. imberbe*	[37]

(Table 1) contd….

No	Compound Name	Botanical Source	Reference
93	1*α*,23*β*-dihydroxyolean-12-en-29-oic acid-23β-*O*-*α*-4-acetylrhamnopyranoside	*C. padoides*	[38]
94	1,22-dihydroxyolean-12-en-30-oic acid	*C. padoides*	[38]
95	3*β*,6*β*,16*β*-trihydroxylup-20(29)-ene	*C. leprosum*	[39,40]
96	4*α*-carboxy-3*β*,16*α*-dihydroxycycloart-24-ene	*C. leprosum*	[40]
97	4*α*-carboxy-1*α*,3*β*-dihydroxy-25-hydroperoxy-trans-cycloart-23(24)-ene	*C. leprosum*	[40]
98	23-acetoxy-3*β*-acetylimberbic acid	*C. sundaicum*	[41]
99	23-acetoxyimberbic acid-29-methyl ester	*C. sundaicum*	[41]
100	23-*O*-[*α*-L-(3',4'-diacetylrhamnopyranosyl)]-3β-acetylimberbic acid	*C. sundaicum*	[41]
101	23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]-3β-acetylimberbic acid	*C. sundaicum*	[41]
102	23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]-3β-acetylimberbic acid-29-methyl ester	*C. sundaicum*	[41]
103	23-*O*-[*α*-L-(2',4'-diacetylrhamnopyranosyl)]imberbic acid	*C. sundaicum*	[41]
104	1-*O*-[*α*-L-(rhamnopyranosyl)]-23-acetoxy-3*β*-acetylimberbic acid	*C. sundaicum*	[41]
105	1-*O*-[*α*-L-(rhamnopyranosyl)]-23-acetoxyimberbic acid-29-methyl ester	*C. sundaicum*	[41]
106	1-*O*-[*α*-L-(rhamnopyranosyl)]-23-acetoxy-3*β*-acetylimberbic acid-29-methyl ester	*C. sundaicum*	[41]
107	3*β*-hydroxyolean-12-en-28-oic acid	*C. oliviforme*	[42]
108	23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]imberbic acid	*C. oliviforme* *C. sundaicum*	[41,42]
109	23-acetoxy-3*β*-acetylimberbic acid-29-methyl ester	*C. oliviforme*	[42]
110	23-*O*-[*α*-L-rhamnopyranosyl]-1,3 *β*-diacetylimberbic acid	*C. oliviforme*	[42]
111	11*α*-acetoxy-20,24-epoxy-25-hydroxy-dammar-3-one	*C. nigricans*	[43]
112	20,24-epoxy-11*α*,25-dihydroxy-dammar-3-one	*C. nigricans*	[43]
113	20,24-epoxy-12*β*,25-dihydroxy-dammar-3-one	*C. nigricans*	[43]
114	arcapitin A	*C. nigricans*	[43]
115	ursolic acid	*C. zeyheri* *C. quadrangulare* *C. vendae* *C. yannanense*	[44,45,46,54]
116	corosolic acid	*C. vendee*	[46]
117	oleanolic acid	*C. zeyheri*	[46]
118	maslinic acid	*C. zeyheri* *C. vendae* *C. yannanense*	[44,46,54]
119	2*α*,3*β*-dihydroxyurs-12-èn-28-oic acid	*C. zeyheri*	[44]
120	6*β*-hydroxymaslinic acid	*C. zeyheri*	[44]
121	terminolic acid	*C. zeyheri*	[44]
122	methylsumaresinolate	*C. zeyheri*	[44]
123	combretanone A	*C. quadrangulare*	[45]
124	combretanone B	*C. quadrangulare*	[45]
125	combretanone C	*C. quadrangulare*	[45]
126	combretanone D	*C. quadrangulare*	[45]

(Table 1) contd….

No	Compound Name	Botanical Source	Reference
127	combretanone E	*C. quadrangulare*	[45]
128	combretanone F	*C. quadrangulare*	[45]
129	combretanone G	*C. quadrangulare*	[45]
130	combretic acid A	*C. quadrangulare*	[45]
131	combretic acid B	*C. quadrangulare*	[45]
132	3-oxo-cycloart-1,11,24-trien-23,21-olide	*C. erythrophyllum*	[47]
133	3*β*,16*α*-dihydroxy-13(17)-mansumbinen-28-oic acid	*C. coccineum*	[48]
134	(16R)-16-*O*-*α*-L-arabinofuranosyl-3*β*-hydroxydammara-20,24-dièn-29-oic acid	*C. rotundifolium*	[49]
135	(16R)-16-*O*-*α*-L-arabinosyl-3*β*-hydroxymansumbin-13-en-28-oic acid	*C. coccineum*, *C. rotundifolium*	[48,49]
	Flavonoids		
136	kamatakenin	*C. quadrangulare*	[25]
137	isokaempferide	*C. quadrangulare*	[25]
138	5,7,4’-trihydroxy-3,3’-dimethoxyflavone	*C. quadrangulare*	[25]
139	5,4’-dihydroxy-3,7,3’-trimethoxyflavone	*C. quadrangulare*	[25]
140	(+)-catechin	*C. quadrangulare*	[29]
141	(+)-gallocatechin	*C. quadrangulare*	[31]
142	(-)-epicatechin	*C. quadrangulare* *C. micranthum*	[31,36]
143	(-)-epigallocatechin	*C. quadrangulare* *C. micranthum*	[31,36]
144	vitexin	*C. quadrangulare* *C. micranthum*	[29,36]
145	5,7,3’,5’-tetrahydroxy-3,4’-dimethoxyflavone	*C. quadrangulare*	[45]
146	combretol	*C. quadrangulare*	[45]
147	3’,5-dihydroxy-3,4’,5,7-tetramethoxyflavone	*C. quadrangulare*	[45]
148	pachypodol	*C. quadrangulare*	[45]
149	quercetin 3,4’-dimethyl ether	*C. quadrangulare*	[45]
150	myricetin 3,3’,4’-trimethyl ether	*C. quadrangulare*	[45]
151	3’,4’,5,7-tetrahydroxyflavan	*C. micranthum*	[34]
152	3’,4’,5’,5,7-pentahydroxyflavan	*C. micranthum*	[34]
153	isovitexin	*C. micranthum*	[34]
154	orientin	*C. micranthum*	[34]
155	homoorientin	*C. micranthum*	[34]
156	myricetin-3-*O*-glucoside	*C. micranthum*	[34]
157	2’’-*O*-galloylvotexin	*C. micranthum*	[34]
158	2’’-*O*-galloylisovotexin	*C. micranthum*	[34]
159	2’’-*O*-galloylorientin	*C. micranthum*	[34]
160	2’’-*O*-galloylhomoorientin	*C. micranthum*	[34]

(Table 1) contd….

No	Compound Name	Botanical Source	Reference
161	kinkeloid A_1	*C. micranthum*	[34]
162	kinkeloid A_2	*C. micranthum*	[34]
163	kinkeloid B_1	*C. micranthum*	[34]
164	kinkeloid B_2	*C. micranthum*	[34]
165	kinkeloid C_1	*C. micranthum*	[34]
166	kinkeloid C_2	*C. micranthum*	[34]
167	kinkeloid D_1	*C. micranthum*	[34]
168	kinkeloid D_2	*C. micranthum*	[34]
169	apigenin	*C. erythrophyllum*	[50]
170	genkwanin	*C. erythrophyllum*	[50]
171	5-hydroxy-7,4′-dimethoxyflavone	*C. erythrophyllum*	[50]
172	Rhamnocitrin	*C. erythrophyllum* *C. apiculatum*	[50,51]
173	kaempferol	*C. erythrophyllum* *C .apiculatum*	[50,51]
174	quercetin-5,3′-dimethylether	*C. erythrophyllum*	[50]
175	rhamnazin	*C. erythrophyllum*	[50]
176	dillenetin	*C. lanceolatum*	[52]
177	isorhamnetin	*C. lanceolatum*	[52]
178	quercetin	*C. leprosum,* *C. apiculatum*	[39,40,53]
179	3-*0*-methylquercetin	*C. leprosum,* *C. erythrophyllum*	[40,50]
180	quercetrin	*C. leprosum,* *C. apiculatum*	[39,51]
181	5,3’,4’-trihydroxy-3,7-dimethoxyflavone	*C. leprosum*	[40]
182	5,3’-dihydroxy-3,7,4’-trimethoxyflavone	*C. leprosum*	[40]
183	cardamonin	*C. apiculatum*	[51]
184	pinocembrin	*C. apiculatum*	[51]
185	2,4,4’-trihydroxychalcone	*C. yannanense*	[53]
186	eriodictyol	*C. yannanense*	[53]
	Diarylpropanes		
187	combrequinone A	*C. yannanense*	[53]
188	combrequinone B	*C. yannanense*	[53]
189	combrequinone C	*C. yannanense*	[53]
190	combretol A	*C. yannanense*	[54]
191	combretol B	*C. yannanense*	[54]
192	combretol C	*C. yannanense*	[54]
193	combretol D	*C. yannanense*	[54]
194	combretol E	*C. yannanense*	[54]

(Table 1) contd….

No	Compound Name	Botanical Source	Reference
195	1-(2-methoxy-4-hydroxyphenyl) 3-(3-hydroxy-4-methoxy phenyl)-propane	*C. yannanense*	[53]
196	1-(4-hydroxy-2,5-dimethoxyphenyl)-3-(4-hydroxy-3-methoxyphenyl)propane	*C. griffithii*	[55]
197	1-(3-hydroxy-2,4-dimethoxyphenyl)-3-(4-hydroxy-3-methoxyphenyl)propane	*C. griffithii*	[55]
198	1-(4,5-dihydroxy-2-methoxyphenyl)-3-(3,4-dimethoxyphenyl)propane	*C. griffithii*	[55]
199	1-(2-hydroxy-4-methoxyphenyl)-3-(4-hydroxy-3-methoxyphenyl)propane	*C. griffithii*	[55]
200	1-[2-(5-methoxy-1,4-benzoquinone)])-3-(4-hydroxy-3-methoxyphenyl)propane	*C. griffithii*	[55]
	Phenanthrenes and 9,10-Dihydrophenanthrenes		
201	4,7-dihydroxy-2,3,6-trimethoxyphenanthrene	*C. molle,* *C. apiculatum*	[56]
202	2,6-dihydroxy-3,4,7-trimethoxyphenanthrene	*C. apiculatum*	[56]
203	4,6,7-trihydroxy-2,3-dimethoxyphenanthrene	*C. molle* *C. apiculatum*	[56]
204	2,3,7-dihydroxy-4,6-trimethoxyphenanthrene	*C. apiculatum*	[56]
205	3,6,7-dihydroxy-2,4-dimethoxyphenanthrene	*C .apiculatum*	[56]
206	3,7-dihydroxy-2,4,6-trimethoxyphenanthrene	*C. apiculatum*	[56]
207	7-hydroxy-2,4,6-trimethoxyphenanthrene	*C. psidioides*	[56]
208	7-hydroxy-2,3,4,6-tetramethoxyphenanthrene	*C. psidioides* *C. cafrum*	[56]
209	2,7-dihydroxy-3,4,6-trimethoxyphenanthrene	*C. psidioides* *C. cafrum*	[56]
210	2,6,7-trihydroxy-3,4-dimethoxyphenanthrene	*C. psidioides*	[56]
211	3,6-dihydroxy-2,4,7-trimethoxyphenanthrene	*C. hereroense*	[56]
212	2,6-dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene	*C. molle* *C. apiculatum*	[56]
213	4,7-dihydroxy-2,6-dimethoxy-9,10-dihydrophenanthrene	*C. apiculatum*	[56]
214	2,6-dihydroxy-4,7-trimethoxy-9,10-dihydrophenanthrene	*C. apiculatum*	[56]
215	4,7-dihydroxy-2,3,6-trimethoxy-9,10-dihydrophenanthrene	*C. molle* *C. apiculatum*	[56]
216	2-hydroxy-3,4,6,7-tetramethoxy-9,10-dihydrophenanthrene	*C. apiculatum* *C. cafrum*	[56]
217	6,7-dihydroxy-2,3,4-trimethoxy-9,10-dihydrophenanthrene	*C. apiculatum* *C. cafrum*	[56]
218	4,6,7-trihydroxy-2,3-dimethoxy-9,10-dihydrophenanthrene	*C. molle* *C. apiculatum*	[56]
219	7-hydroxy-2,4,6-trimethoxy-9,10-dihydrophenanthrene	*C. psidioides*	[56]
220	7-hydroxy-2,3,4,6-tetramethoxy-9,10-dihydrophenanthrene	*C. psidioides* *C. apiculatum*	[56]
221	2,7-dihydroxy-3,4,6-trimethoxy-9,10-dihydrophenanthrene	*C. psidioides* *C. apiculatum* *C. cafrum*	[56]
222	2,6,7-trihydroxy-3,4-dimethoxy-9,10-dihydrophenanthrene	*C. psidioides*	[56]
223	3,6-dihydroxy-2,4,7-trimethoxy-9,10-dihydrophenanthrene	*C. hereroense*	[57]

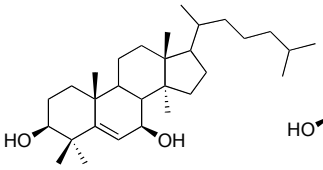
(Table 1) contd….

No	Compound Name	Botanical Source	Reference
	Stilbenes and Dihydrostilbenes		
224	combretastatin A-1	*C. cafrum* *C. erythrophyllum*	[58,59]
225	(-)-combretastatin	*C. erythrophyllum*	[59]
226	combretastatin A-1,2'-*β*-D-glucoside	*C. erythrophyllum*	[59]
227	combretastatin B-1,2'-*β*-D-glucoside	*C. erythrophyllum*	[59]
228	combretastatin A-4	*C. cafrum*	[60]
229	combretastatin B-5	*C. woodii*	[61]
230	3,4′-dihydroxy-4,5-dimethoxybibenzyl	*C. molle*	[62]
231	4′-hydroxy-3,4,5-trimethoxybibenzyl	*C. psidioides*	[63]
232	4,4′-dihydroxy-3,5-dimethoxybibenzyl	*C. psidioides*	[63]
233	3-hydroxy-2,3'methoxybibenzyl	*C. apiculatum*	[64]
234	2'-hydroxy-3,4,5-trimethoxybibenzyl	*C. apiculatum*	[64]
235	2,3'-dihydroxy-4',5'-dimethoxybibenzyl	*C. apiculatum*	[64]
236	2,4'-dihydroxy-3,5-dimethoxybibenzyl	*C. apiculatum*	[64]
237	3'-hydroxy-3,4,5-trimethoxybibenzyl	*C. apiculatum*	[64]

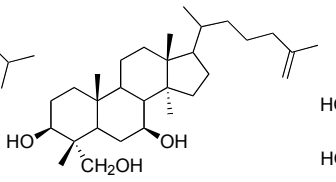
methyl ester (**15**), quadrangularic acid E-H (**38,16,18,23**), J-M (**17, 24, 25, 22**), methyl quadrangularate A-C, D, I, N, O, P (**29-31, 34, 19, 36, 33, 44**), 24-epiguadrangularic acid M, G, L (**20, 21, 26**), norquadrangularic acid A-C (**28**, **44**, **45**), methyl 24-epiquadrangularate C (**32**), quadrangularol A and B (**35, 37**), quadranoside I-XI (**61, 50, 62, 57**, **63, 66-69, 72-73**), jessic acid (**43**), 23-deoxojesic acid (**39**), methyl 23-deoxojessoate (**42**), 7-hydroxy-23-deoxojessic acid (**27**), 1-*O*-acetyl-23-deoxojessic acid (**40**), arjunic acid (**52**), 6*β*-hydroxyarjunic acid (**51**), arjunolic acid (**53**), arjunglucoside II (**54**), arjunetin (**74**), arjungenin (**6**), asiatic acid (**80**), 19*α*-hydroxyasiatic acid (**55**), 6*β*-hydroxyhovenic acid (**49**), betulinic acid (**47**), 2*α*,6*β*-dihydroxybetulinic acid (**48**), 2 *α*,3*β*,23-trihydroxyurs-12,18-dien-oic acid (**58**), glucosyl 2*α*,3*β*,23-trihydroxyurs-12,18-dien-28-oate (**59**), glucosyl 2*α*,3*β*,23-trihydroxyurs-12,19(20)-dien-28-oate (**60**), 2*α*,3*β*,23-trihydroxyurs-12,19-dien-28-oic acid *β*-*D*-glucopyranosyl (**64**), 28-*O*-*β*-D-glucopyranosyl-6*β*,23-dihydroxytormentic acid (**71**), *β*-D-glucopyranosyl 2*α*,3*β*,6*β*-trihydroxyolean-12-en-28-oate (**79**), 4*β*,14*α*-dimethyl-5*α*-ergosta-9*β*,19-cyclo-24(31)-en-3*β*-hydroxy-4*α*-carboxylic acid (**41**), ursolic acid (**115**), pinfaensin (**65**), rosamutin (**70**) nigaichigoside F1 (**56**), chebuloside II (**75**), combretanones A-G (**123-129**), combretic acid A and B (**130-131**) [23-30, 45].

Nine 1,3-hydroxylated pentacyclic olean-12-ene triterpenoids were isolated from the leaves of south African *Combretum imberbe* by preparative HPLC. Complete spectral analysis of these compounds showed that they are, imberic acid (**84**), 1-hydroxyolean-12-en-30-oic acid (**85**), 3,30-dihydroxyolean-12-en-29-one (**86**), 1,3,24-trihydroxyolean-12-en-29-oic acid (**87**), 1,23-dihydroxyolean-12-en-29-oic acid-3*β*-*O*-2,4-diacetyl-1-rhamnopyranoside (**88**) [36]. Four other glycoside derivatives of the above triterpenoids type were also isolated from the leaves of the same species and named, 1*α*,3*β*-dihydroxyolean-12-en-29-oic acid 23-*O*-*α*-L-(4-acetylrhamnopyranoside) (**89**), 1*α*,3*β*,23-trihydroxyolean-12-en-29-oate 23-*O*-*α*-(3,4-diacetylrhamnopyranoside) (**90**), 1*α*,3*β*,23-trihydroxyolean-12-en-29-oate 23-*O*-*α*-(3,4-diacetylrhamnopyranosyl)-29-*O*-*α*-rhamnopyranoside (**91**), 1*α*,3*β*, 23-trihydroxyolean-12-en-29-oate 23-*O*-*α*-(4-acetoxyrhamnopyranosyl)-29-*α*-rhamnopyranoside (**92**) [37]. Another compounds with a similar squeleton 1*α*,23*β*-dihydroxyolean-12-en-29-oic acid-23β-*O*-*α*-4-acetylrhamno-pyranoside (**93**) was isolated from the dichloromethane extract of the leaves of South African *C. padoides* leaves together with 1,22-dihydroxyolean-12-en-30-oic acid (**94**) [38] and *C. leprosum* led to the isolation of 3*β*,6*β*,16*β*-trihydroxylup-20(29)-ene (**95**), 4*α*-carboxy-3*β*,16*α*-dihydroxycycloart-24-ene (**96**) and 4*α*-carboxy-1*α*,3*β*-dihydroxy-25-hydroperoxy-trans-cycloart-23(24)-ene (**97**) [39].

Bioassay-guided purification of the ethyl acetate extracts obtained from the leaves and flowers of *Combretum sundaicum* led to the isolation of 10 pentacyclic triterpenoids possessing olean-12-en-28-oic acid and olean-12-en-29-oic acid aglycons. These compounds are presented in (Table **1**) and named, 23-acetoxy-3*β*-acetylimberbic acid (**98**), 23-acetoxyimberbic acid-29-methyl ester (**99**), 23-*O*-[*α*-L-(3',4'-diacetylrhamnopyranosyl)]-3β-acetylimberbic acid (**100**), 23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]-3β-acetylimberbic acid (**101**), 23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]-3β-acetylimberbic acid-29-methyl ester (**102**), 23-*O*-[*α*-L-(2',4'-diacetylrhamnopyranosyl)]imberbic acid (**103**), 1-*O*-[*α*-L-



1



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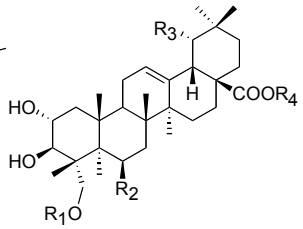
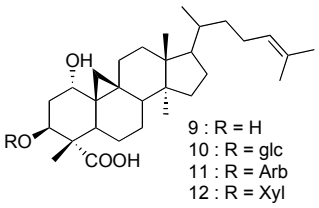
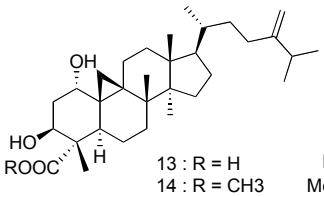


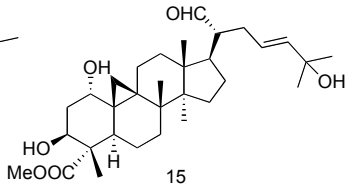
3 : R1 = galloyl R2 = OH R3 = H R4 = glc
4 : R1 = H R2 = OH R3 = OH R4 = H
5 : R1 = H R2 = H R3 = OH R4 = H
6 : R1 = H R2 = H R3 = OH R4 = glc
7 : R1 = H R2 = OH R3 = OH R4 = glc
8 : R1 = H R2 = H R3 = OH R4 = glc



9 : R = H
10 : R = glc
11 : R = Arb
12 : R = Xyl



13 : R = H
14 : R = CH3



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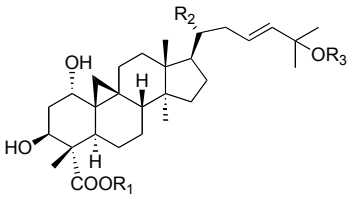
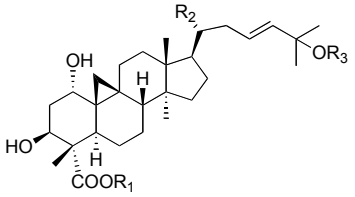
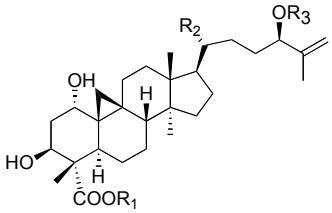


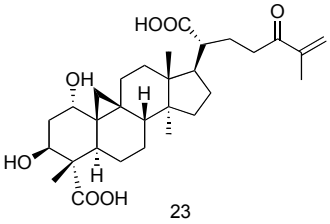
16 : R1 = Me R2 = COOH R3 = OH
17 : R1 = H R2 = R3 = Me



16 : R1 = Me R2 = COOH R3 = OH
17 : R1 = H R2 = R3 = Me



21: R1 = Me R2 = COOH R3 = H
22: R1 = H R2 = Me R3 = H



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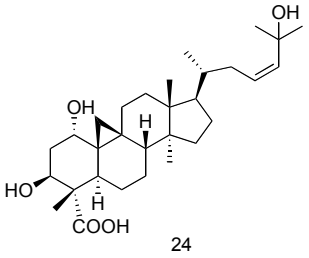

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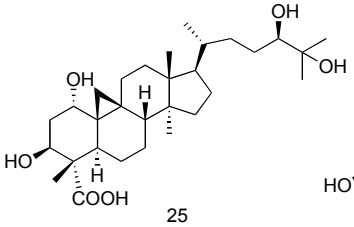

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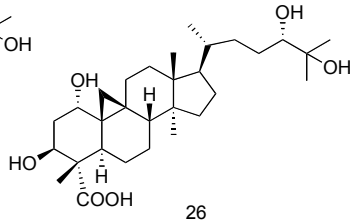

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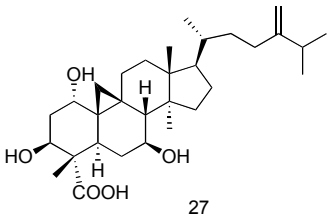

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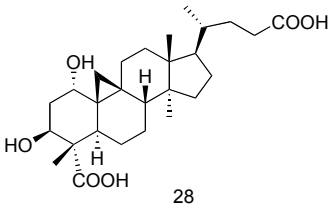

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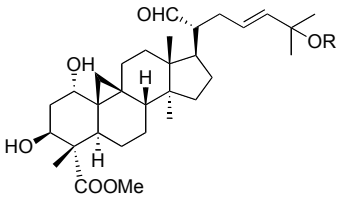
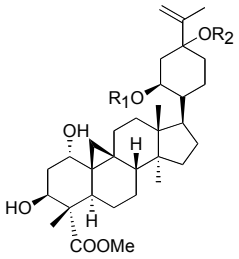
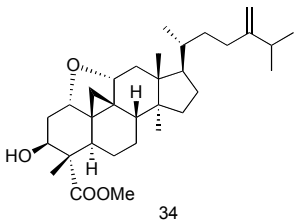


29 : R = H
30 : R = OH



31 : R1 = Me R2 = b -H
32 : R1 = Me R2 = a -H
33 : R1 = H R2 = b-H



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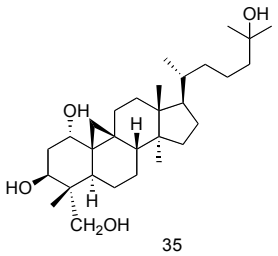

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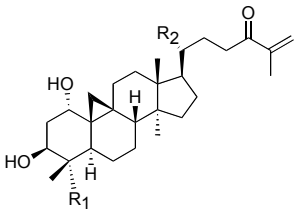
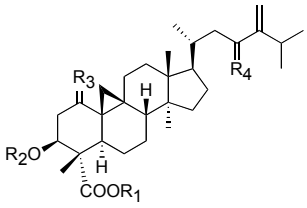
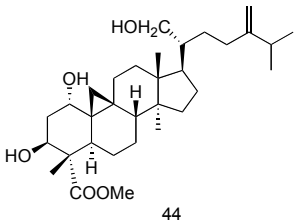


36 : R1 = COOMe R2 = CHO
37 : R1 = CH2OH R2 = Me



38 : R1 = R2 = H R3 = O R4 = CH2
39 : R1 = R2 = H R3 = a-OH b -H R4 = CH2
40 : R1 = R2 = H R3 = a-OAc b -H R4 = CH2
41 : R1 = R2 = H R3 = R4 = CH2
42 : R1 = CH3 R2 = H R3 = a-OH b -H R4 = CH2
43 : R1 = R2 = H R3 = a-OH b -H R4 = O



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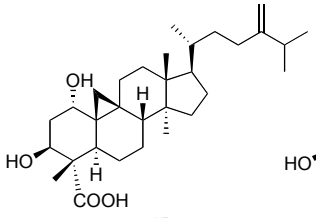

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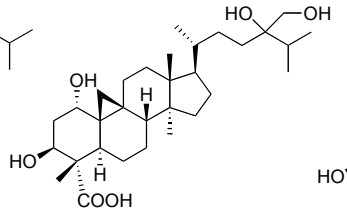

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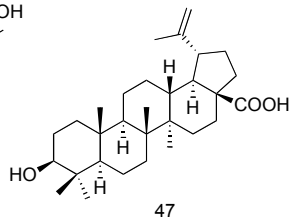

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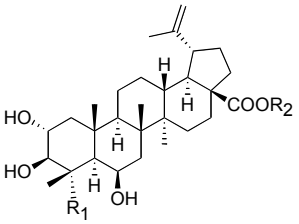
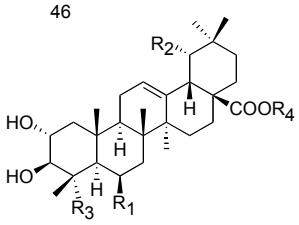
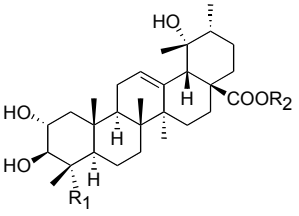


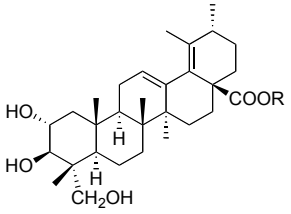
48 : R1 = CH3 R2 = H
49 : R1 = CH2OH R2 = H
50 : R1 = CH2OH R2 = glc



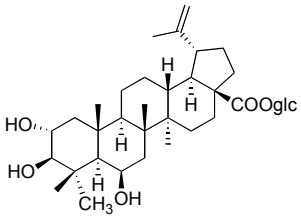
51 : R1 = OH R2 = OH R3 = CH3 R4 = H
52 : R1 = H R2 = OH R3 = CH3 R4 = H
53 : R1 = H R2 = H R3 = CH2OH R4 = H
54 : R1 = H R2 = H R3 = CH2OH R4 = glc
55 : R1 = H R2 = OH R3 = CH2OH R4 = glc



56 : R1 = CH2OH R2 = H
57 : R1 = CH2OH R2= glc
58 : R1 = CH3 R2 = glc



59 : R = H
60 : R = glc



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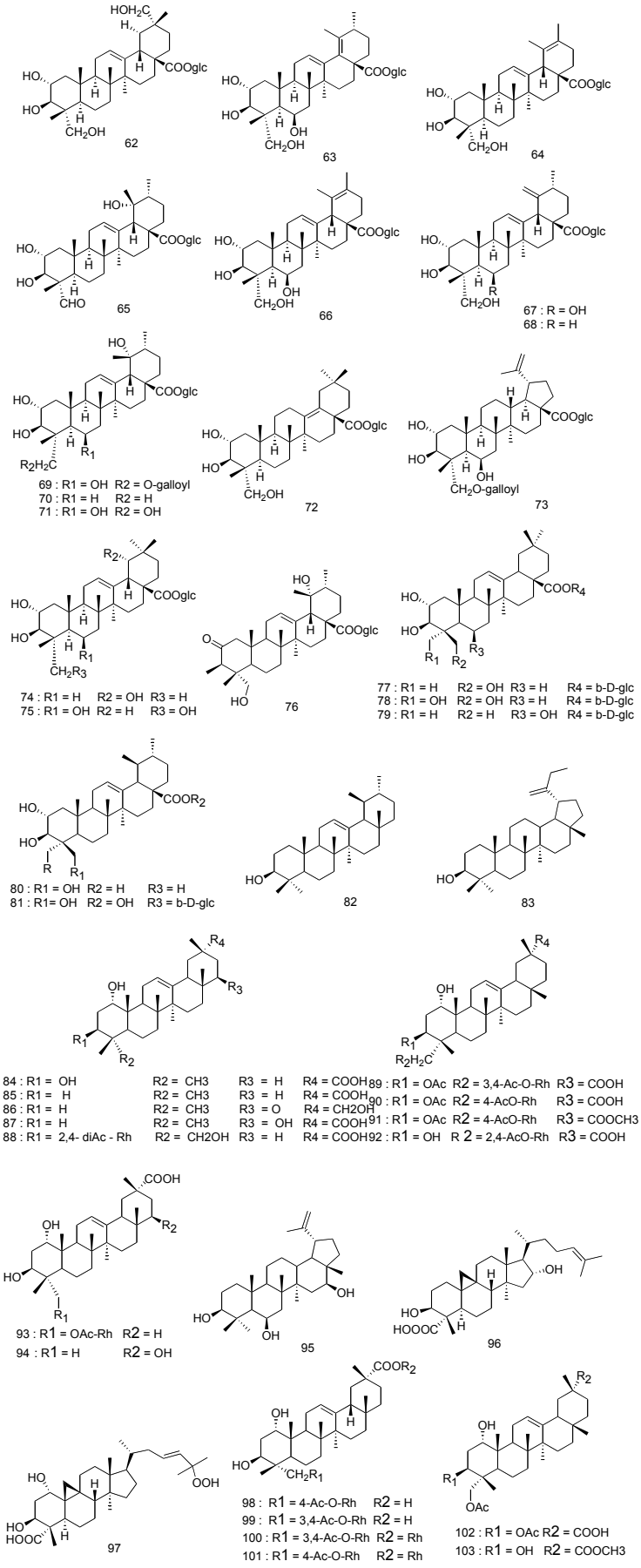

62
63
64
65
66
67 : R = OH
68 : R = H
69 : R1 = OH R2 = O-galloyl
70 : R1 = H R2 = H
71 : R1 = OH R2 = OH
72
73
74 : R1 = H R2 = OH R3 = H
75 : R1 = OH R2 = H R3 = OH
76
77 : R1 = H R2 = OH R3 = H R4 = b-D-glc
78 : R1 = OH R2 = OH R3 = H R4 = b-D-glc
79 : R1 = H R2 = H R3 = OH R4 = b-D-glc
80 : R1 = OH R2 = H R3 = H
81 : R1= OH R2 = OH R3 = b-D-glc
82
83
84 : R1 = OH R2 = CH3 R3 = H R4 = COOH
85 : R1 = H R2 = CH3 R3 = H R4 = COOH
86 : R1 = H R2 = CH3 R3 = O R4 = CH2OH
87 : R1 = H R2 = CH3 R3 = OH R4 = COOH
88 : R1 = 2,4- diAc - Rh R2 = CH2OH R3 = H R4 = COOH
89 : R1 = OAc R2 = 3,4-Ac-O-Rh R3 = COOH
90 : R1 = OAc R2 = 4-AcO-Rh R3 = COOH
91 : R1 = OAc R2 = 4-AcO-Rh R3 = COOCH3
92 : R1 = OH R 2 = 2,4-AcO-Rh R3 = COOH
93 : R1 = OAc-Rh R2 = H
94 : R1 = H R2 = OH
95
96
97
98 : R1 = 4-Ac-O-Rh R2 = H
99 : R1 = 3,4-Ac-O-Rh R2 = H
100 : R1 = 3,4-Ac-O-Rh R2 = Rh
101 : R1 = 4-Ac-O-Rh R2 = Rh
102 : R1 = OAc R2 = COOH
103 : R1 = OH R2 = COOCH3

(rhamnopyranosyl)]-23-acetoxy-3*β*-acetylimberbic acid (**104**), 1-*O*-[*α*-L-(rhamnopyranosyl)]-23-acetoxyimberbic acid-29-methyl ester (**105**), 1-*O*-[*α*-L-(rhamnopyranosyl)]-23-acetoxy-3*β*-acetylimberbic acid-29-methyl ester (**106**), 23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]imberbic acid (**108**) [41].

In addition, *β*-D-glucopyranosyl 3*β*,19*α*-dihydroxy-2-oxo-urs-12-en-28-oate (**76**) was isolated from the leaves of Cameroonian *C. bracteatum* [32]; *β*-D-glucopyranosyl 2*α*,3*β*,24-trihydroxyolean-12-en-28-oate (**77**), bellericoside (**78**), *β*-D-glucopyranosyl 2*α*,3*β*,6*β*-trihydroxyolean-12-en-28-oate (**79**), asiatic acid (**80**), *β*-D-glucopyranosyl 2*α*,3*β*,23,24-tetrahydroxyurs-12-en-28-oate (**81**) from stems of *C. laxum* [33]; α-amyrin (**82**), lupeol (**83**) from *C. micranthum* [34]; ursolic acid (**115**), corosolic acid (**116**), oleanolic acid (**117**), maslinic acid (**118**) from *C. vendee* and *C. Zeyheri* [39,40]; 3*β*-hydroxyolean-12-en-28-oic acid (**107**), 23-*O*-[*α*-L-(4'-acetylrhamnopyranosyl)]imberbic acid (**108**), 23-acetoxy-3*β*-acetylimberbic acid-29-methyl ester (**109**), 23-*O*-[*α*-L-rhamnopyranosyl]-1,3 *β*-diacetylimberbic acid (**110**) from *C. oliviforme* [42]; 11*α*-acetoxy-20,24-epoxy-25-hydroxy-dammar-3-one (**111**), 20,24-epoxy-11*α*,25-dihydroxy-dammar-3-one (**112**), 20,24-epoxy-12*β*,25-dihydroxy-dammar-3-one (**113**), arcapitin A (**114**) from *C nigricans* [43]; 2*α*,3*β*-dihydroxyurs-12-èn-28-oic acid (**118**) 6*β*-hydroxymaslinic acid (**120**) terminolic acid (**121**), methylsumaresinolate (**122**) were isolated from *C. Zeyheri* [44]; 3-oxo-cycloart-1,11,24-trien-23,21-olide (**132**) from *C. erythrophyllum* [47]; 3*β*,16*α*-dihydroxy-13(17)-mansumbinen-28-oic acid (**133**) from *C. coccineum* [48] and (16R)-16-*O*-*α*-L-arabinofuranosyl-3*β*-hydroxydammara-20,24-dièn-29-oic acid (**134**), (16R)-16-*O*-*α*-L-arabinosyl-3*β*-hydroxymansumbin-13-en-28-oic acid (**135**) from *C. rotundifolium* [49].

Phenolic Compounds

Flavonoids

Flavonoids are also one of the major components of the genus *Combretum*. A total of 51 flavonoids belonging to the flavonols, flavanone, flavonones and chalcone structural groups (**136-186**) have been isolated and identified from *Combretum* species (Table **2**).

Chemical investigation of the leaves of *C. quadrangulare* resulted in the isolation and structural determination of 9 flavonoids. These compounds are, kamatakenin (**136**), isokaempferide (**137**), 5,7,4'-trihydroxy-3,3'-dimethoxyflavone (138), 5,4'-dihydroxy-3,7,3'-trimethoxyflavone (**139**), (+)-catechin (**140**) [25], (+)-gallocatechin (141), (-)-epicatechin (142), (-)-epigallocatechin (**143**), vitexin (**144**) [31,34], 5,7,3',5'-tetrahydroxy-3,4'-dimethoxyflavone (**145**), combretol (**146**), 3',5-dihydroxy-3,4',5,7-tetramethoxyflavone (147), 3',5-dihydroxy-3,4',5,7-tetramethoxyflavone (148), quercetin 3,4'-dimethyl ether (**149**), myricetin 3,3',4'-trimethyl ether (**150**) [45].

C. micranthum was also reported to posses various and special types of flavonoid squeletons. Some of the identified compounds are, 3',4',5,7-tetrahydroxyflavan (**151**), 3',4',5',5,7-pentahydroxyflavan (**152**), isovitexin (**153**), orientin (**154**), homoorientin (**155**), myricetin-3-*O*-glucoside (**156**), 2''-*O*-galloylvotexin (**157**), 2''-*O*-galloylisovotexin (**158**), 2''-*O*-galloylorientin (**159**), 2''-*O*-galloylhomoorientin (**160**). New ring structures named piperidine-Flavan alkaloids were isolated from the nBuOH fraction of the leaves of *C. micranthum*. The 8 kinkeloids as they were named are, kinkeloid A_1 (**161**), kinkeloid A_2 (**162**), kinkeloid B_1 (**163**), kinkeloid B_2 (**164**), kinkeloid C_1 (**165**), kinkeloid C_2 (**166**), kinkeloid D_1 (**167**), kinkeloid D_2 (**168**) [34].

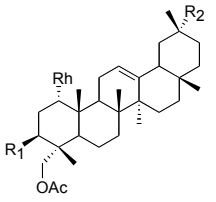
Apigenin (**169**), genkwanin (**170**), 5-hydroxy-7,4′-dimethoxyflavone (**171**), rhamnocitrin (**172**), kaempferol (**173**), quercetin-5,3′-dimethylether (**174**) and rhamnazin (**175**) was identified as flavonoid constituents from *C. erythrophyllum* [50]. Quercetin (**178**), 3-*0*-methylquercetin (**179**), quercetrin (**180**), 5,3',4'-trihydroxy-3,7-dimethoxyflavone (**181**) and 5,3'-dihydroxy-3,7,4'-trimethoxyflavone (**182**) was also isolated from *C. leprosum* [39,40]; cardamonin (**183**) and pinocembrin (**184**) from *C. apiculatum* [51]; dillenetin (**176**) and isorhamnetin (**177**) from *C. lanceolatum* [52] and 2,4,4'-trihydroxychalcon (**185**) and eriodictyol (**186**) from *C. yannanense* [53].

Diarylpropanes

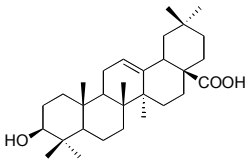
Nine 1,3-diarylpropanes, combrequinone A-C (**187-189**), combretol A–E (**190-194**) and 1-(2-methoxy-4-hydroxyphenyl) 3-(3-hydroxy-4-methoxy phenyl)-propane (**195**) were isolated from the aerial parts of *C. yunnanense* [53,54]. Investigations of the methanolic extract of stem of *C. griffîthii* led to the isolation and structural elucidation of five other diarylpropanes named**,** 1-(4-hydroxy-2,5-dimethoxyphenyl)-3-(4-hydroxy-3-methoxyphenyl)propane (**196**), 1-(3-hydroxy-2,4-dimethoxyphenyl)-3-(4-hydroxy-3-methoxyphenyl)propane (**197**), 1-(4,5-dihydroxy-2-methoxyphenyl)-3-(3,4-dimethoxyphenyl)propane (**198**), 1-(2-hydroxy-4-methoxyphenyl)-3-(4-hydroxy-3-methoxyphenyl)propane (**199**) and 1-[2-(5-methoxy-1,4-benzoquinone)])-3-(4-hydroxy-3-methoxyphenyl)propane (**200**) [55].

Phenanthrenes and 9, 10-Dihydrophenanthrebnes

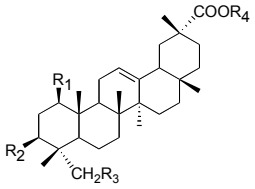
Several phenanthrenes and 9, 10-dihydrophenanthrebnes have been isolated from various species of the genus Combretum. They are, 4,7-dihydroxy-2,3,6-trimethoxyphenanthrene (**201**), 2,6-dihydroxy-3,4,7-trimetho-xyphenanthrene (**202**), 4,6,7-trihydroxy-2,3-dimethoxyphen-anthrene (**203**), 2,3,7-dihydroxy-4,6-trimethoxyphenanthrene (**204**), 3,6,7-dihydroxy-2,4-dimethoxyphenanthrene (**205**), 3,7-dihydroxy-2,4,6-trimethoxyphenanthrene (**206**) from the heartwood of *C. apiculatum*; 7-hydroxy-2,4,6-trimethoxyphenanthrene (**207**), 7-hydroxy-2,3,4,6-tetramethoxyphenanthrene (**208**), 2,7-hydroxy-3,4,6-tetramethoxyphenanthrene (**209**), 2,6,7-trihydroxy-3,4-dimethoxyphenanthrene (**210**) from the heartwood *of C. Psidioides* and 3,6-dihydroxy-2,4,7-trimethoxyphenanthrene (**211**) from the heartwood of *C. Hereroense* for phenanthrenes and 2,6-dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene (**212**), 4,7-dihydroxy-2,6-dimethoxy-9,10-dihydrophenanthrene (**213**), 2,6-dihydroxy-4,7-dimethoxy-9,10-dihydrophenanthrene (**214**), 4,7-dihydroxy-2,3,6-trimethoxy-9,10-dihydrophenanthrene (**215**), 2-hydroxy-3,4,6,7-tetramethoxy-9,10-dihydrophenanthrene (**216**),



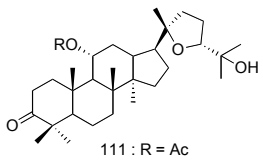
104 : R1 = OAc R2 = COOH
105 : R1 = OH R2 = COOCH3
106 : R1 = OAc R2 = COOCH3



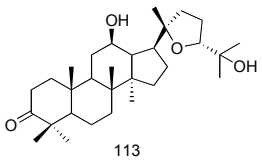
107



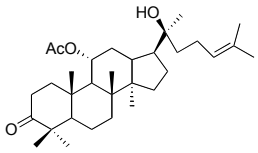
108 : R1 = OH R2 = OH R3 = 4-Ac-O-Rh R4 = H
109 : R1 = OH R2 = Ac R3 = OAc R4 = Me
110 : R1 = R2 = Ac R3 = -O-Rh R4 = H



111 : R = Ac
112 : R = H



113



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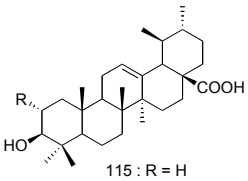
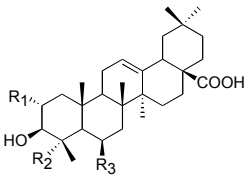
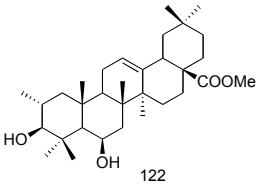


115 : R = H
116 : R = OH



117 : R1 = H R2 = Me R3 = H
118 : R1 = OH R2 = Me R3 = H
119 : R1 = OH R2 = Me R3 = H
120 : R1 = OH R2 = Me R3 = OH
121 : R1 = OH R2 = CH2OH R3 = OH



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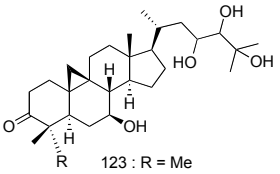
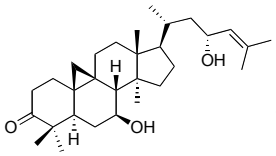


123 : R = Me
124 : R = CH2OH



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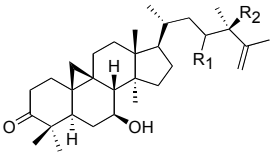
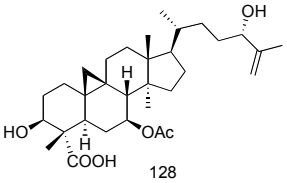


126 : R1 = H R2 = OH
127 : R1 = HO R2 = H



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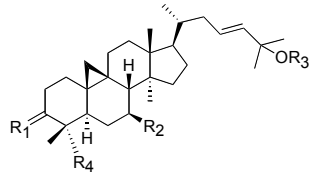
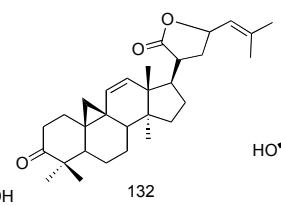


129 : R1 = O R2 = H R3 = H R4 = Me
130 : R1 = O R2 = H R3 = Me R4 = Me
131 : R1 = b-OH R2 = Ac R3 = H R4 = COOH



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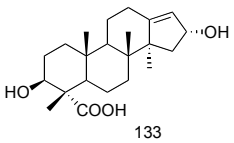

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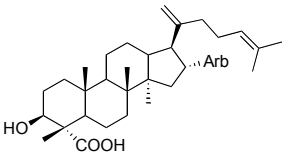

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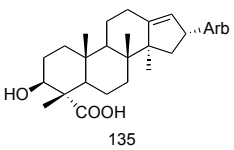

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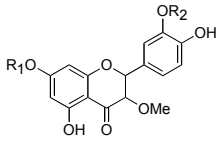
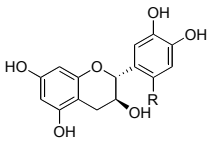
Table 2. Other Non-essential Oil Compounds Isolated and Identified from Combretum

No	Compound Name	Botanical Source	Reference
	Gallic acid and derivatives		
238	gallic acid	*C. quadrangulare*	[29]
239	methyl gallate	*C. quadrangulare* *C. erythrophyllum*	[29,62]
240	1-*O*-galloyl-6-*O*-(4-hydroxy-3,5-dimethoxy)benzoyl-*β*-D-glucose	*C. quadrangulare*	[65]
	Ellagic acid and derivatives		
241	ellagic acid	*C. yannanense*	[66]
242	4-(*α*-rhamnopyranosyl)ellagic acid	*C. yannanense*	[66]
243	4-(4''-*O*-acetyl-*α*-rhamnopyranosyl)ellagic acid	*C. yannanense*	[66]
244	3,3',4'-tri-*O*-methylflavellagic acid	*C. kraussii*	[67]
245	3,3'-di-*O*-methylellagic acid	*C. kraussii*	[67]
246	3,4,3'-tri-*O*-methylflavellagic acid-4'-*β*-D-glucoside	*C. kraussii*	[67]
247	2,3-(S)-hexahydroxydiphenoyl-D-glucose	*C. glutinosum*	[68]
248	punicalin	*C. glutinosum*	[68]
249	punicalagin	*C. molle* *C. glutinosum*	[20,68]
250	combreglutinin	*C. glutinosum*	[68]
	Steroids		
251	*β*-sitosterol	*C. quadrangulare,* *C. yannanense*	[26,54]
252	*β*-sitosterol glucoside	*C. quadrangulare*	[29]
253	24-ethylcholesta-7,22,25-triene-3-*O*-*β*-D-glucopyranoside	*C. padoides*	[38]
254	D-glucopyranoside-3*β*-stigmast-5-en-3-yl	*C. leprosum*	[40]
	Isolariciresinols		
255	5-methoxy-(-)-isolariciresinol	*C. quadrangulare*	[29]
256	5-methoxy-9*β*-xylopyranosyl-(-)-isolariciresinol	*C. quadrangulare*	[29]
	Cyclobutanes		
257	1*α*,2*β*-di-(2,6-dimethoxy-4-hydroxybenzoyl)-(3*α*,4*β*)-diphenylcyclobutane	*C. albopunctatum*	[69]
258	1α-(2-methoxy-4,6-dihydroxy-benzoyl)-2*β*-(2,6-dimethoxy-4-hydroxybenzoyl)-(3*α*,4*β*)-diphenylcyclobutane	*C. albopunctatum*	[69]
	Lipids		
259	1,2-di-*O*-*α*-linolenoyl-3-*O*-*β*-*D*-galactopyranosyl-*sn*-glycerol	*C. bracteatum*	[32]
260	1,2-di-*O*-*α*-linolenoyl-3-*O*-[*α*-*D*-galactopyranosyl-(1 6)-*O*-*β*-*D*-galactopyranosyl]-*sn*-glycerol	*C. bracteatum*	[32]
	Coumarin		
261	scopoletin	*C. yannanense*	[54]

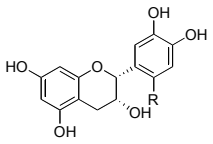
6,7-dihydroxy-2,3,4-trimethoxy-9,10-dihydrophenanthrene (**217**) and 4,6,7-trihydroxy-2,3-dimethoxy-9,10-dihydrophenanthrene (**218**) from *C. apiculatum;* 7-hydroxy-2,4,6-trimethoxy-9,10-dihydrophenanthrene (**219**), 7-hydroxy-2,3,4,6-tetramethoxy-9,10-dihydrophenanthrene (**220**), 2,7-dihydroxy-3,4,6-trimethoxy-9,10-dihydrophenanthrene (**221**), 2,6,7-trihydroxy-3,4-dimethoxy-9,10-dihydrophenanthrene (**222**) *C. Psidioides*, 3,6-dihydroxy-2,4,7-



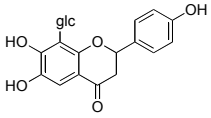
136 : R1 = Me R2 = H
137 : R1 = R2 = H
138 : R1 = H R2 = Me
139 : R1 = Me R2 = Me



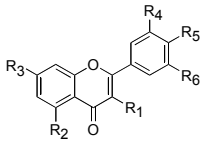
140 : R = H
141 : R = OH



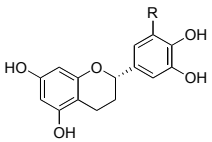
142 : R = H
143 : R = OH



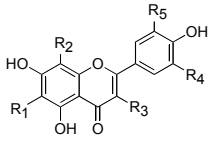
144



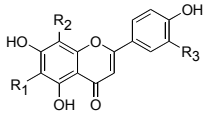
145 : R1 = OMe R2 = OH R3 = OH R4 = OH R5 = OMe R6 = OH
146 : R1 = OMe R2 = OH R3 = OMe R4 = OMe R5 = OMe R6 = OMe
147 : R1 = OMe R2 = OH R3 = OMe R4 = OH R5 = OMe R6 = OMe
148 : R1 = OMe R2 = OH R3 = OMe R4 = OMe R5 = OH R6 = H
149 : R1 = OMe R2 = OH R3 = OH R4 = OH R5 = OMe R6 = H
150 : R1 = OMe R2 = OH R3 = OH R4 = OMe R5 = OMe R6 = OH



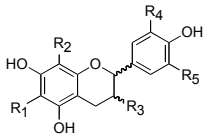
151 : R = H
152 : R = OH



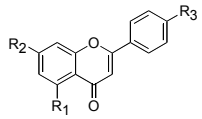
153 : R1 = C-glc R2 = R3 = R4 = R5 = H
154 : R1 = R3 = R5 = H R2 = C-glc R4 = OH
155 : R1 = C-glc R2 = R3 = R5 = H R4 = OH
156 : R1 = R2 = H R3 = O-glc R4 = R5 = OH



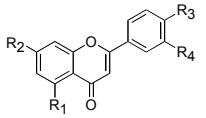
157 : R1 = H R2 = O- galloyl-C-glc R3 = H
158 : R1 = O- galloyl-C-glc R2 = R3 = H
159 : R1 = H R2 = O- galloyl-C-glc R3 = H
160 : R1 = O- galloyl-C-glc R2 = H R3 = OH



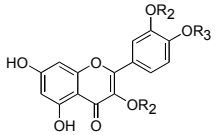
161 : R1 = 2-piperidinyl R2 = R3 = R4 = R5 = H
162 : R2 = 2-piperidinyl R1 = R3 = R4 = R5 = H
163 : R1 = 2-piperidinyl R2 = R3 = R5 = H R4 = OH
164 : R2 = 2-piperidinyl R1 = R3 = R5 = H R4 = OH
165 : R1 = 2-piperidinyl R2 = R3 = H R4 = R5 = OH
166 : R2 = 2-piperidinyl R1 = R3 = H R4 = R5 = OH
167 : R1 = 2-piperidinyl R2 = H R3 = R4 = R5 = OH
168 : R2 = 2-piperidinyl R1 = H R3 = R4 = R5 = OH



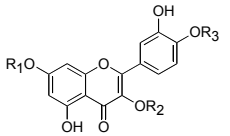
169 : R1= OH R2 = OH R3 = OH
170 : R1= OH R2 = OMe R3 = OH
171 : R1= OH R2 = OMe R3 = OMe



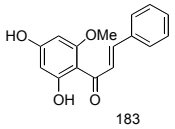
172 : R1= OH R2 = OMe R3 = OH R4 = H
173 : R1= OH R2 = OH R3 = OH R4 = H
174 : R1= OMe R2 = OH R3 = OH R4= OMe
175 : R1= OH R2 = OMe R3 = OH R4= OMe



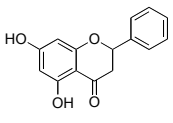
176 : R1= H R2 = Me R3 = Me
177 : R1= H R2 = Me R3 = H
178 : R1= H R2 = H R3 = H
179 : R1= Me R2 = H R3 = H
180 : R1= Rh R2 = H R3 = H



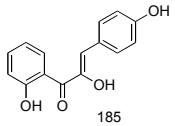
181 : R1= Me R2 = Me R3 = H
182 : R1= R2 = R3 = Me



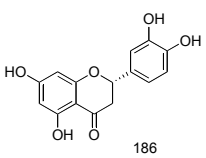
183



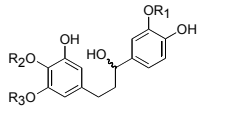
184



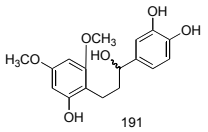
185



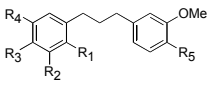
186



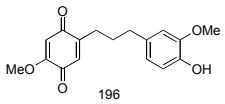
187 : R1 = H R2 = R3 = CH3
188 : R1 = CH3 R2 = H R3 = CH3
189 : R1 = R2 = R3 = CH3
190 : R1 = R2 = H R3 = CH3



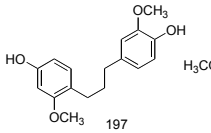
191



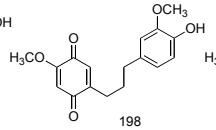
192 : R1 = OMe R2 = H R3 = OH R4 = OMe R5 = OH
193 : R1 = OMe R2 = OH R3 = OMe R4 = H R5 = OH
194 : R1 = OMe R2 = H R3 = OH R4 = OH R5 = OMe
195 : R1 = OH R2 = H R3 = OMe R4 = H R5 = OH



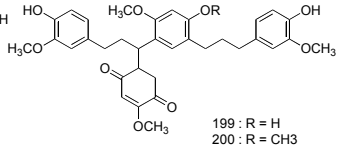
196



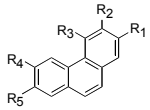
197



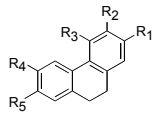
198



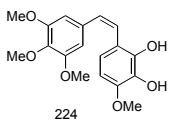
199 : R = H
200 : R = CH3



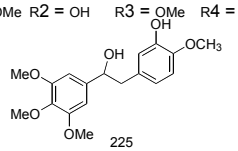
201 : R1 = OMe R2 = OMe R3 = OH R4 = OMe R5 = OH
202 : R1 = OH R2 = OMe R3 = OMe R4 = OH R5 = OMe
203 : R1 = OMe R2 = OMe R3 = OH R4 = OH R5 = OH
204 : R1 = OH R2 = OH R3 = OMe R4 = OMe R5 = OH
205 : R1 = OMe R2 = OH R3 = OMe R4 = OH R5 = OH
206 : R1 = OMe R2 = OH R3 = OMe R4 = OMe R5 = OH
207 : R1 = OMe R2 = H R3 = OMe R4 = OMe R5 = OH
208 : R1 = OMe R2 = OMe R3 = OMe R4 = OH R5 = OH
209 : R1 = OH R2 = OMe R3 = OMe R4 = OMe R5 = OH
210 : R1 = OH R2 = OMe R3 = OMe R4 = OH R5 = OH
211 : R1 = OMe R2 = OH R3 = OMe R4 = OH R5 = OMe



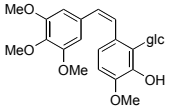
213 : R1 = OH R2 = OMe R3 = OMe R4 = OH R5 = OMe
214 : R1 = OH R2 = H R3 = OMe R4 = OH R5 = OMe
215 : R1 = OMe R2 = OMe R3 = OH R4 = OMe R5 = OH
216 : R1 = OMe R2 = OMe R3 = OH R4 = OH R5 = OH
217 : R1 = OMe R2 = OMe R3 = OMe R4 = OH R5 = OH
218 : R1 = OH R2 = OMe R3 = OMe R4 = OMe R5 = OMe
219 : R1 = OMe R2 = H R3 = OMe R4 = OMe R5 = OH
220 : R1 = OMe R2 = OMe R3 = OMe R4 = OMe R5 = OH
221 : R1 = OH R2 = OMe R3 = OMe R4 = OMe R5 = OH
222 : R1 = OH R2 = OMe R3 = OMe R4 = OH R5 = OH
223 : R1 = OMe R2 = OH R3 = OMe R4 = OH R5 = OMe



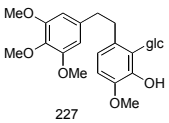
224



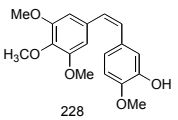
225



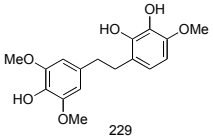
226



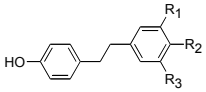
227



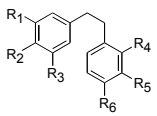
228



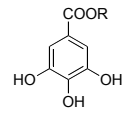
229



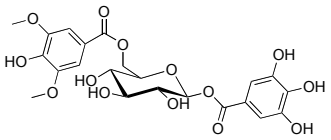
230 : R1 = OMe R2 = OMe R3 = OH
231 : R1 = OMe R2 = OMe R3 = OMe
232 : R1 = OMe R2 = OH R3 = OMe



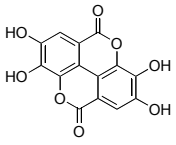
233 : R1 = OMe R2 = H R3 = H R4 = H R5 = OH R6 = OMe
234 : R1 = OMe R2 = OMe R3 = OMe R4 = H R5 = H R6 = OH
235 : R1 = OMe R2 = OMe R3 = OH R4 = H R5 = H R6 = OH
236 : R1 = OMe R2 = OH R3 = OMe R4 = H R5 = H R6 = OH
237 : R1 = OMe R2 = OMe R3 = OMe R4 = H R5 = OH R6 = H



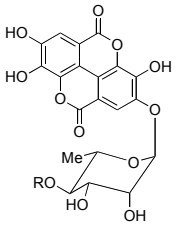
238 : R = H
239 : R = Me



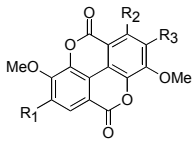
240



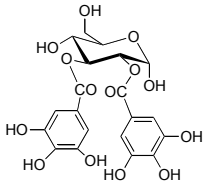
241



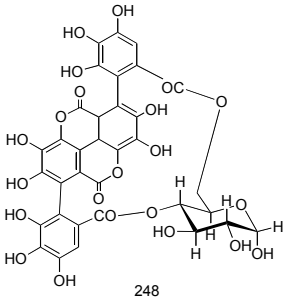
242 : R = H
243 : R = Ac



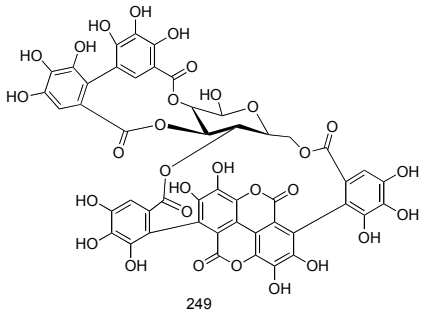
244 : R1 = OMe R2 = OH R3 = OH
245 : R1 = OH R2 = H R3 = OH
246 : R1 = OMe R2 = OH R3 = glc



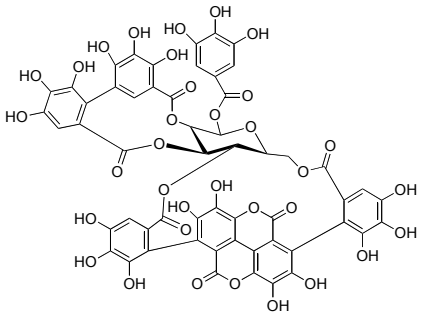
247



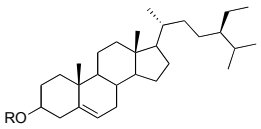
248



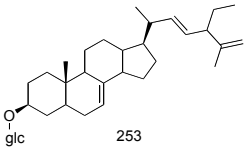
249



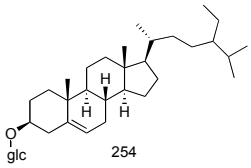
250



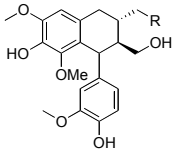
251 : R = H
252 : R = glc



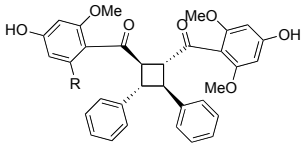
glc 253



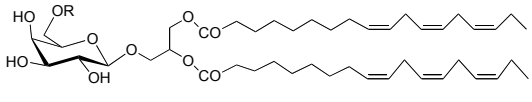
glc 254



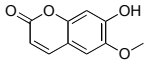
255 : R = OH
256 : R = xylopyranosyl



257 : R = OH
258 : R = OMe



259 : R = H
260 : R = a-D-galac



261

trimetho-xy-9,10-dihydrophenanthrene (**223**) from *C. Hereroense* for 9, 10-dihydrophenanthrebnes [56-60].

Stilbenes and Dihydrostilbenes

Six stilbenes and eight dihydrostilbenes have been isolated and identified from the *Combretum* species. These compounds include combretastatin A-1(**224**), (-)-combretastatin (**225**), combretastatin A-1,2'-*β*-D-glucoside (**226**), combretastatin B-1,2'-*β*-D-glucoside (**227**) from *C. erythrophyllum;* combretastatin A-4 (**228**) from the stem wood of *C. Cafrum*; combretastatin B-5 (**229**) from the leaves of South African *C. woodii*; 3,4′-dihydroxy-4,5-dimethoxybibenzyl (**230**) from *C. molle*; 4′-hydroxy-3,4,5-trimethoxybibenzyl (**231**) and 4,4′-dihydroxy-3,5-dimethoxybibenzyl (**232**) from *C. Psidioides* and, 3-hydroxy-2,3'methoxybibenzyl (**233**), 2'-hydroxy-3,4,5-trimethoxybibenzyl (**234**), 2,3'-dihydroxy-4',5'-dimethoxybibenzyl (**235**), 2,4'-dihydroxy-3,5-dimethoxybibenzyl (**236**) and 3'-hydroxy-3,4,5-trimethoxybibenzyl (**237**) from the leaves and stem barks of *C. apiculatum* [56, 58, 60-64].

Others Compounds

Gallic acid (**238**), methyl gallate (**239**) and 1-*O*-galloyl-6-*O*-(4-hydroxy-3,5-dimethoxy)benzoyl-*β*-D-glucose (**240**), was yielded from *C. quadrangulare* [29, 65]. Ellagic acid derivatives were also identified from *Combretum* species. These include, ellagic acid (**241**), 4-(*α*-rhamnopyranosyl)ellagic acid (**242**) and 4-(4''-*O*-acetyl-*α*-rhamnopyranosyl)ellagic acid (**243**) from the branches of Chinese *C. yannanense*; 3,3',4'-tri-*O*-methylflavellagic acid (**244**), 3,3'-di-*O*-methylellagic acid (**245**) and 3,4,3'-tri-*O*-methylflavellagic acid-4'-*β*-D-glucoside (**246**) from the leaves of *C. kraussii* and 2,3-(S)-hexahydroxydiphenoyl-D-glucose (**247**) punicalin (**248**), punicalagin (**249**) and combreglutinin (**250**) from the leaves and stem barks of *C. glutinosum* [65-68].

Four steroids were found from *Combretum* species. These steroids are, *β*-sitosterol (**251**) and *β*-sitosterol glucoside (**252**) from *C. quadrangulare* [26, 29]; 24-ethylcholesta-7,22,25-triene-3-*O*-*β*-D-glucopyranoside (**253**) from *C. padoides* [38] and D-glucopyranoside-3*β*-stigmast-5-en-3-yl (**254**) from *C. leprosum* [40].

In addition, 5-methoxy-(-)-isolariciresinol (**255**) and 5-methoxy-9*β*-xylopyranosyl-(-)-isolariciresinol (**256**) were isolated and identified from *C. quadrangulare* [29]; 1*α*,2*β*-di-(2,6-dimethoxy-4-hydroxybenzoyl)-(3*α*,4*β*)-diphenylcyclobutane (**257**) and 1α-(2-methoxy-4,6-dihydroxy-benzoyl)-2*β*-(2,6-dimethoxy-4-hydroxybenzoyl)-(3*α*,4*β*)-diphenylcyclobutane from (**258**) *C. albopunctatum* [69]; 1,2-di-*O*-*α*-linolenoyl-3-*O*-*β*-*D*-galactopyranosyl-*sn*-glycerol (**259**) and 1,2-di-*O*-*α*-linolenoyl-3-*O*-[*α*-*D*-galactopyranosyl-(1 6)-*O*-*β*-*D*-galactopyranosyl]-*sn*-glycerol (**260**) from *C. bracteatum* [32] and lastly scopoletin (**261**) from *C. yannanense* [54].

CONCLUSION

In different parts of Asia and Africa, *Combretum* species are widely used in folk medicine for the treatment of hepatitis, malaria, respiratory infections, and cancer. Phytochemical investigations on 31 species of this genus led to the isolation of 261 components including 135 triterpenoids, 51 flavonoids, 14 diarylpropanes, 23 phenanthenes and derivatives, 14 stilbenoids and derivatives etc. On the basis of the above investigation, it is evident that *C. quadrangulare* is the most investigated specie and triterpenoids being the major constituents of the genus. Future studies should be directed on phytochemical investigation of those species with limited scientific literature.

CONFLICT OF INTEREST

The author(s) confirm that this article content has no conflicts of interest.

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