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REVIEW ARTICLE

Review on phytochemical constituents of the genus *Trichilia* and biological activities

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ABSTRACT

Studies conducted on the chemical composition of the genus *Trichilia* have isolated and identified 334 different compounds such as monoterpenes, diterpenes, sesquiterpenes, triterpenes, limonoids, steroids, coumarins, lignans, flavonoids, amino acid, phenolic acids, and lactones. This genus is used in traditional medicine for the manufacture of antibacterial, antioxidant, antiviral and antimalarial drugs. Indeed, our research with numerous *Trichilia* species has revealed that these plants exhibit antioxidant, antibacterial, anticholinesterase, neuroprotective, anti-inflammatory, and anti-anaphylactic properties against pathogens of major clinical value. The properties of analgesia, liver protection, and immunomodulation are also being studied. This study summarizes the main therapeutic uses of Genus *Trichilia* of species mentioned in the article and encourages future research into their usage in the treatment of various ailments as antimicrobial and anticancer.

Keywords: *Trichilia*; secondary metabolites; biological activities; antimicrobial; anticancer

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1. Introduction

The variety *Trichilia* is in the family Meliaceae in the significant gathering Angiosperms. The Plant List of variety *Trichilia* incorporates 425 logical plant names of species rank for the Genus *Trichilia*, of these 71 are acknowledged species names[1]. *Trichilia* (85 species), which happen regularly as understory trees in swamp backwoods from Mexico toward the West Indies, tropical South America, and tropical Africa[2].

The Plant List incorporates a further fifty-five scientific plant names of infraspecific rank for the Genus *Trichilia*. We don't expect the plant list to be finished for names of infraspecific rank. These are principally included on the grounds that names of species rank are equivalent words of acknowledged infraspecific names[2]. Chemically, plants of the family Meliaceae are characterized by the presence of tetranortriterpenoids called as limonoids/meliacins[3]. Of all botanicals, this family is one of the most important to humans. Mainly because of the ease with which some seeds can be grown on its high-quality wood and plantations[4]. Furthermore, because to its veritably complex chemical structures and natural exertion, the Meliaceae family piques the curiosity of researchers interested in bioproducts. The genus *Trichilia* have been established in 1756, and it now has 70 species found in Africa, the Indo-Malay area and the tropical America. In these areas, roughly 53 species are found in Brazil. Because of the biological activity of secondary metabolites contained in these plants, this species is of importance to Brazilian flora[5]. It is high in terpenoids; limonoids, triterpenes and steroidsand polyphenols; flavonoids and tannins, according to phytochemical research[6,7].

Due to the enormous biotechnological potential of *Trichilia*, the scarcity of research on its use in healthcare and the importance of discovering natural substances with potent therapeutic activity, this review is important to give a clear knowledge in research to find treatment is necessary.

2. Method and materials

We gathered all of the data of 17 years from four sources namely Google Scholar, Scopus, PubMed, and Research Gate by searching for certain keywords and selecting the ones that were relevant to our paper between 2004 and 2021. Following that, after shifting other portions, we summarized the abstract. We organized all of the data into *Trichilia* species. Individual species were looked up based on their medicinal properties and phytochemical research. In addition, we have included references such as the author's name, article titles, year of publication, organization, type of publication, and doi number. The chemical structure was designed using chemdraw software following the reference articles.

3. Biosynthesis and biogenesis process in genus *Trichilia*

Alternative processes in plants produce a wide spectrum of secondary mrtabolites, including alkaloids, phenols, terpenes etc. 2-C-methylerythritol 4-phosphate (MEP) pathways and mevalonic-acid (MVA) pathway are two primary routes for the production of terpenes which occur in plastid and cytosol (**Figure 1**).

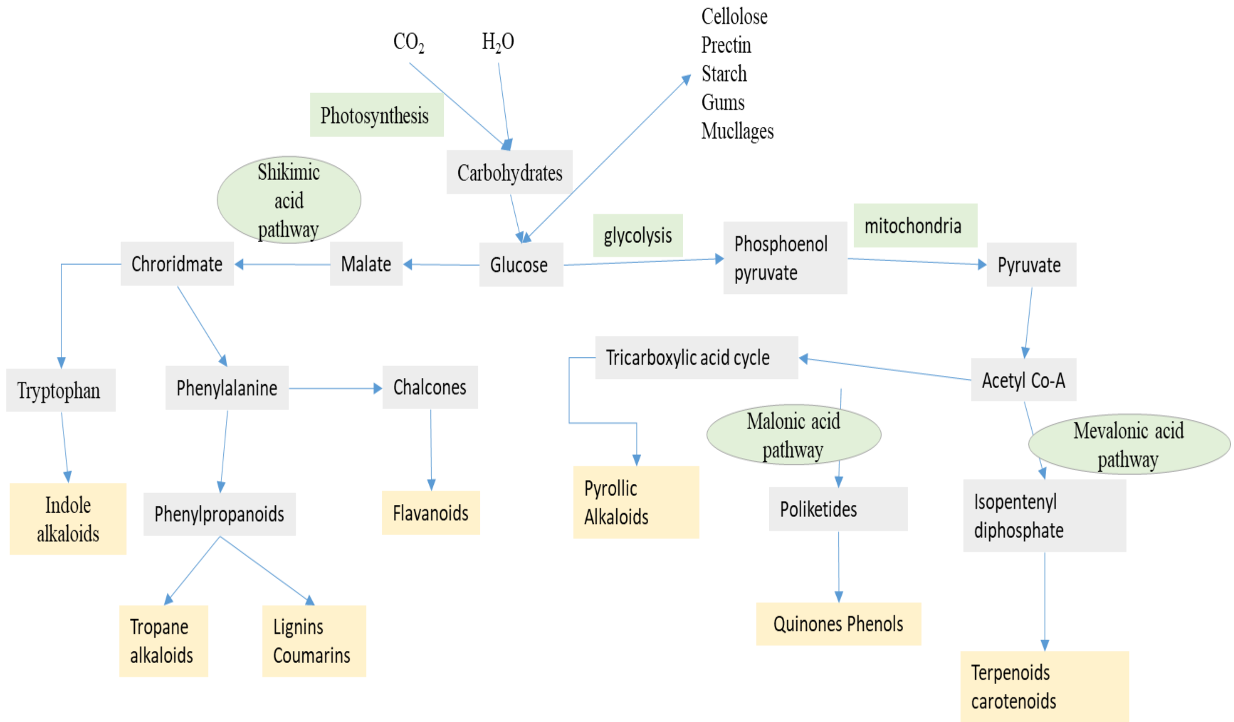


Figure 1. Biosynthesis process of Secondary metabolites in plant[8].

Dimethylallyl pyrophosphate (DMAPP) and Isopentenyl pyrophosphate (IPP) are produced from glyceraldehyde-3-phosphate and pyruvat, and function as common precursors for all terpenoids[9].

Plants use the shikimic acid route and the malonic acid pathway to make phenolic chemicals[10]. For the production of phenolics, fungi and bacteria have been found to use the malonic acid route[11].

As an example of biogenesis process in T. adolfi, the limonoids are derived from triterpenes. An azadirone-type metabolite (intermediate 6) might be thought of as the precursor. A cyclization to generate a tetrahydrofuran ring might be achieved by the C-7/C-8 bond oxidation to a lactone through the hydrolysis. A 180° bond rotation occurs around in C-9/C-10. The ε-lactone ring, and hence the five-ring system, might be produced via further oxidation of the C-3/C-4 bond. Then this five-ring system help to formulate the the 5 trichilones A-E (**Figure 2**)[12].

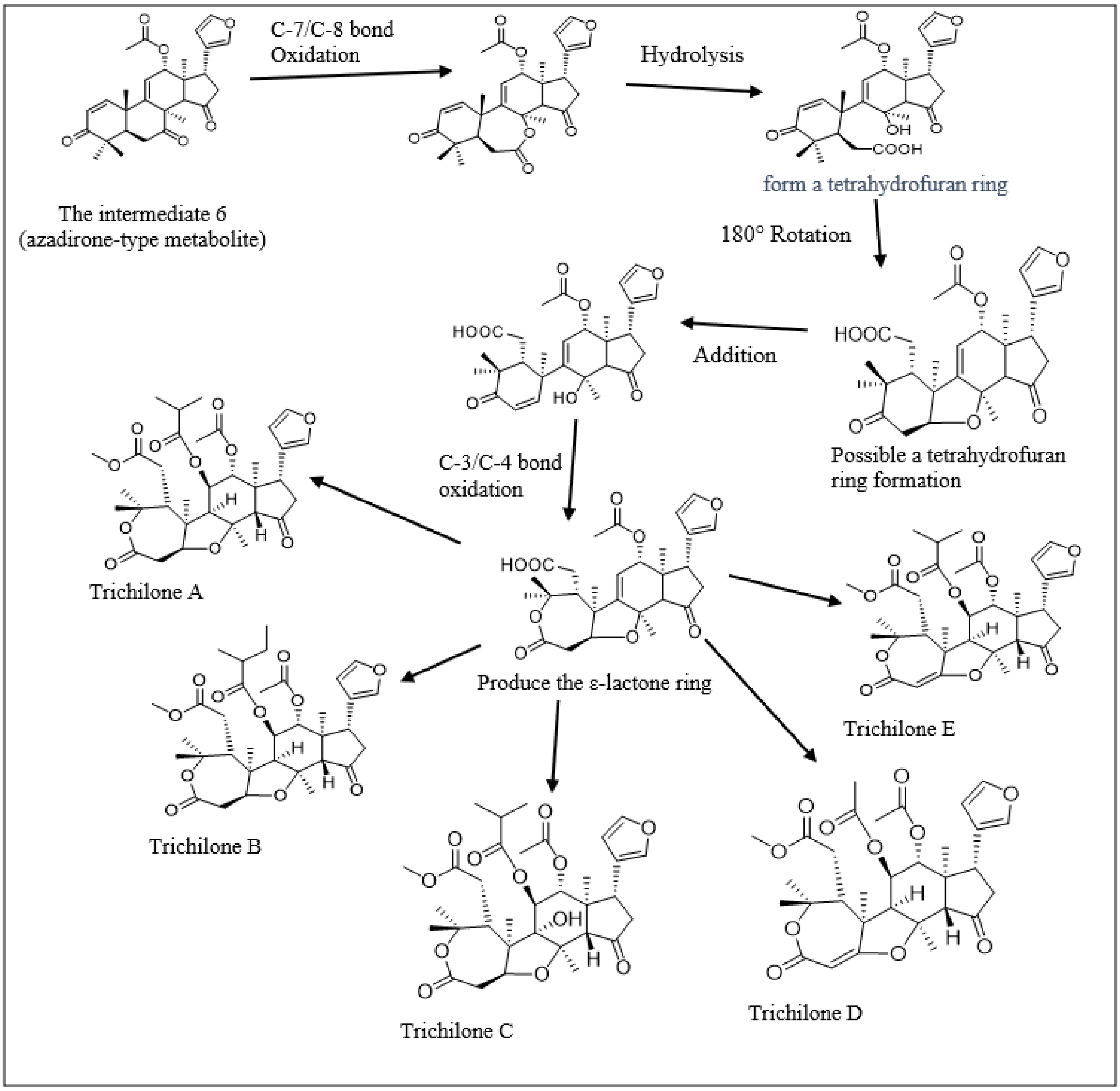


Figure 2. Biogenetic Pathways for the Limonoids formation Trichilones A–E from *T. adolfi*[12].

4. Biological activities of genus *Trichilia*

a. *Trichilia catigua:*

   i Antidepressant effect: It shows antidepressant effect from hydroalcoholic bark extract[13]. In vitro, acute treatment of the *Trichilia* catigua ethyl-acetate fraction (EAF) has an antidepressant-like effect on the chemical molecule phenylpropanoid[14].

   ii Antinociceptive effect: It also have Antinociceptive from Hydroalcoholic bark extract. The responsible compounds are flavonoid, cinchonine IIb[15].

iii Antioxidant activity: In vitro antioxidant activity of crude extracts from *T. Catigua* stem bark in various chemical and biological models can be attributed in part to flavonoids and phenolic, quercetin, rutin chemicals contained in the plant extracts.

iv Neuroprotection: In VITRO, *T. catigua* bark ethyl acetate fraction promoted functional recovery, reduced delayed hippocampus cell loss, and buffered continuing neurodegenerative processes[16].

v Antiviral: The bark part of *Trichilia catigua* aqueous acetone extract, aqueous and ethyl acetate fraction shows antiviral effect[17].

vi Antidiabetic: Procyanidin B2, catechin, chlorogenic acid, cinchonine IIb IIa Ia, epicatechin are the chemical components responsible for the antidiabetic activity of the ethyl acetate fraction of *Trichilia catigua* of bark part[18].

vii Antioxidant, anticholinesterase, anti-fatigue: *Trichilia* catigua extract contains antioxidant and anticholinesterase effects, as well as a minor protective effect against forced exercise and mice exhaustion (EC50 43 ug/mL). All of these research show that this plant possesses antioxidant properties and can be employed in herbal medications for this reason, as well as being promising in the fight against neurodegenerative illnesses. *Trichilia catigua* contains flavonoids (quercetin, procyanidin, epicatechin, and cinchonine), which have antioxidant and anti-inflammatory properties[19].

viii Antimicrobial (fungi and bacteria), Antioxidant, anti-inflammatory, anti-amnesic: The antiviral activity of *Trichilia catigua* crude extract, aqueous, and ethyl acetate fractions in the propagation of Herpes simplex virus (HSV-1), bovine herpesvirus (bohv-1), and poliovirus (PV-1). For all viruses, the crude extract and fractions demonstrated moderate toxicity and strong antiviral activity, with inhibitory concentrations for herpesvirus[20]. The antibacterial activity of a crude extract from the bark of Trichlia catigua A. Juss and its fractions of ethyl and aqueous acetate is investigated. Both the extract and the fraction of Bacillus subtilis given by this plant yielded outstanding results. *Trichilia* catigua extracts and fractions are also excellent candidates for future research into antiviral, antibacterial, and antifungal medicines. The antibacterial properties of the tannins found in this plant are well recognized[21].

b. *Trichilia emetica*

i Antibacterial and hepatoprotective action: Hepatoprotective effects were found in both the aqueous extract and the ethyl ether fractions of the *Trichilia emetica* Vahl root. The fraction was more effective against Streptococcus pneumoniae and Moraxella catarrhalis, Staphylococcus aureus and Streptococcus pyogenes, and Haemophilus influenzae than other fractions. Polyphenols and tannins may be responsible for the plant's antibacterial activity, and it was not hazardous until large quantities were used in experiments[22]. *Trichilia emetica* Vahl, a fraction of ethyl acetate, has antibacterial activity against Gram-negative and Gram-positive bacteria strains[23].

ii Antimicrobial activity: The methanolic extract of this plant's fruit inhibited the development of five fungus, including *Candida albicans*, *Cryptococcus neoformans*, *Aspergillus flavus*, *Tricophyton mentagrophytes*, and *Tricophyton violacium*, but not bacteria[24].

c. *Trichilia hirta*

Immuno-stimulator, cytotoxic cancer cells, antitumor, Anticancer: *Trichilia hirta* L. Root aqueous extracts shown immunorestorative and cytotoxic action. In comparison to the non-neoplastic strain, the aqueous extract shown specific cytotoxicity against T-47D and SK-mel-3 tumor cells (VERO). *Trichilia hirta* L. has a substantial in vivo immunorestorative impact as well as selective cytotoxicity, suggesting that it might be a viable cancer therapeutic option[25].

Trichlia hirta L. has leukocyte-stimulating properties, which makes it an attractive candidate for immunoprotective drug development[26].

Trichilia hirta L. polysaccharide-rich fraction inhibited lung cancer cells and human cervical carcinoma cells from proliferating, and control fibroblasts cell[27]. When comparing breast cancer and melanoma cells to non-tumor cells, leaf extract exhibited selective cytotoxicity (VERO). These extracts were found to include saponins, tannins, flavonoids, polysaccharides, and coumarins. Flavonoids have an immunomodulatory effect[28].

d. *Trichilia rubescens*

Antimalarial activity

The limonoids, trichirubins A and B in the ethyl acetate extract of *Trichilia rubescens* have been shown to exhibit substantial antimalarial action. As a result, it was identified as a putative source of antimalarial activity[29].

e. *Trichilia prieureana*

Antimicrobial activity

Trichilia prieureana have Only one research evaluating the bark's common usage as an antibacterial was discovered[30].

f. *Trichilia dregeana*

Antimicrobial activity

Ethyl acetate leaf extract of *Trichilia dregeana* selectively inhibited COX-2, confirming its anti-inflammatory effect. Ethyl acetate bark extract was observed to inhibit the acetylcholinesterase pathway, suggesting anticholinesterase activity. None of the extracts showed mutagenic activity, and the alcohol extract of the leaf against E. coli was distinguished by its antibacterial activity[31].

As for antibacterial activity, it was observed that aqueous and acetone extracts show in vitro activity against the pathogen Ureaplasma urearichkuma. In addition, the combination of the aqueous extract of *Trichilia dregeana* and the aqueous extract of *Albizia adianthifolia* showed excellent activity against Oligella ureolytica and high cell viability against renal epithelial cells[32].

g. *Trichilia heudelotii*

Antifungal, cytotoxic activity

Trichilia heudelotii Planc (Harm) (bark, leaf and stem part) aqueous, acetone and ethanol extracts have been evaluated for antifungal and cytotoxic activity and contain steroids, chalcones, alkaloids, tannins, phenols, anthraquinones, glycosides, flavonoids[33].

Despite the promising activity of this plant against some human pathogens, high toxicity of the extract has been observed and future studies can be conducted to better study these effects. It is worth noting that no tests have been performed to show the selectivity index[34].

h. *Trichilia silvatica*

Antioxidants, anti-inflammatory, anti-proliferative

Trichilia silvatica has loads to offer, that is cautioned through the presence of phenolic compounds, flavonoids and tannins observed in its extracts[34]. *Trichilia silvatica* possesses the anti-inflammatory, antioxidant and anti-proliferative activities of the methanolic extracts of leaves and bark[35].

i. *Trichilia lepidota*

Cytotoxic

Fractions of hexane and methanol extracts of leaves, and limonoids of fruits have been established for their cytotoxic effects on the leukemic cell lines MOLT4 and U937. Hexane extract showed the most important cytotoxic activity against both strains[6].

j. *Trichilia monadelpha*

Anti-anaphylactics

Ethanol extracts and petroleum ethers from the stem bark of *Trichilia monadelpha* exhibit anti-anaphylactic and anti-inflammatory activities, and have been traditionally used in the treatment of allergies and other inflammatory diseases.

Alkaloids may be responsible for the anti-anaphylactic effects of etheric extracts and flavonoids in ethanolic extracts have been found to have proven anti-allergic effects[36].

k. *Trichilia connaroides*

Anti-hyperlipidemic

The medicinal properties consisting of the anti-hyperlipidemic effects of chloroform and methanol extracts extracted from the leaves of *Trichilia connaroides* were discovered[37].

Eleven species identify in the literature and possess many biological activities namely: antimicrobial, anti-inflammatory, antiproliferative, antitumor, cytotoxic, antianaphylactic and antihyperlipidemic.

4. Chemical constituents

Species of the genus *Trichilia* with a high relative frequency indicate the presence of secondary metabolites of the terpenoid metabolic pathway and also MVA and Malonic acid pathway. Among the metabolites present in *Trichilia*, highly oxygenated limonoids and triterpenes were observed with a remarkable frequency. They deserve special attention as they are considered major markers of chemosystematics in the family Meliaceae[34,35]. This compound is also called meliacin because of its bitter taste. By August 2013, phytochemical studies of the genus *Trichilia* had allowed the isolation and identification of 334 compounds belonging to (10) classes below:

a. Monoterpenes
b. Sesquiterpenes
c. Diterpenes
d. Triterpenes
e. Steroids
f. Limonoids
g. Flavonoids
h. Coumarins
i. Glycosylated lignans
j. Other compounds

4.1. Monoterpenes from *Trichilia*

Phytochemical screening revealed the presence of β-cyclocitral from the *T. Connaroides* leaf extract, and eucalyptol, cuminol, and cis-ocymene from the wood extract. Azulene, 2-methyl-2-bornene is found in parts of the leaves, roots, stem and wood[38]. Naphthalene substances contained in the crude extract of barks of *T. Pallida*[39] (**Table 1** and **Figure 3**).

Table 1. Monoterpenes from*Trichilia*.

Compounds	**Species**	**Reference**
β-cyclocitral cis-ocimene cuminol eucalyptol 2-methyl-2-bornene azulene	*T. connaroides*	[40]
Naphthalene	*T. pallida*	[41]

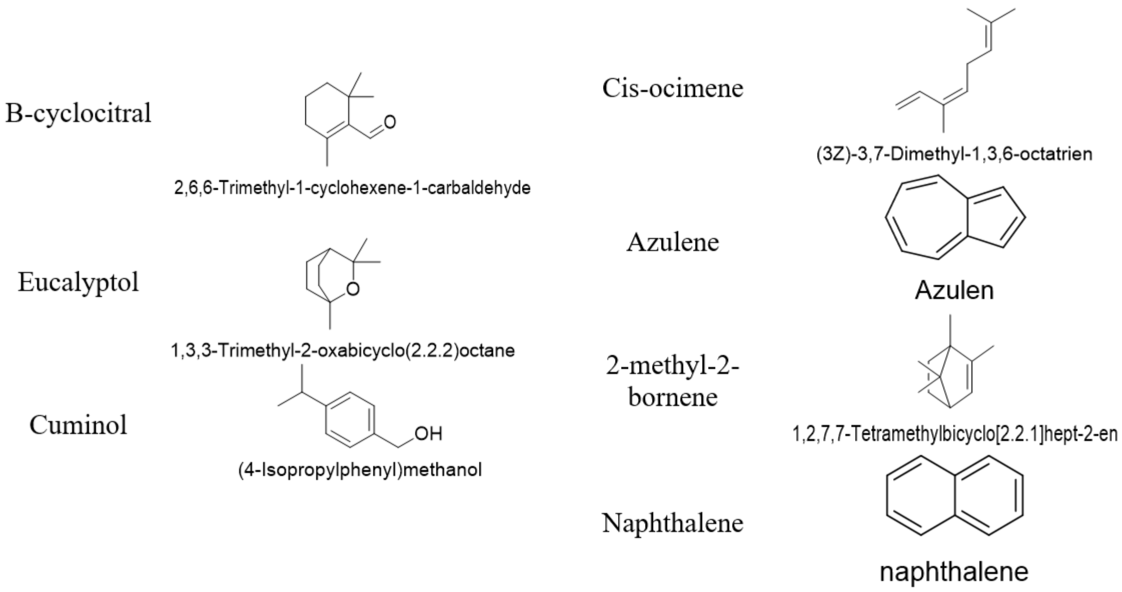


Figure 3. Structures of the monoterpenes from *Trichilia*.

4.2. Sesquiterpenes from *Trichilia*

The *Trichilia* genus revealed fifty-seven sesquiterpenes with varied skeletons, the majority of which were cyclic sesquiterpenes[42].

Sesquiterpenoides are abundant in *Trichilea connaroides* bark volatiles. Azulene, cubebene, ylengene, and copaene is the primary components found in the total volatiles. Azulene, caryophyllene, copaene, and -bourbonene is the primary volatile chemicals found in leaf extract. Azulene, 2-methyl-2-bornene, -bergamotene, -cedrene, and -chamigrene were the primary volatiles found in root extract. The primary components detect in the total volatiles of pericrap extract were caryophyllene, cis-calamenene, copaene, cadiene-1, -diene, and -caryophyllene in *Trichilea connaroides*[43].

Two new modified furanoeremophilane-type sesquiterpenes derived from *Trichilia cuneata*, 13-hydroxy-14-nordehydrocacalohastine and 13-acetoxy-14-nordehydrocacalohastine, demonstrated inhibitory actions for membrane lipid peroxidation in mitochondria and microsomes[44]. *Trichilia emetica* Vahl yielded Kurubasch aldehyde, a sesquiterpenoid with a hydroxylated humulene structure, as a free alcohol[44].

There are two types of Sesquiterpenoides in *T. catigua* (Stem). They are 7,4-dihydroxycalamenene and 7-hydroxy-1-oxo-14-norcalamenene[40].

T. claussenii leaves extract contains the epoxide cariofilene Sesquiterpenoides[40].

The leaves extract of *T. cipo* yielded β-elemene, β-selinene, epoxide cariofilene, epoxide humulene Sesquiterpenoides were obtained from *T. cipo* leaves and wood extract also contains the epoxide cariofilene, β-elemene, β-eudesmol[41].

β-eudesmol, cryptomeridiol, germacra-3,10(14)-dien-9,11-diol-4-carbaldehyde, 14-hydroxyelemol and germacra-10(14)-en-9,11,15-triol are found in *T. claussenii* (wood extract)[45].

(2S,3S,6R,7R)-humulene-2,3,6,7-diepoxide, (2R,3R,6R,7R)-humulene-2,3,6,7-diepoxide and mustacone are found in the extract of leaves of *T. silvatica*[46]. Spathulenol, a sesquiterpene, is discovered in the fruits of *Trichilia hirta*[47].

Three novel sesquiterpenoids were discovered in a methanol extract of *Trichilia claussenii* stems: 14-hydroxyelemol, germacra-10(14)-en-9,11,15-triol, and germacra-3,10(14)-dien-9,11-diol-4-carbaldehyde. Beta-eudesmol, cryptomeridiol, and the triterpenoid 22,25-dihydroxy-9beta,19-cyclolanost-23-en-3-one, all recognized sesquiterpenoids, were also isolated. A dichloromethane extract of *T. lepidota* leaves yielded a mixture of hydrocarbons ($C_{29}H_{60}$, $C_{31}H_{64}$, and $C_{33}H_{68}$), a mixture of sesquiterpene epoxides caryophyllene and humulene, spathulenol[48].

Quadrijugol and kudtdiol, two type major sesquiterpenoids is found in *T. quadrijuga* (wood)[49]. Spathulenol is also found in the leaves extract of *T. quadrijuga*[49] (**Figure 4**).

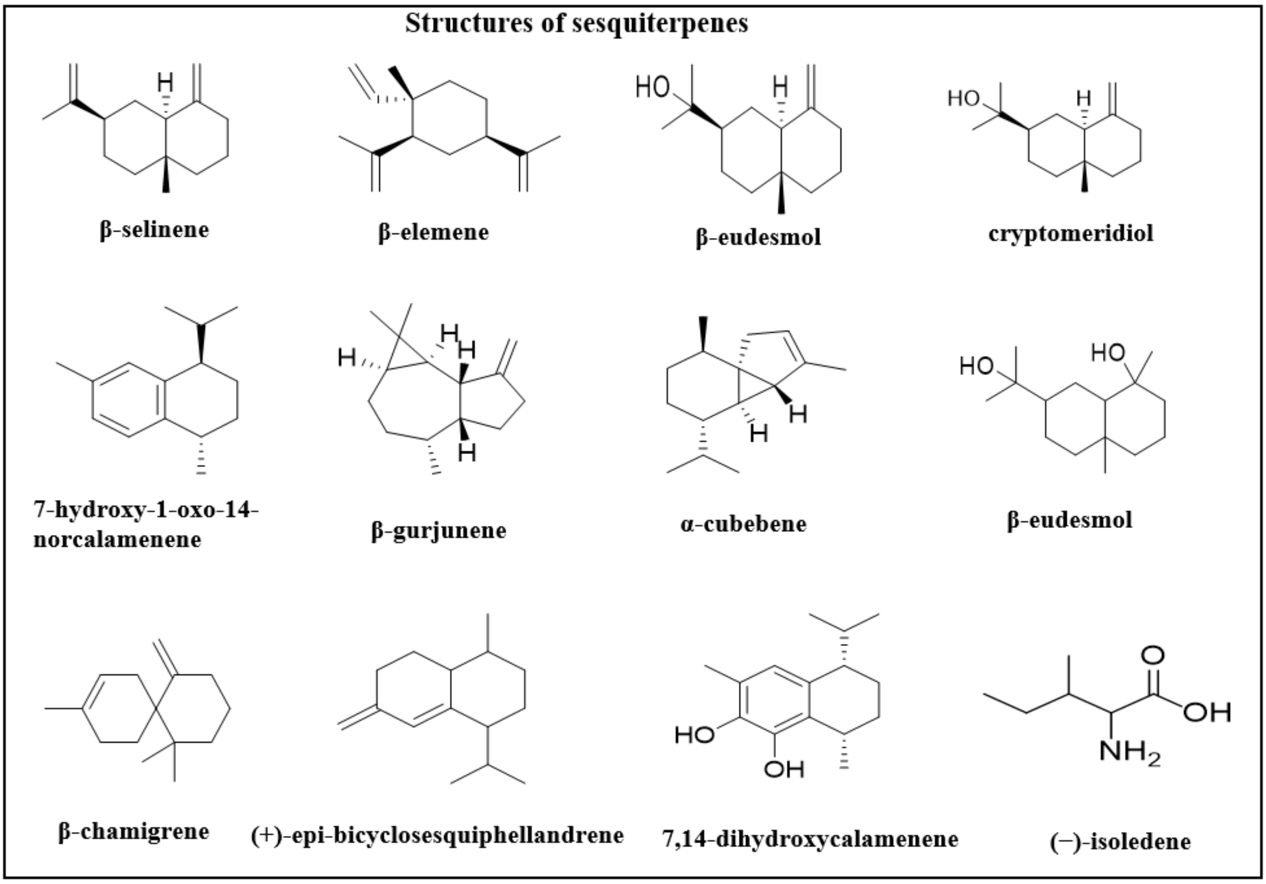
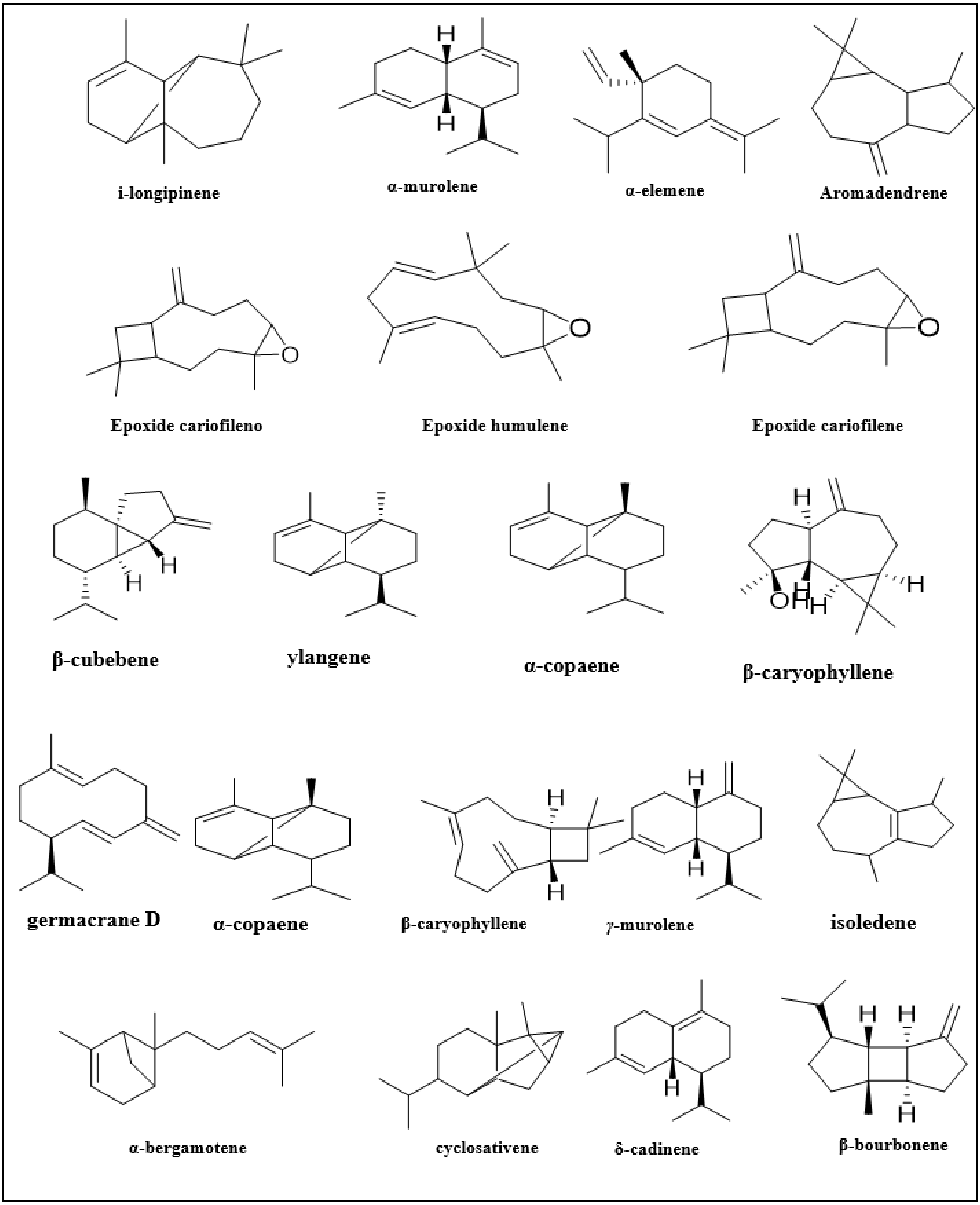


Figure 4. (*Continued*).



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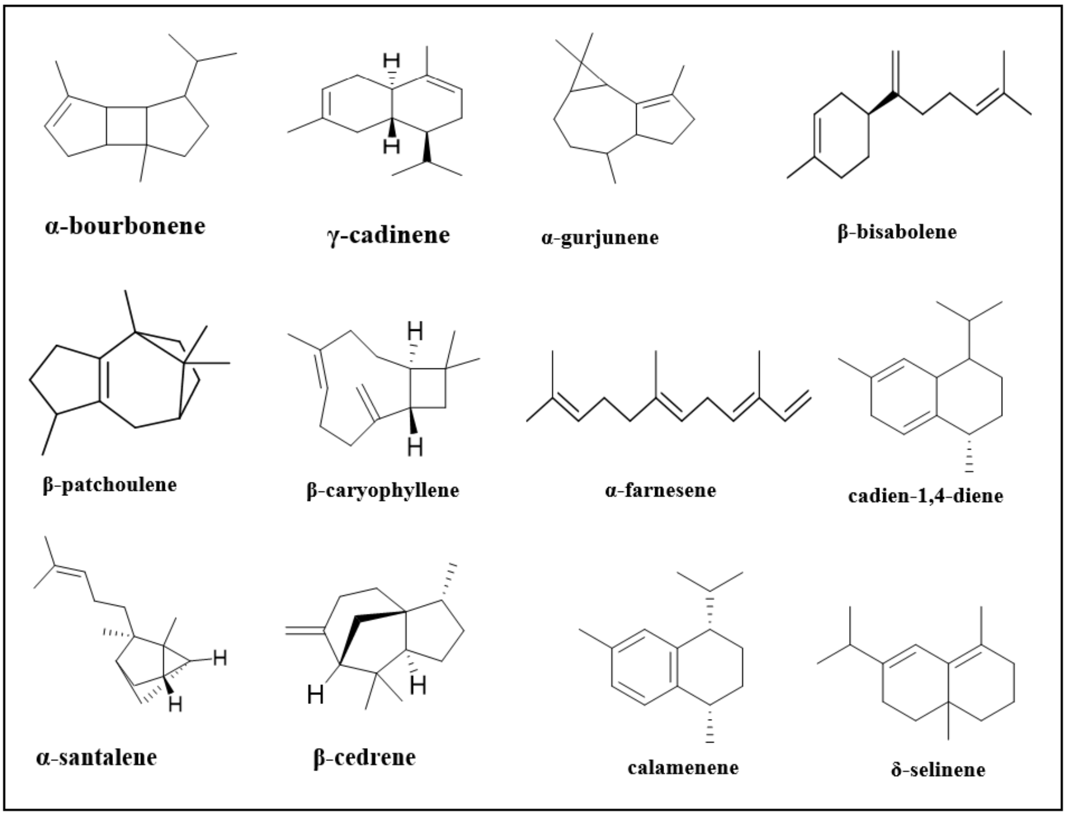


Figure 4. Structures of sesquiterpenes from *Trichilia.*

4.3. Diterpenes from *Trichilia*

Only Saven diterpenes have been found in the genus *Trichilia*. *T. heudellotti* leaves extract contains 12β-hydroxysandaracopimar-15-ene, nimbiol, 7-ketoferruginol, isopimarinol. (1R, 3E, 7Z, 11S, 12S)-dolabella-3,7,18-trien-17-oic acid, (1R, 3E, 6R, 7Z, 11S, 12S)-dolabella-3,7,18-trien-6,17-olide, (1R, 3S, 4R, 7Z, 11S, 12S)-3-hydroxydolabella-7,18-dien-4,17-olide diterpenes is obtained *T. trifolia*[50,51] (**Figure 5**).

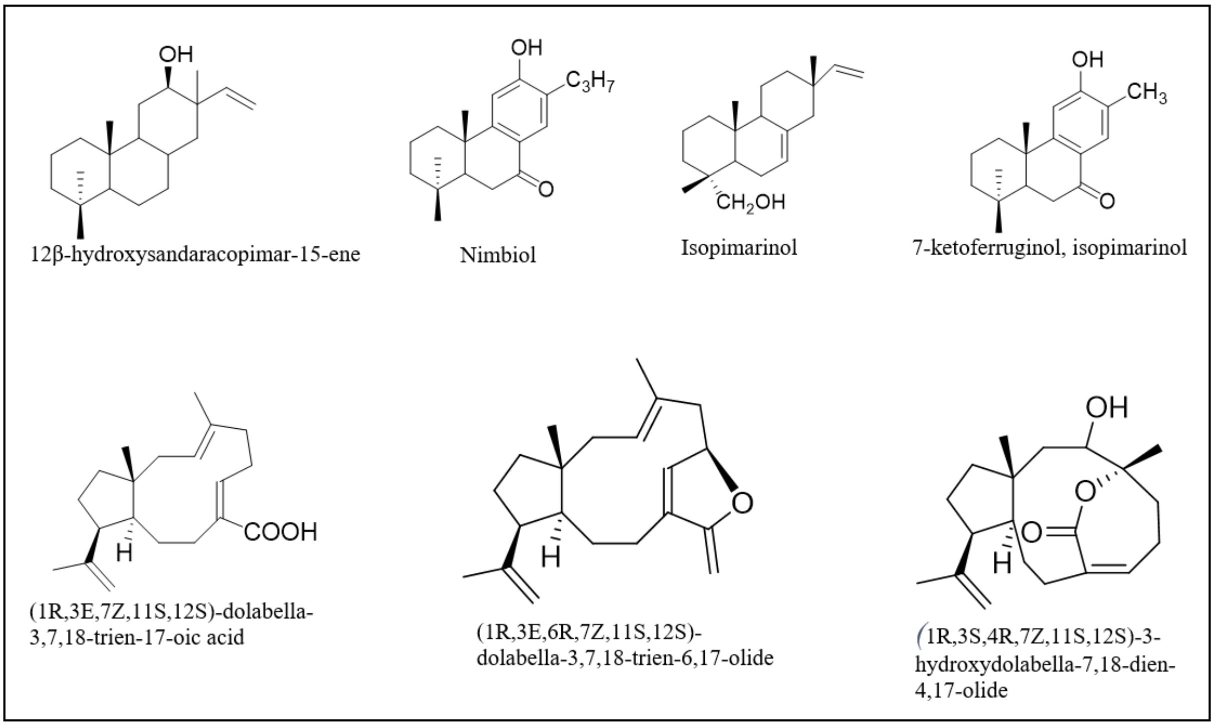


Figure 5. Structures of diterpenes from *Trichilia.*

4.4. Triterpenes from *Trichilia*

Trichilia has 32 tetracyclic triterpenes (**Figure 6**), the majority of which are found in the leaves. *Trichilia* contains fourteen cycloartane-type triterpenes (**Figure 7**), the majority of which are extracted from the leaves. Only four A-seco-ring triterpenes (**Figure 8**) have been discovered, all from the *T. elegans* and *T. emetica* species. Only seven pentacyclic triterpenes (**Figure 9**) have been identified from *Trichilia* genus leaves and wood[51] (**Table 2)**.

Table 2. Triterpenes from *Trichilia*.

Species	Tetracyclic triterpenes	Pentacyclic triterpenes	Cycloartane-type triterpenes	Triterpenes with A-seco-ring
T. connaroides	• Melianone • Melianol • Lipomelianol • Melianodiol • Dihydroniloticin • Lipo-3-episapelin A			
T. casaretti		Lupeol	1) 24-methylen-cicloartan-12-oxo-3β,22α-diol 2) 24-methylen-cicloartan-3β,22-diol 3) trichiliol 4) 24,25-dihydroxycicloartan-22-enol 5) 22(R)-hydroxycicloartan-24-en-3-ol	
T. hirta	• Melianone • Melianol • bourjotinolone A • nilocitin • dihydronilocitin B • melianone • piscidinol • melianone lactone		• hirtinone	
T. pallida		• friedelan-28-ol • lupeol • α-amirine • β-amirine	1) 24-methylen-cycloartan-3β-ol 2) 24-methylen-cycloartan-3β-26-diol 3) cycloartan-23-en-3β,25-diol	
T. estipulata	• vellozonol • vellozone • carnaubadiol • carnauba-21-ol-3-one • fouqueriol • isofouquerione			
T. hispida	• hispidol A • hispidol B • sapelin A • sapelin B • sispidone • bourjotinolone A			
T. rubra		• friedelan-28-ol • friedelin		• 24-methylen-cycloartan-3β,22-diol

Table 2. (*Continued*).

Species	Tetracyclic triterpenes	Pentacyclic triterpenes	Cycloartane-type triterpenes	Triterpenes with A-seco-ring
T. claussenii			1) 24-methylen-26-hydroxycicloartan-3-one 2) 24-methylen-cicloartanol etherified 3) 3) 22,25-dihydroxy-9β,19-ciclolanostan-23-en-3-one	
T. lepidota	• lepidotrichilin A • lepidotrichilin B • 21,23-epoxy-7α, 21α-dihydroxyapotirucalla-14,24-dien-3-one • 21,23-epoxy-7α, 21β-dihydroxyapotirucalla-14,24-dien-3-one • dysorone D • desoxyflindissone			
T. prieuriana	• prieurone • 29-hydroxypreurione • Prieurianoside			
T. ramalhoi		• lupenone • lupeol		
T. elegans			1) methyl-1ξ, 7(R)-diacetoxy-23(R), 25(S)-dihydroxy-20(S)-21,25-epoxy-3,4-seco-apotirucall-4(28), 4(15)-dien-3-oate 2) methyl-1ξ, 7(R)-diacetoxy-3R,25-dihydroxy-20S, 24(R)-21,24-epoxy-3,4-seco-apotirucall-4(28), 14(15)-dien-3-oate 3) methyl-1ξ,7(R)-diacetoxy-23(R),24,25-trihydroxy-20(S)-21,24-epoxy-3,4-seco-apotirucall-4(28), 14(15)-dien-3-oate	
T. silvatica		• pseudotaraxasterol • α-amirine • β-amirine • lupeol		
T. quadrijuga	• dihydroniloticin • niloticin • bourjotinolone B • piscidinol A			
T. emetica (T. roka)			methyl-1(S), 23(R)-diacetoxy-7(R), 24,25-trihydroxy-20(S)-21,24-epoxy-3,4-seco-apotirucall-4(28), 14(15)-dien-3-oate	
T. reticulata	• dihydroxyniloticin • melianone • melianodiol • 9,19-ciclolanost-23-ene-3,25(3β,23E)		1) 9,19-cycloartan-24-en-3,23-dione 2) 3-(acetyloxy)-9,19-cycloartan-24-en-23-one 3) cycloartan-23-en-3β,25-diol (109)	
T. schomburgkii	• piscidinol A • niloticin • dihydroxyniloticin			

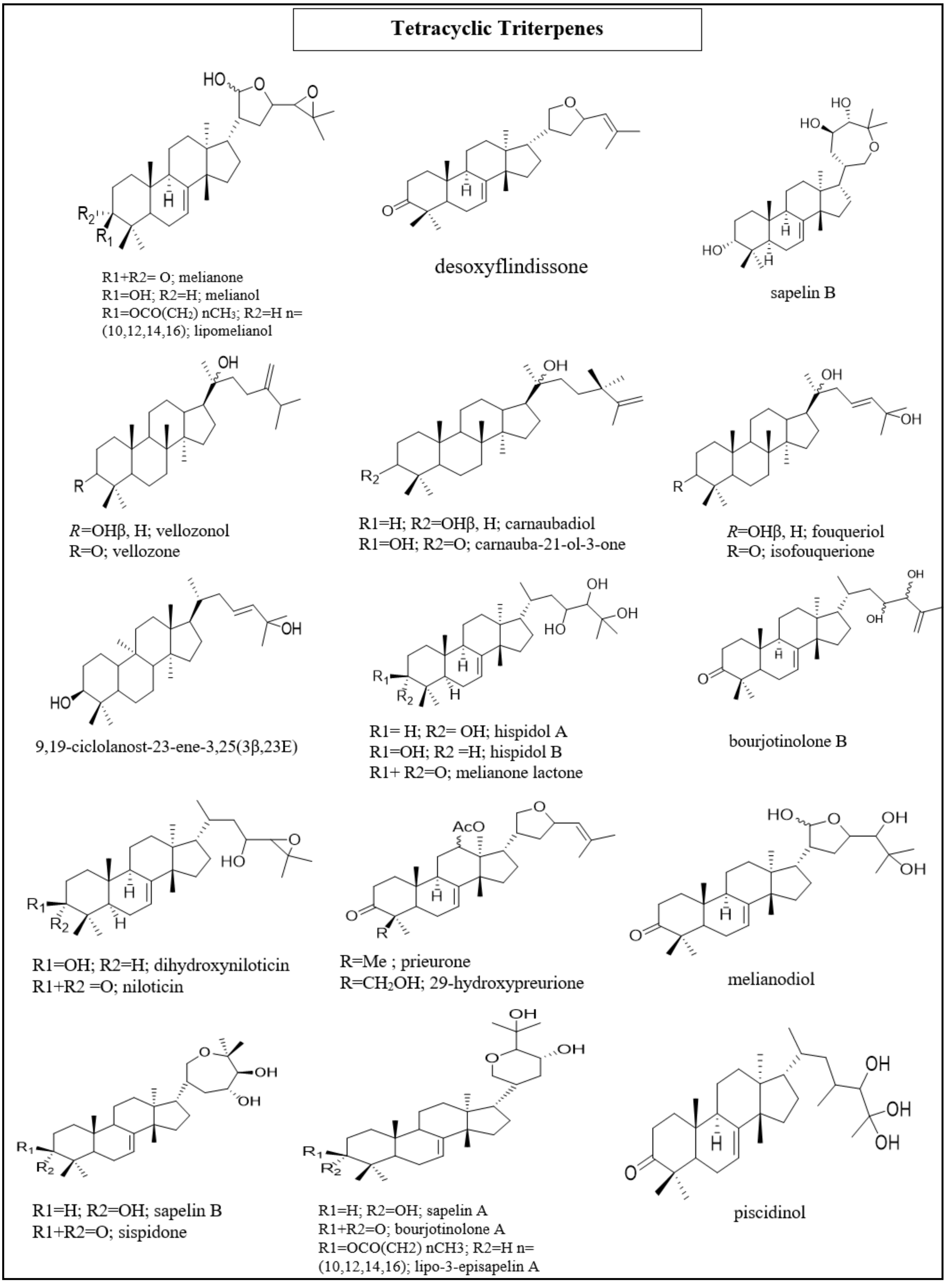


Figure 6. (*Continued*).

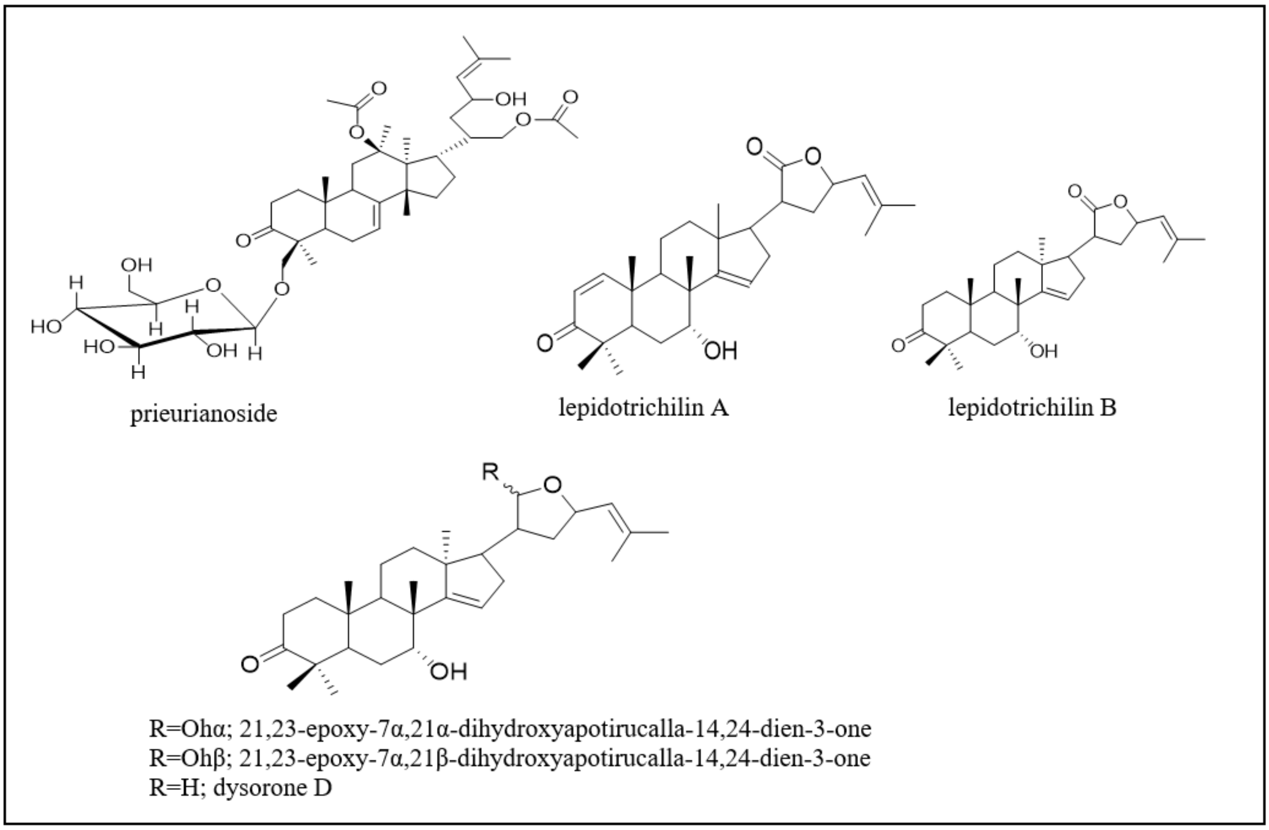


Figure 6. Structures of tetracyclic triterpenes from *Trichilia.*

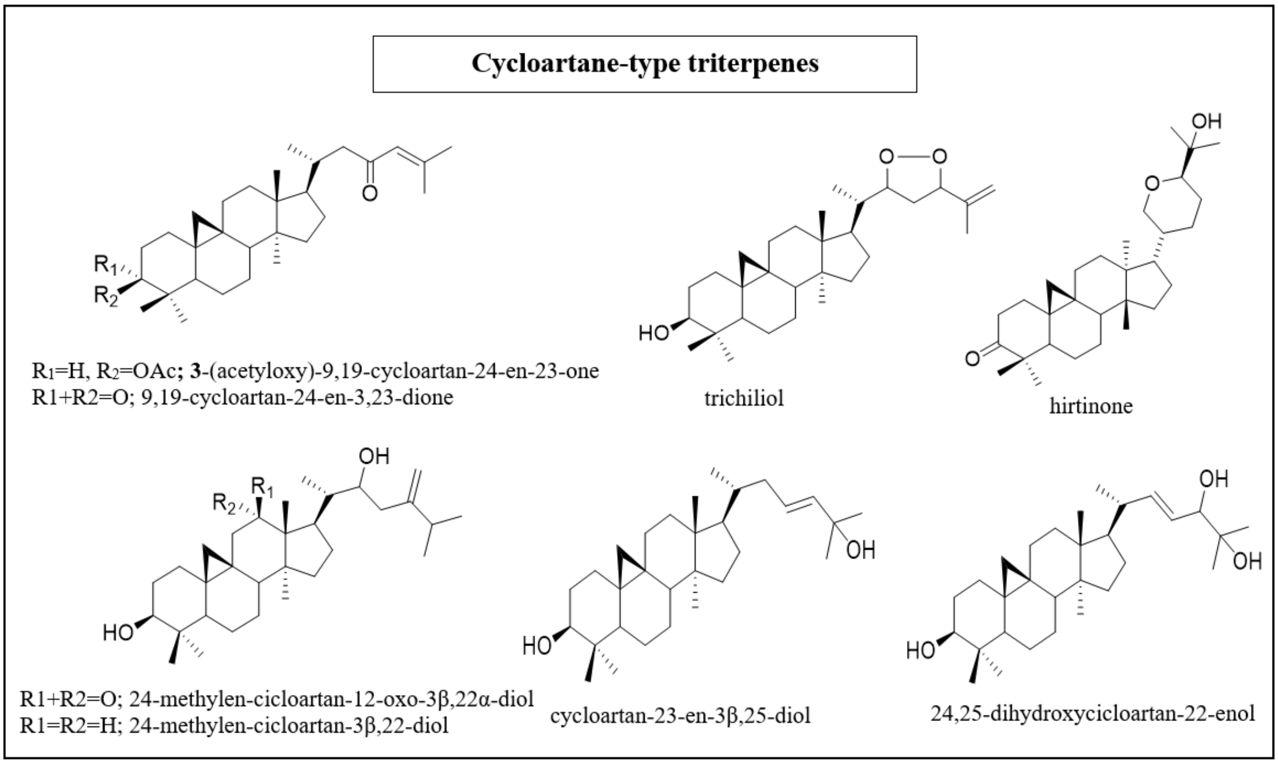
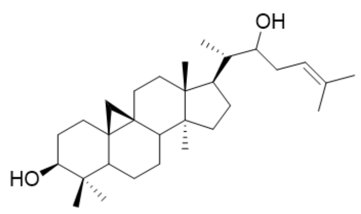
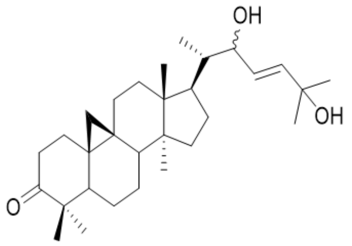


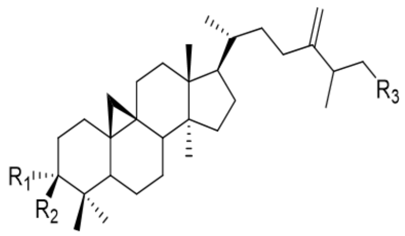
Figure 7. (*Continued*).



22(R)-hydroxycicloartan-24-en-3-ol



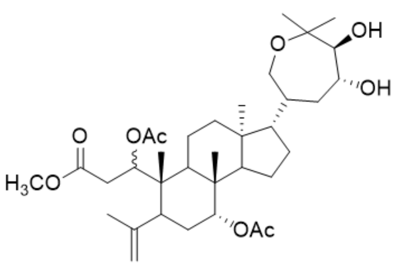
22,25-dihydroxy-9β,19-ciclolanostan-23-en-3-one



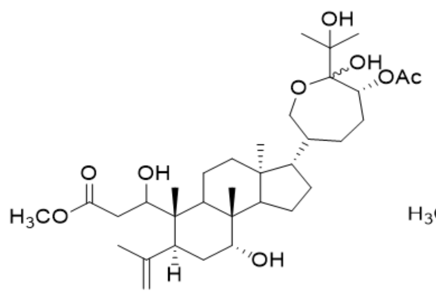
R1+R2=O; R3=OH; 24-methylen-26-hydroxycicloartan-3-one
R1=R3=H; R2=CH3(CH2) nCO n=12 a 24; 24-methylen-cicloartanol etherified
R1=R3=H; R2=OH; 24-methylen-cycloartan-3β-ol
R1=H; R2=R3=OH; 24-methylen-cycloartan-3β-26-diol

Figure 7. Structures of Cycloartane-type triterpenes from *Trichilia.*

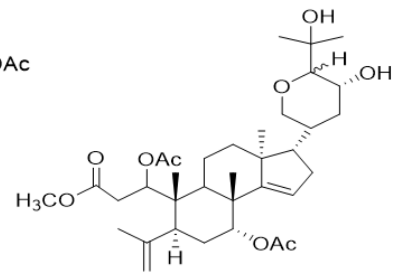
Triterpenes with A-seco-ring



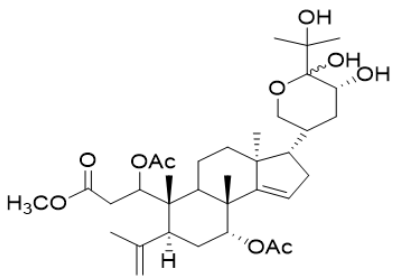
methyl-1ξ,7(R)-diacetoxy-23(R),25(S)-dihydroxy-20(S)-21,25-epoxy-3,4-seco-apotirucall-4(28),4(15)-dien-3-oate



methyl-1(S),23(R)-diacetoxy-7(R),24,25-trihydroxy-20(S)-21,24-epoxy-3,4-seco-apotirucall-4(28),14(15)-dien-3-oate



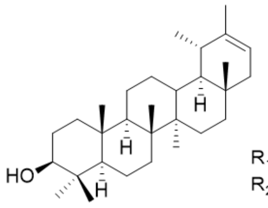
methyl-1ξ,7(R)-diacetoxy-3R,25-dihydroxy-20S,24(R)-21,24-epoxy-3,4-seco-apotirucall-4(28), 14(15)-dien-3-oate



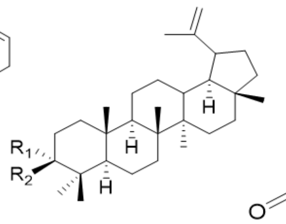
methyl-1ξ,7(R)-diacetoxy-23(R),24,25-trihydroxy-20(S)-21,24-epoxy-3,4-seco-apotirucall-4(28), 14(15)-dien-3-oate

Figure 8. Structures of Triterpenes with A-seco-ring from *Trichilia.*

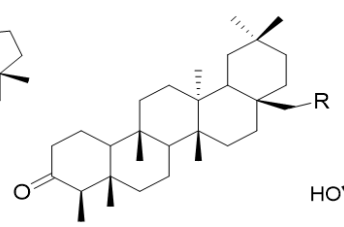
Pentacyclic triterpenes



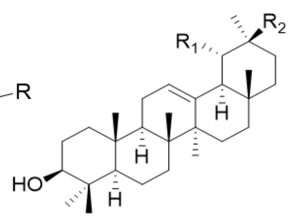
pseudotaraxasterol



R1+ R2=O; lupenone
R1=H; R2=OH; lupeol



R=H; friedelin
R=OH; friedelan-28-ol



R1=CH3; R2=H; α-amirine
R1=H; R2=CH3; β-amirine

Figure 9. Structures of Pentacyclic triterpenes from *Trichilia.*

4.5. Steroids from *Trichilia*

Thirty steroids were isolated from the leaves and stems of *T. claussenii* and *T. connaroides* species[52] (**Table 3** and **Figure 10**).

Table 3. List of Steroids from *Trichilia.*

1) 2-hydroxyandrost-1,4-dien-3,16-dione (trichiliasterone B)	17) α-spinasterol
2) β-sitosterol	18) sitostenone
3) stigmasterol	19) campesterol
4) 3-O-β-glycopyranoside sitosterol	20) 7-oxo-24α-sitosterol
5) 3-O-β-glycopyranoside stigmasterol	21) trichiliasterone
6) β-sitosterol etherified	22) trichiliasterone B
7) stigmasterol etherified	23) campesterol
8) 2α,3α-dihydroxyandrostan-16-one-2β,19-hemiketal	24) 24-methylen-colesterol
9) 2α,3β-dihydroxypregnan-16-one-2β,19-hemiketal	25) 24-methylen-3β,4β,22-trihydroxycolesterol
10) 2β,3β,4β-trihydroxypregnan-16-one	26) 24-methylen-3β,22-dihydroxycolesterol
11) 2α,3α,4β-trihydroxypregnan-16-one	27) itesmol
12) 2β,3β-dihydroxypregnan-16-one	28) volkendousin
13) 3β-hydroxy-colestan-23-ene	29) 3β-hydroxy-colestan-23-ene
14) 7-oxo-24β-sitosterol	30) ergost-5,24(28)-dien-3,12-diol-(3β,12β)
15) 3β,4α-dihydroxypregnan-21-one	31) ergost-5,24(28)-diene-3,12-diol-3-hexadecanoate (3β,12β)
16) 3β,4α-dihydroxypregnan-16-one	32) 24-methyl-12-β-hydroxycolest-4-en-3-one

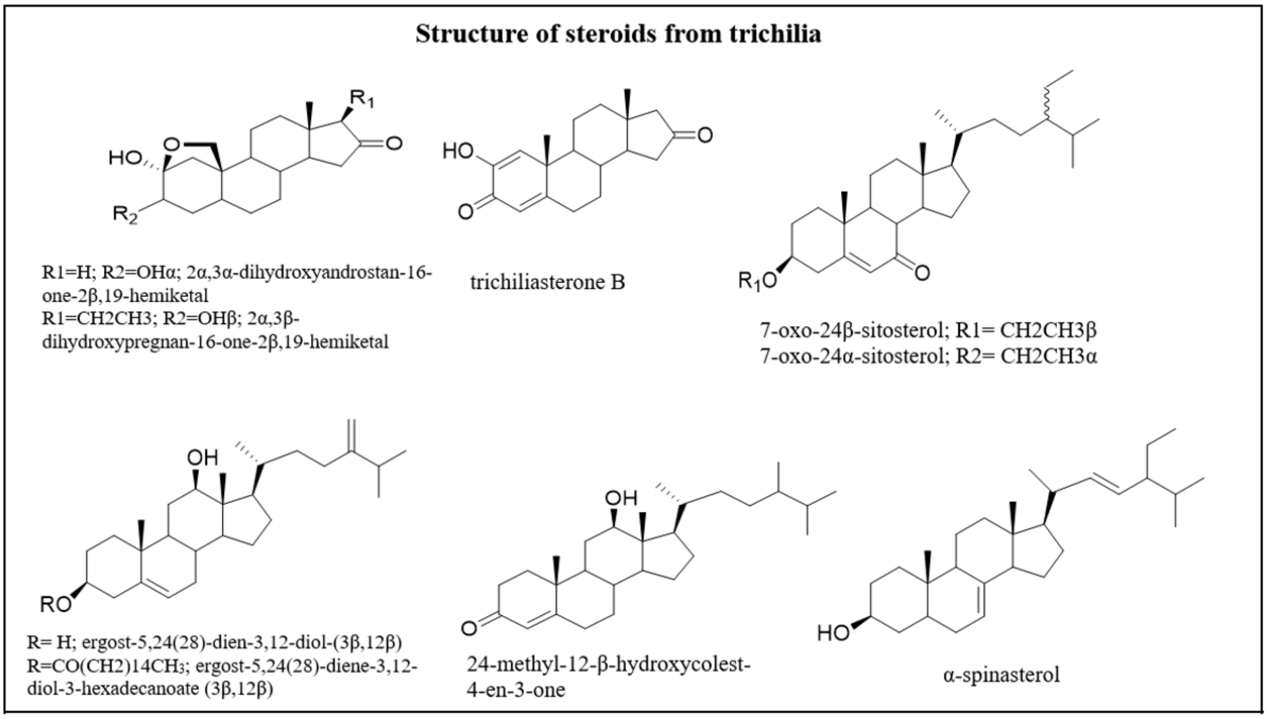


Figure 10. (*Continued*).

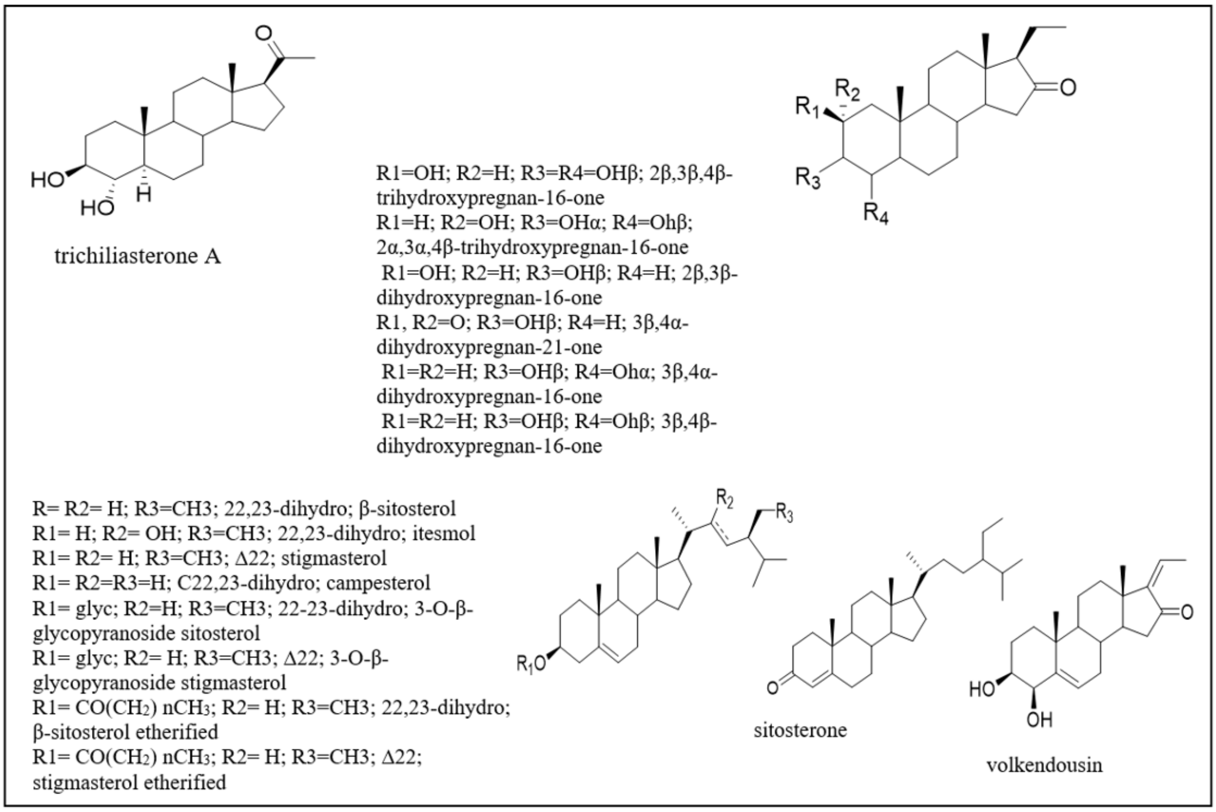


Figure 10. Structures of steroids from *Trichilia*.

4.6. Limonoids from *Trichilia*

According to I. Curcino Vieira evaluated in 2014, there are three types of limonoids (**Figure 11**) in the genus *Trichilia*. Twenty-four meliacin-type limonoids were isolated over fifty percent from T. *elegans* seeds. Recenty, among all the compounds isolated and identified in a study of Twenty-one species of the genus *Trichilia*, constituting a total of 227 limonoids (**Tables 4–15** and **Figures 12–21**). These compounds were found in the African, American, and Asian continents.

Table 4. Limonoids (furan-ring) from *Trichilia*.

Limonoids (furan-ring)			
Cedrelone	methyl angolensate	11β-methoxycedrelone	trichilin B
trichilin A	15-acetyltrichagmalin C	trijugin A	trijugin C
trijugin B	trichagmalin E	trijugin E	trijugin F
trijugin B acetate	trichanolide	trijugin H	methyl-8α-hydroxy-8,30-
trijugin D	dregeana-3	trichiliton	dihydroangolesate
trijugin G	dregeana-5	trichagmalin C	trichagmalin A
Δ8,14-2-hydroxy-6-	trichilin E; aphonastatine	trichagmalin D	Triacetyl-14,15-deoxy-
deoxyswietenine	7-acetyltrichilin A	trichagmalin E	havanensin
trichagmalin B	trichilin G	15-acetyltrichagmalin E	1,7-diacetyl apotirucalla-
1,2-dimethyltrichagmalin A	1-acetyltrichilin	trichagmalin F	havanensin
15-acetyltrichagmalin E	Tr-B	30-acetyltrichagmalin F	3,7-diacetyl-havanensin
1,30-diacetyltrichagmalin F	rohituca-5	2-hydroxy-3-O-tigloyl-6-O-	neo-havanensin
trichiliton B	21,24,25,26,27-pentanor-15,22-	acetyl-swietenolide	heudelottin C
dregeana-4	oxo-7α,23-dihydroxy-	1β,2β,21,23-diepoxy-7α-	12-(2'-desacetyl)-dregeanin
hispidin C; rohituka-7	apotirucalla(eupha)-1-en-3-one	hydroxy-24,25,26,27-	hirtine
dregeanin	dregeana-2	tetranor-14,20,22-trien-3-one	methyl-11β-acetoxy-6-hydroxy-
12-(2'-deacetyl)-dregeanin	dregeana-1	3,7-diacetyl-havanensin	12α(2-methyl-propionyloxy)-3,
11β-acetoxyobacunone	sendanin	trichavensin	7-dioxo-1,5,14,20,22-
Tr-A	Tr-C	trichilenone acetate	meliacapentaen-29-oate
dregeana-4	rohituca-3	heudelottin C	hispidin B
rohituca-7	Nimani-1	dregeanin	8-hydroxyandirobin
	prieurianin	hirtine	

Table 4. (*Continued*).

Limonoids (furan-ring)			
1,7-diacetyl-14,15-deoxy-havanensin	rubralin C	deacetylhirtine	methyl-6-hydroxy-11β-acetoxy-12α-(2-methylbutanoyloxy)
3,7-diacetyl-14,15-deoxyhavanensin	rubrin B	hispidin C; rohituka-7	3,7-dioxo-14β,15β-epoxy-1,5-meliacadien-29-oate
heudelottin	rubrin F	hispidin A	*Trichilia* lactone D-5
heudebolin	trifolin	methyl 6-hydroxy-11β-acetoxy-12α-(2-methylpropanoyloxy)-3,	12-(2'-deacetyl)-dregeanin
azadirone	6β-acetoxyobacunol	7-dioxo-14β,15β-epoxy-1,5-meliacadien-29-oate	rubralin B
hispidin C; rohituka-7	6β-acetoxy-7α-acetylobacunol	prieurianin acetate	rubrin A
methyl angolensate	havanensin	rubralin A	nymania-1; Rubrin E
methyl 6,11β-dihydroxy-12α-(2-methylpropanoyloxy)-3,	heudelottin E	hispidin A; rubrin C	7-deacetoxy-7-oxogedunin
7-dioxo-14β,15β-epoxy-1,5-meliacadien-29-oate		rubrin D	α-gedunine
deacetylhirtine		rubrin G	limonine
7-deacetylgedunine			
Trichilia lactone D-4			

Table 5. Limonoids (Meliacin type & Degraded) from *Trichilia.*

limonoids (Meliacin type)		**limonoids (Degraded)**
fotogedunin A	1,2-dihydro 1α-acetoxyelegantin B	trichiconnarin A
7-deoxo-7β-acetoxykihadanin A	7-deacetyl-21-hydroxyneotrichilenonelide	trichiconnarin B
7-deoxo-7β-hidroxykihadanin A	7α-23-dihydroxy-3-oxo-24,25,26,27-tetranorapotirucall-1,14,20(22)-trien-21,23-olide	
7-deoxo-7α-hidroxykihadanin A	carda-14,20(22)-dienolide-1,3,7-tris(acetyloxy)-21-hydroxy-4,4,8-trimethyl-α,3α,5α,7α,13α,17α,21R)	
7-deoxo-7α-acetoxykihadanin A	fotogedunin B	
kihadanin A	7-deoxo-7β-acetoxykihadanin B	
elegantin A	7-deoxo-7β-hidroxykihadanin B	
trichirubun A	7-deoxo-7α-acetoxykihadanin B	
1,2-dihydro-1α-acetoxyelegantin A	kihadanin B	
methyl-11β-acetoxy-6,23-dihydroxy-12α(2-methylpropionyloxy)-3,7,21-trioxo-1,5,14,20-meliacatetraen-29-oate	elegantin B	
7-deacetyl-23-hydroxyneotrichilenonelide	trichirubun B	
21-hydroxyneotrichilenonelide		
hydroxybutenolide		

The limonoids may be classed based on their fundamental skeleton, which is made up of four intact rings like A, B, C, and D rings derived from the triterpene precursor. Depend on the various of rearrangements and oxidations.

i Intact rings,

ii Rearranged limonoids and

iii Ring-seco

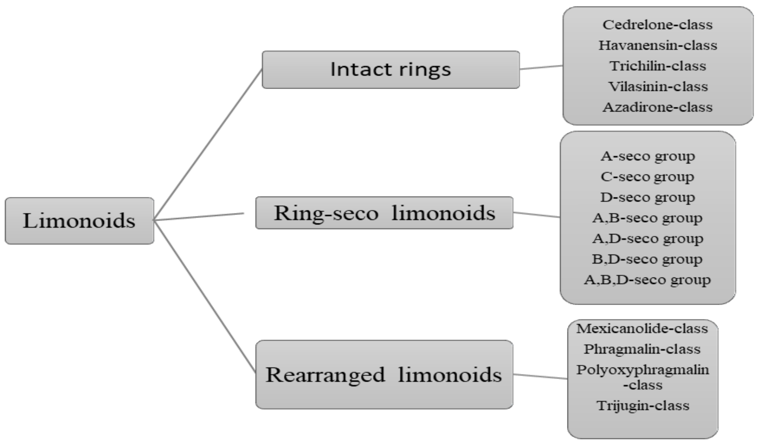


Figure 11. The limonoids' basic skeleton from *Trichilia*. **(A)** Limonoids with intact rings; **(B)** limonoids with Ring-seco; **(C)** rearranged limonoids.

Table 6. Cedrelone-class compounds from *Trichilia*.

Species	Plant part	Cedrelone-class compounds	References
T. americana	Leaves	11b-hydroxy-12a-propanoyloxycedrelone 1a,11b-dihydroxy-1,2-dihydrocedrelone 1a-methoxy-1,2-dihydrodeacetylhirtin 1a-hydroxy-1,2-dihydrohirtin 1a-hydroxy-1,2-dihydrodeacetylhirtin 1,2-dihydrodeacetylhirtin Americanolide D Americanolide C Americanolide B Americanolide A Hirtin Deacetylhirtin	[34]
T. hirta	Seeds and fruits	Hirtin Deacetylhirtin	[53–55]
	Fruits	Curcinomarcoide 23-c-hydrpxybutenolide Methyl 11b-acetoxy-6-hydroxy-12a-(2-methylpropionyloxy)-3,7-dioxo-1,5,14,20,22-meliacarpentaen-29-oate	[54,56]
T. pallida	Roots	Methyl 6-hydroxy-11b-acetoxy-12a-(2-methylbutanoyloxy)-3,7-dioxo-14b,15b-epoxy-1,5-meliacadien-29-oate Hirtin Methyl 6-hydroxy-11b-acetoxy-12a-(2- methylpropanoyloxy)-3,7-dioxo-14b,15b-epoxy-1,5- meliacadien-29-oate Deacetylhirtin Methyl 6,11b-dihydroxy-12a-(2-methylpropanoyloxy)-3,7-dioxo-14b,15b-epoxy-1,5-meliacadien-29-oate	[54]
T. catigua	Aril	Cedrelone	[57]

Table 7. Havanensin-class Compounds from *Trichilia*.

Species	Plant part	Havanensin-class Compounds	References
T. sinensis	Roots	Trisinlin A	[57]
T. havanensis	-	Havanensin 1,3-Diacetylhavanensin Havanensin triacetate 3,7-Diacetylhavanensin Neohavanensin Neotrichilenone Neohavanensin triacetate	[58]
	Seeds	3,7-Diacetylhavanensin Havanensin triacetate 1,3-Diacetylhavanensin 14,15-Deoxyhavanensin-1,7-diacetate 14,15-Deoxyhavanensin triacetate 3-oxo-14,15-deoxyhavanensin-1,7-diacetate Hydroxybutenolide	[59–61]
T. trifolia	-	Trifolin	[62]

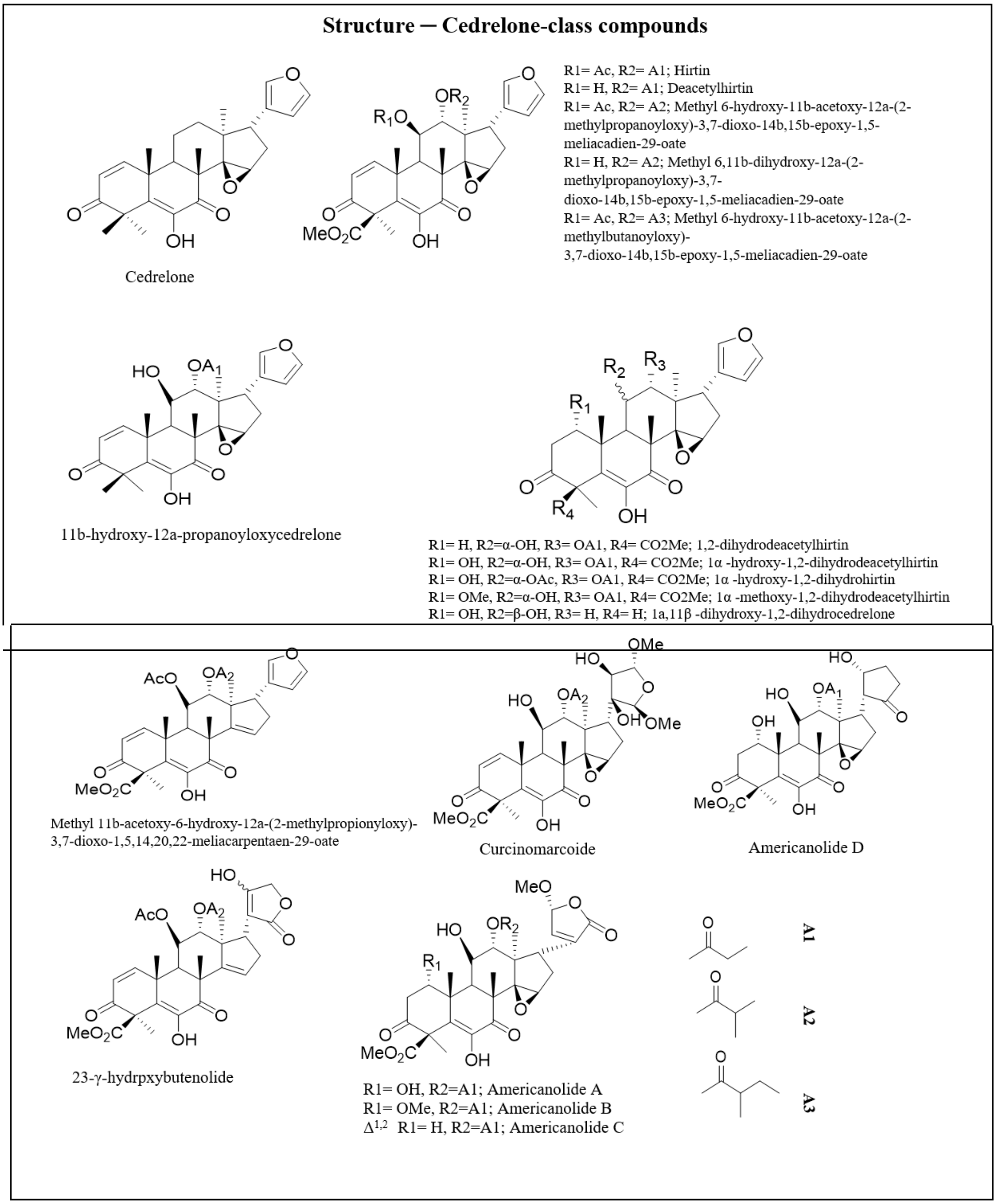


Figure 12. Structures—Cedrelone-class compounds from *Trichilia*.

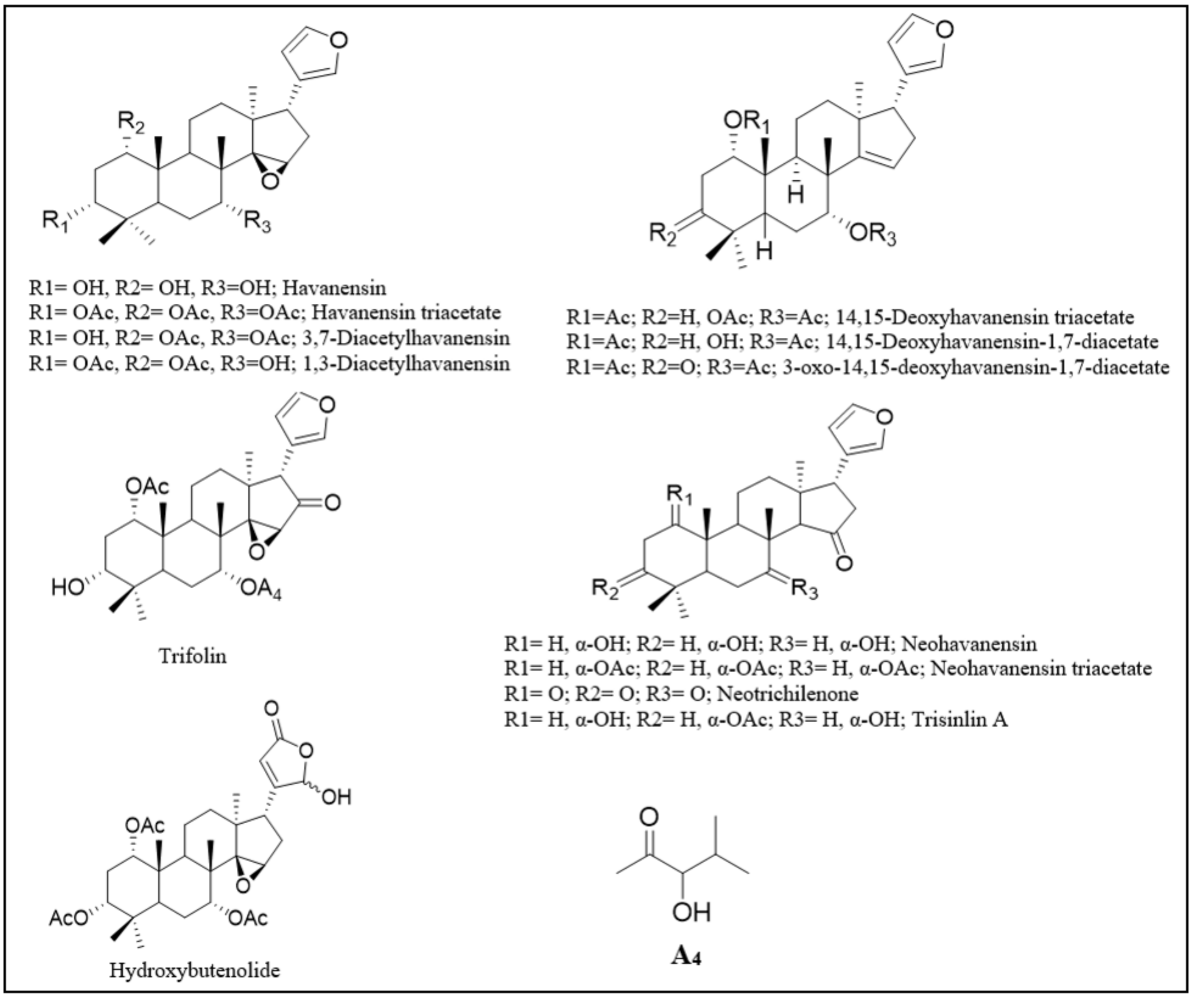
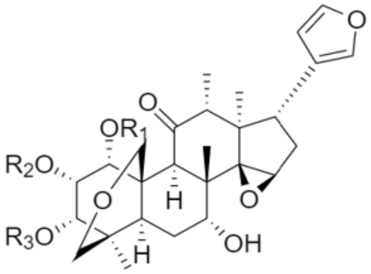


Figure 13. Structures—havanensin-class from *Trichilia.*

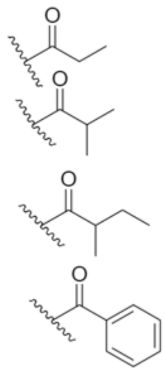
Table 8. Trichilin-class Compounds from *Trichilia.*

Species	Plant part	Trichilin-class Compounds	References
T. emetica	Fruits	Sendanin	[63]
	Roots bark	Trichilin G Trichilin F Trichilin C Trichilin D Trichilin B Trichilin A 7-acetyltrichilin A Aphanastatin	[64,65]
	Stems bark	Trichilin A	[66]
T. sinensis	Roots	12-O-deacetyltrichilin H Aphanastatin Trichisinlin F 12alfa-hydroxymeliatoosenin I Trichisinlin E Trichisinlin C Trichisinlin B Trichisinlin A 12a-hydroxymeliatoxin B2 12a-hydroxymeliatoxin B1 Meliatoxin B2 Meliatoxin B1	[67]

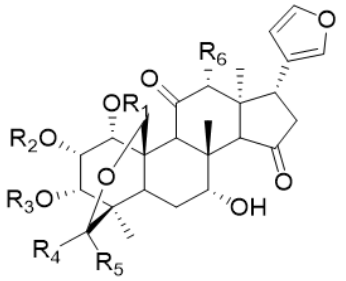
Structures—trichilin-class



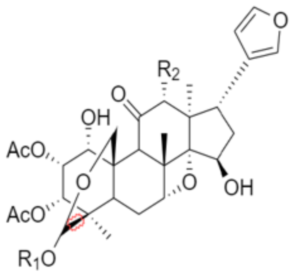
R1=OAc; R2=OAc; R3=OH; Trichilin F
R1=OH; R2=OH; R3=OAc; Trichilin G



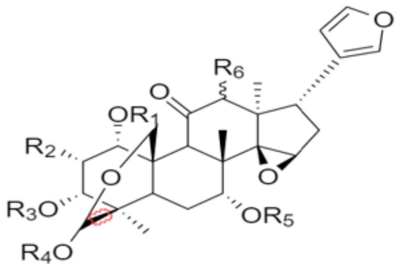
A1
A2
A3
A5



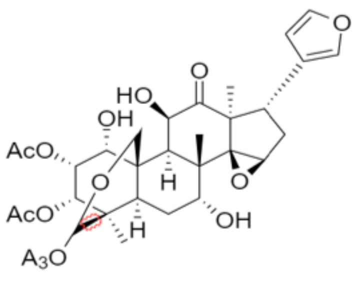
R1= H; R2=Ac; R3= Ac; R4=OA3; R5=H; R6=H; Meliatoxin B1
R1= H; R2=Ac; R3= Ac; R4=OA2; R5=H; R6=H; Meliatoxin B2
R1= H; R2=Ac; R3= Ac; R4=OA3; R5=H; R6=OH; 12a-hydroxymeliatoxin B1
R1= H; R2=Ac; R3= Ac; R4=OA2; R5=H; R6=OH; 12a-hydroxymeliatoxin B2
R1= Ac; R2=H; R3= Ac; R4=OA3; R5=H; R6=H; Trichisinlin A
R1= Ac; R2=Ac; R3= H; R4=H; R5=OMe; R6=H; Trichisinlin B
R1= H; R2=Ac; R3= Ac; R4=OMe; R5=H; R6=H; Trichisinlin C



R1=A2; R2=H; Trichisinlin E
R1=A3; R2=OH; 12α-hydroxymeliatoosenin I



R1=Ac; R2=H; R3=Ac; R4=A3; R5=H; R6=α-H; Trichisinlin F
R1=H; R2=H; R3=Ac; R4=Ac; R5=H; R6=β-OAc; Sendanin
R1=H; R2=OAc; R3=Ac; R4=A3; R5=H; R6=H; Aphanastatin
R1=H; R2=OAc; R3=Ac; R4=A3; R5=Ac; R6= β-OH; 7-acetyltrichilin A
R1=H; R2=Ac; R3=Ac; R4=A2; R5=H; R6=α-OH; 12-O-deacetyltrichilin H
R1=H; R2=OAc; R3=Ac; R4=A3; R5=H; R6= β-OH; Trichilin A
R1=H; R2=OAc; R3=Ac; R4=A3; R5=H; R6=α-OH; Trichilin B
R1=Ac; R2=OH; R3=Ac; R4=A3; R5=H; R6=α-OH; Trichilin D



Trichilin C

Figure 14. Structures—trichilin-class from *Trichila.*

Table 9. Vilasinin-class Compounds from *Trichila*.

Species	Plant part	Vilasinin-class Compounds	References
T. emeteica	Roots bark	Trichilinin	[68]
T. rubescens	Roots bark	TS3 TS1 Rubescin E Rubescin D Rubescin C Rubescin B Rubescin A	[69]

Table 9. (*Continued*).

Species	Plant part	Vilasinin-class Compounds	References
	Bark	TS3 Rubescin C Rubescin B Rubescin A	[70]
	Stems bark	Rubescin J Rubescin I Rubescin D	[71]
	Leaves	Trichirubine B Trichirubine A TS3 TS2 TS1 Rubescin H Rubescin G Rubescin F	[72–74]

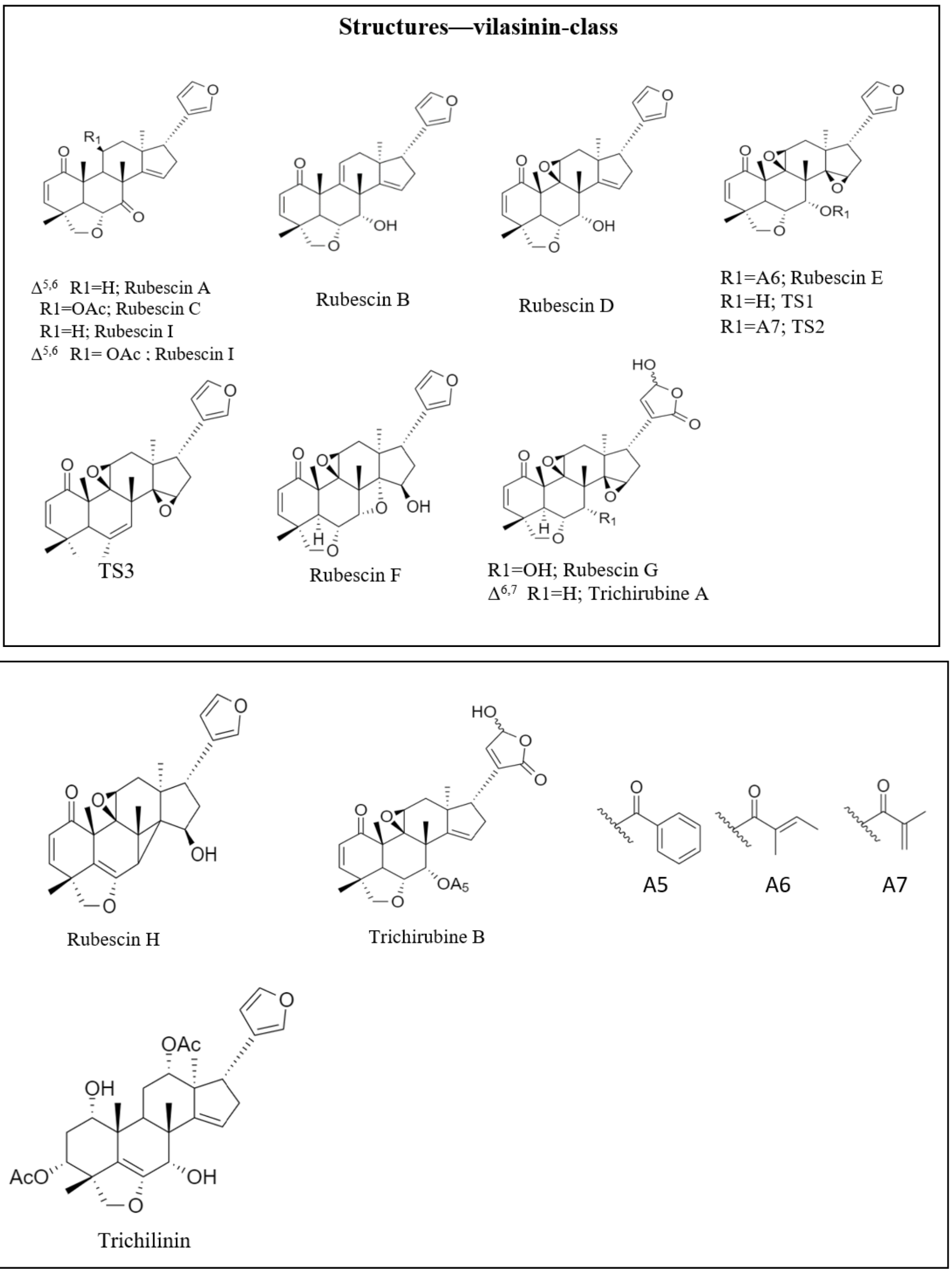


Figure 15. Vilasinin-class Compounds from Trichila.

Table 10. Azadirone-class Compounds.

Species	Plant part	Azadirone-class Compounds	References
T. estipulata	Stems bark	7-deacetyl-23-hydroxyneotrichilenonelide 7-diacetyl-21-hydroxyneotrichilenonelide 7a,23-dihydroxy-3-oxo-24,25,26,27- tetranorapotirucall-1,14,20(22)-trien-21,23-olide 7a,21-dihydroxy-3-oxo-24,25,26,27- tetranorapotirucall-1,14,20(22)-trien-21,23-olide	[75,76]
T. gilgiana	Stems bark	Trigilgianin	[77]
T. havanensis	-	Neotrichilenone Trichilenone	[78]
	Seeds	Azadirone	[79]
T. heudelotti	Wood	Heudelottin F Heudelottin E Heudelottin C Heudelottin	[80]
	Bark	Heudelottin F Heudelottin E Heudelottin C	[81]

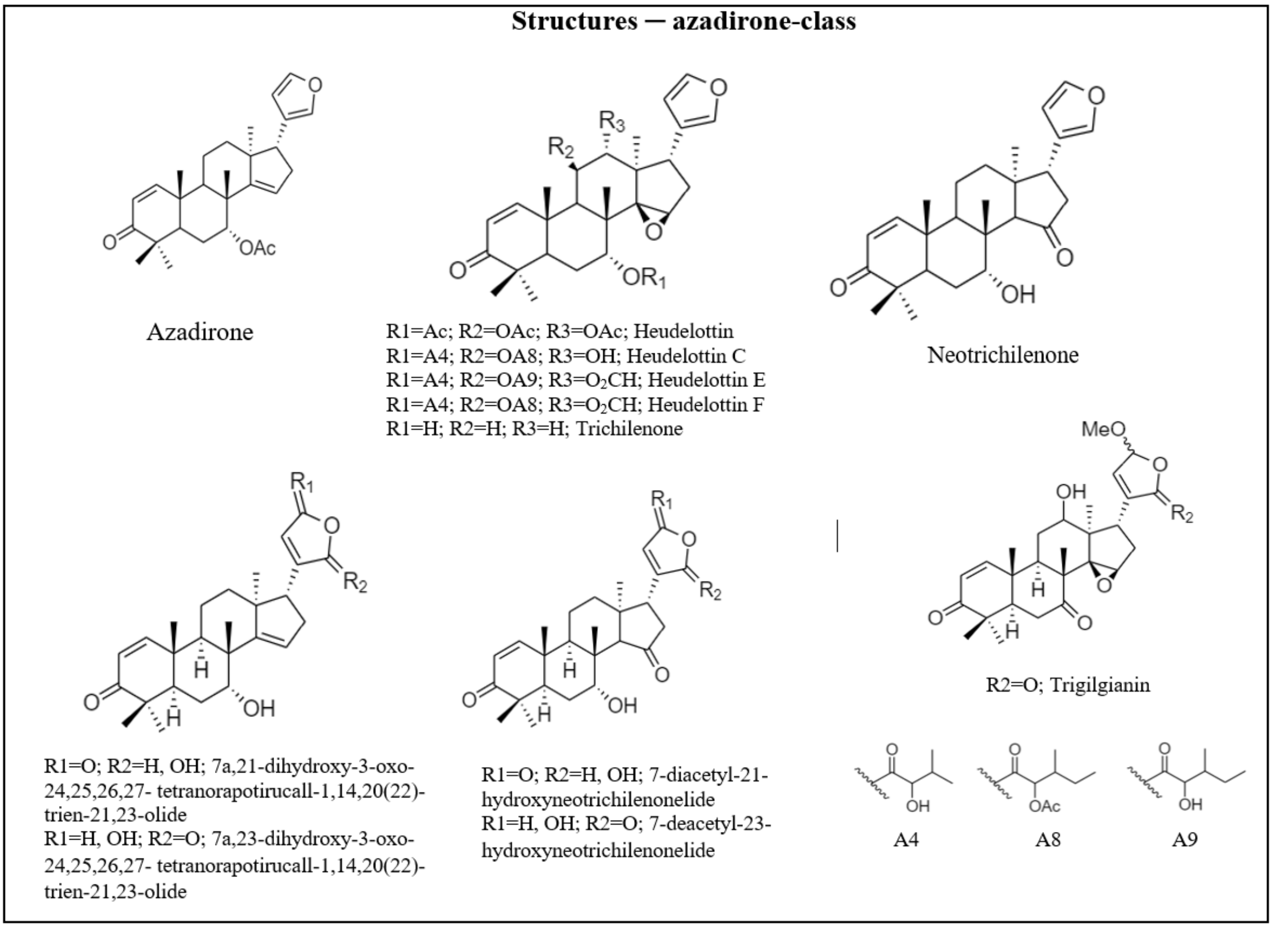


Figure 16. Structures—azadirone-class from Trichila.

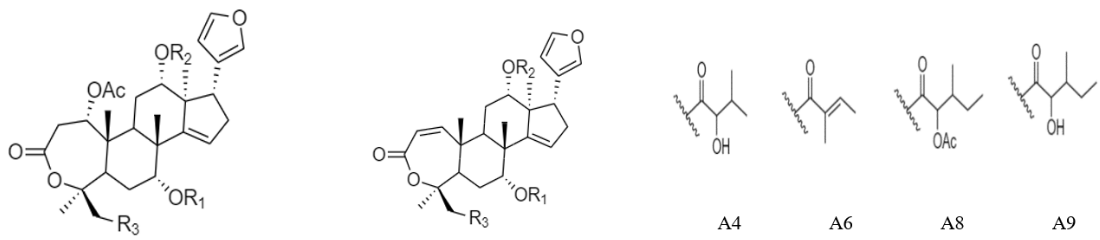
Table 11. A-seco group Compounds from *Trichila*.

Species	Plant part	A-seco group Compounds	References
T. dregeana	Seeds	Dregeana-5 Dregeana-4 Dregeana-3	[82]
T. emetica	Stems bark	Dregeana-4	[83]
T. rubra	Roots	Dregeana-4 Rubralin C Rubralin B Rubralin A	[84]
Species	**Plant part**	**C-seco group Compounds**	**References**
T. heudelotti	Bark	Heudebolin	[85]
Species	**Plant part**	**D-seco group Compounds**	**References**
T. monadelpha	Fruits	Monadelphin B Monadelphin A	[86]
T. pallida	Leaves	Gedunin	[87]
T. schomburgkii	Leaves	7-deacetoxy-7-oxogedunin	[88]
T. trifolia	-	Deacetylgedunin Gedunin	[89]
Species	**Plant part**	**A, B-seco group Compounds**	**References**
T. emetica	Stems bark	Tr-B Rohituka 3 Rubrin E	[89]
T. prieuriana	Roots bark	Dregeanin Prieuranin	[90]
	-	*Trichilia* lactone D5	
T. welwitschii	Seeds	*Trichilia* lactone D5 Dregeanin DM4	[45]
T. rubra	Roots	Prieuranin Rubrin G Rubrin F Rubrin E Rubrin E Rubrin D Rubrin C Rubrin B Rubrin A	[91]
T. hispida	-	Rubrin C Hispidin C Hispidin B	[62]
T. havanensis	Seeds	Trichavensin	[70]
T. dregeana	Seeds	Dregeanin DM4 Dregeana-2 Dregeana-1 Polystachin Rohituka-7	[92]
T. elegans	Seeds	Trichavensin	[93]
Species	**Plant part**	**A, D-seco group Compounds**	**References**
T. trifolia		Obacunol acetate Obacunol	[94]
T. elegans	Seeds	7-deoxo-7a-acetoxykihadanin B 7-deoxo-7a-acetoxykihadanin A Kihadanin B Kihadanin A	[95]

Table 11. (*Continued*).

Species	*Plant part*	*B, D-seco group Compounds*	*References*
T. catigua	Aril	Methyl angolensate	[95]
T. connaroides	Twigs and leaves	Methyl 8a-hydroxy-8,30-dihydroangolensate	[94]
Species	**Plant part**	**A, B, D-seco group Compounds**	**References**
T. elegans	Seeds	1,2-dihydro-1a-acetoxyelegantin B 1,2-dihydro-1a-acetoxyelegantin A Elegantin B Elegantin A	[96]
T. connaroides	Twigs	Trichiconin C Trichiconin B	[97]

Structures —A-seco group

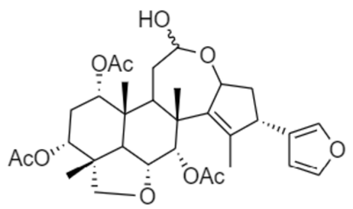


A4 A6 A8 A9

R1=A9; R2=Ac; R3=A9; Rubralin A
R1=A4; R2=Ac; R3=A9; Rubralin B
R1=A6; R2=Ac; R3=H; Rubralin C
R1=A4; R2=A8; R3=OH; Dregeana-3
R1=Ac; R2=A8; R3=H; Dregeana-4

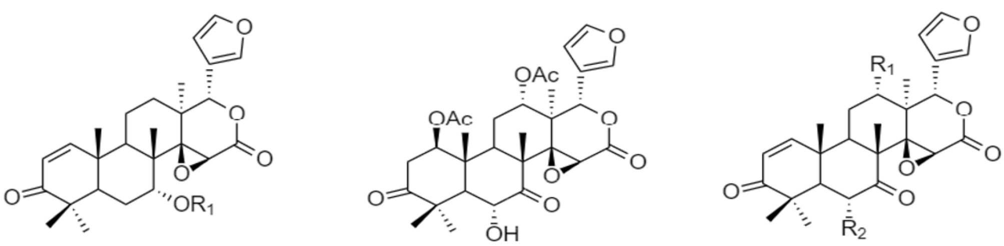
R1=A4; R2=A8; R3=OH; Dregeana-5

Structure—C-seco group



Heudebolin

Structures—D-seco group

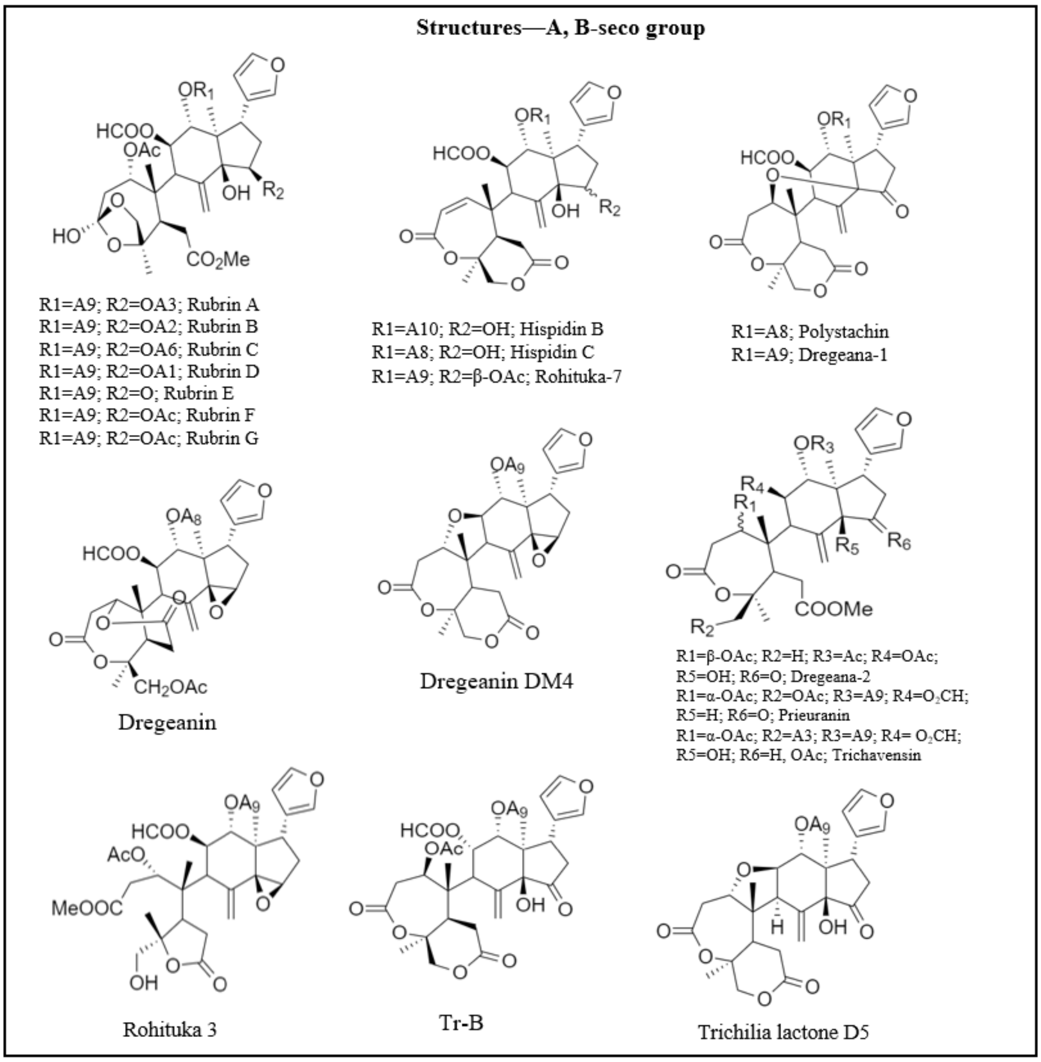


R1=Ac; Gedunin
R1=H; Deacetylgedunin

Monadelphin A

R1=OAc; R2=OH; Monadelphin B
R2=H; R2=H; 7-deacetoxy-7-oxogedunin

Figure 17. (*Continued*).



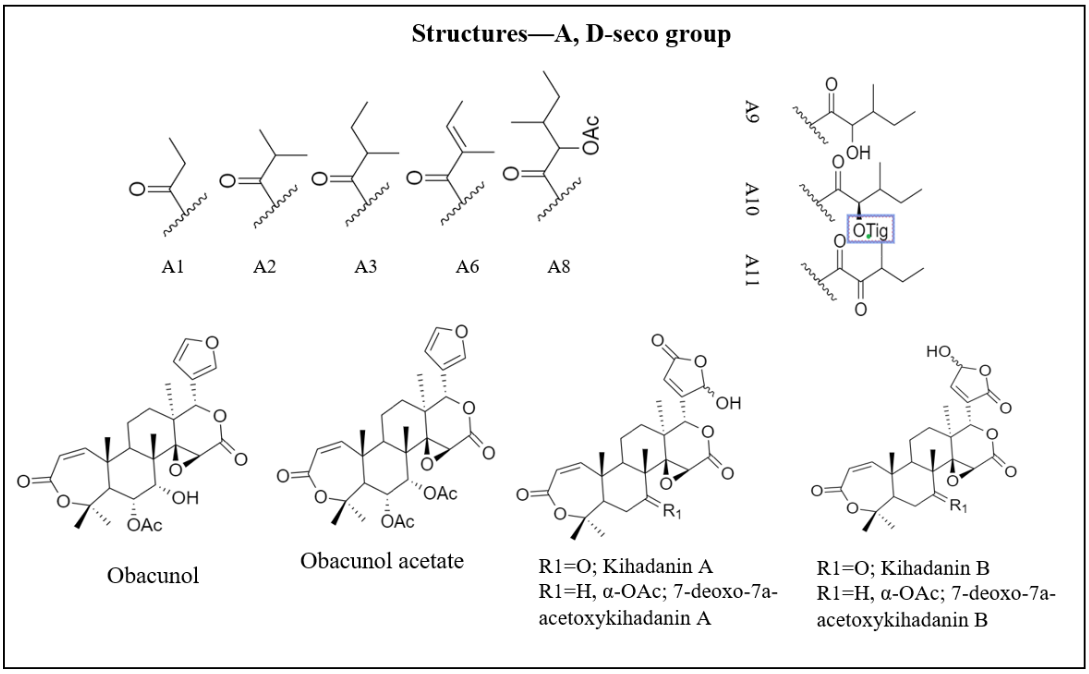


Figure 17. (*Continued*).

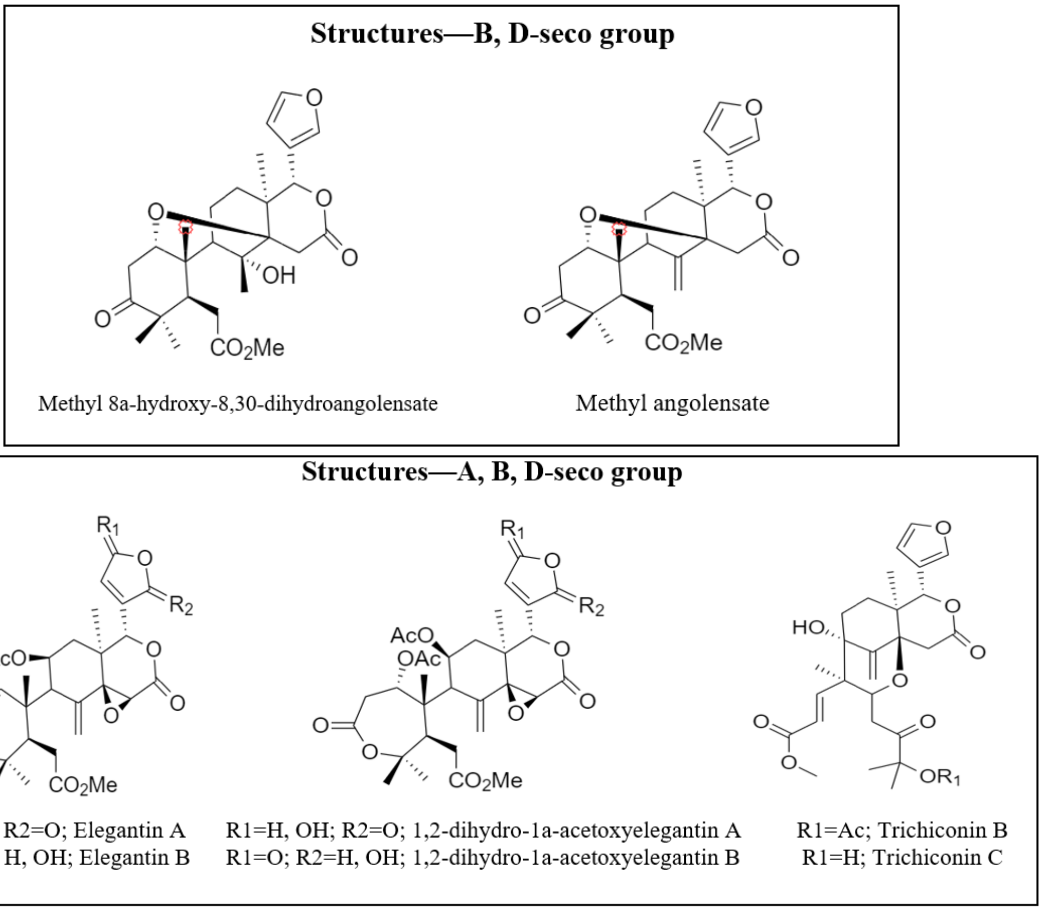


Figure 17. Structures of different seco group from *Trichilia.*

Table 12. List of Mexicanolide-class Compounds from *Trichilia.*

Species	Plant part	Mexicanolide-class Compounds	References
T. connaroides	Twigs	Trichiconin A	[97]
	Pericarps	2-hydroxy-3-O-tigloy1-6-O-acetylswietenolide	[98]
	Fruits	Trichiconlide B 2-hydroxy-3-O-isobutyrylproceranolide Cipadesin N Heytrijunolide D Trichinenlide D Methyl-2-hydroxy-3b-tigloyloxy-1-oxomeliac-8(30)-enate Trichiconnarone B Trichiconnarone A	[99]
	Twigs and leaves	Trichiliasinenoid A/triconoid A Triconoid C Triconoid B	[100]
	Roots	Methyl-2-hydroxy-3b-tigloyloxy-1-oxomeliac-8(30)-enate Khayasin T 6-Desoxyswietenine	[97]

Table 12. (*Continued*).

Species	Plant part	Mexicanolide-class Compounds	References
T. sinensis	Leaves and twigs	(6R)-hydroxymexicanolide Proceranolide Trichiliasinenoid E Trichiliasinenoid D Trichiliasinenoid C Trichiliasinenoid B Trichiliasinenoid A/triconoid A Humilinolide E Methyl-3b-tigloyloxy-2,6-dihydroxy-1-oxomeliac-8(30)-enate Swietemahonin G Heytrijunolide D Heytrijunolide C Heytrijunolide B Heytrijunolide A Trichinenlide T Trichinenlide S Trichinenlide R Trichinenlide Q Trichinenlide P Trichinenlide O Trichinenlide N Trichinenlide M Trichinenlide L Trichinenlide K Trichinenlide J Trichinenlide I Trichinenlide H Trichinenlide G Trichinenlide F Trichinenlide E Trichinenlide D Trichinenlide C Trichinenlide B Trichinenlide A	[101]
	Roots	Humilin B Trichinenlide X Trichinenlide W Trichinenlide V Trichinenlide U Trichinenlide S	[102]

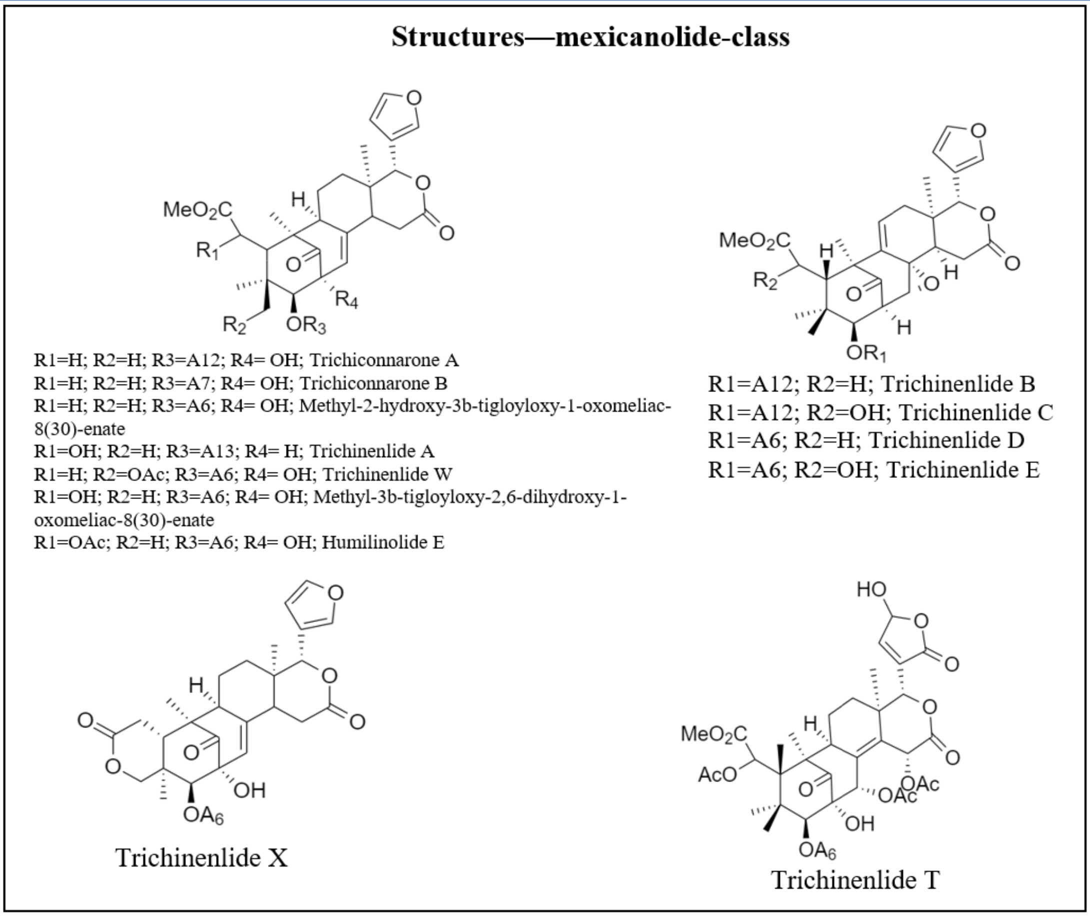
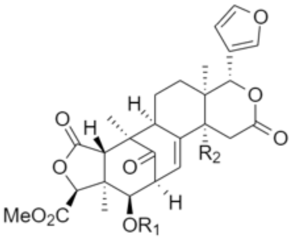
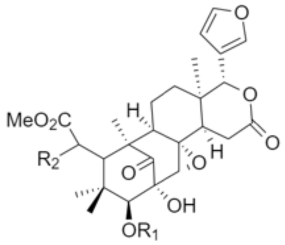


Figure 18. (*Continued*).

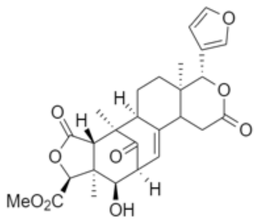
Structures—mexicanolide-class



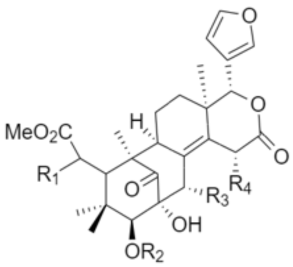
R1=A13; R2=OH; Triconoid B
R1=A13; R2=H; Triconoid A
R1=A5; R2=H; Trichiliasinenoid B



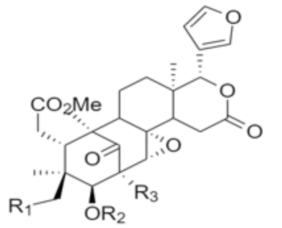
R1=A6; R2=H; Trichinenlide I
R1=A12; R2=H; Trichinenlide J
R1=A6; R2=OH; Trichinenlide K



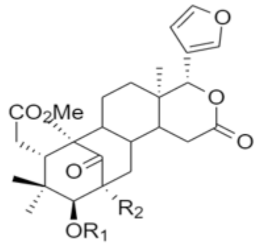
Triconoid C



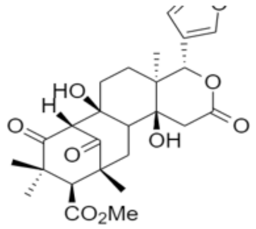
R1=H; R2=A6; R3=OAc; R4=OAc; Trichinenlide L
R1=OAc; R2=A6; R3=OAc; R4=H; Trichinenlide M
R1=H; R2=A6; R3=OAc; R4=H; Trichinenlide N
R1=OAc; R2=A12; R3=OAc; R4=OAc; Trichinenlide O
R1=OAc; R2=A3; R3=OAc; R4=OAc; Trichinenlide P
R1=H; R2=A6; R3=OA2; R4=H; Trichinenlide Q
R1=OAc; R2=A6; R3=OAc; R4=OA6; Trichinenlide R
R1=H; R2=A6; R3=OAc; R4=OA6; Trichinenlide S
R1=H; R2=A6; R3=OA3; R4=OAc; Trichinenlide U
R1=OAc; R2=A6; R3=OH; R4=OH; Heytrijunolide A
R1=OAc; R2=A6; R3=OH; R4=OAc; Heytrijunolide B
R1=OAc; R2=A6; R3=OAc; R4=OAc; Heytrijunolide C
R1=H; R2=A3; R3=H; R4=H; Cipadesin N
R1=H; R2=A2; R3=H; R4=OH; 2-hydroxy-3-O-isobutyrylproceranolide
R1=H; R2=A6; R3=H; R4=H; $\Delta^{8,14}$-2-hydroxy-6-deoxyswietenine
R1=OAc; R2=A6; R3=H; R4=H; 2-hydroxy-3-O-tigloy1-6-O-acetylswietenolide



R1=OAc; R2=A6; R3=OH; Trichinenlide V
R1=H; R2=A6; R3=OH; Ruageanin B
R1=H; R2=A3; R3=OH; Trichanolide
R1=H; R2=A2; R3=OAc; Humilin B



$\Delta^{8,30}$ R1=A6; R2=H; 6-Desoxyswietenine
$\Delta^{8,14}$ R1=A6; R2=H; Khayasin T



Trichiconin A

Figure 18. (*Continued*).

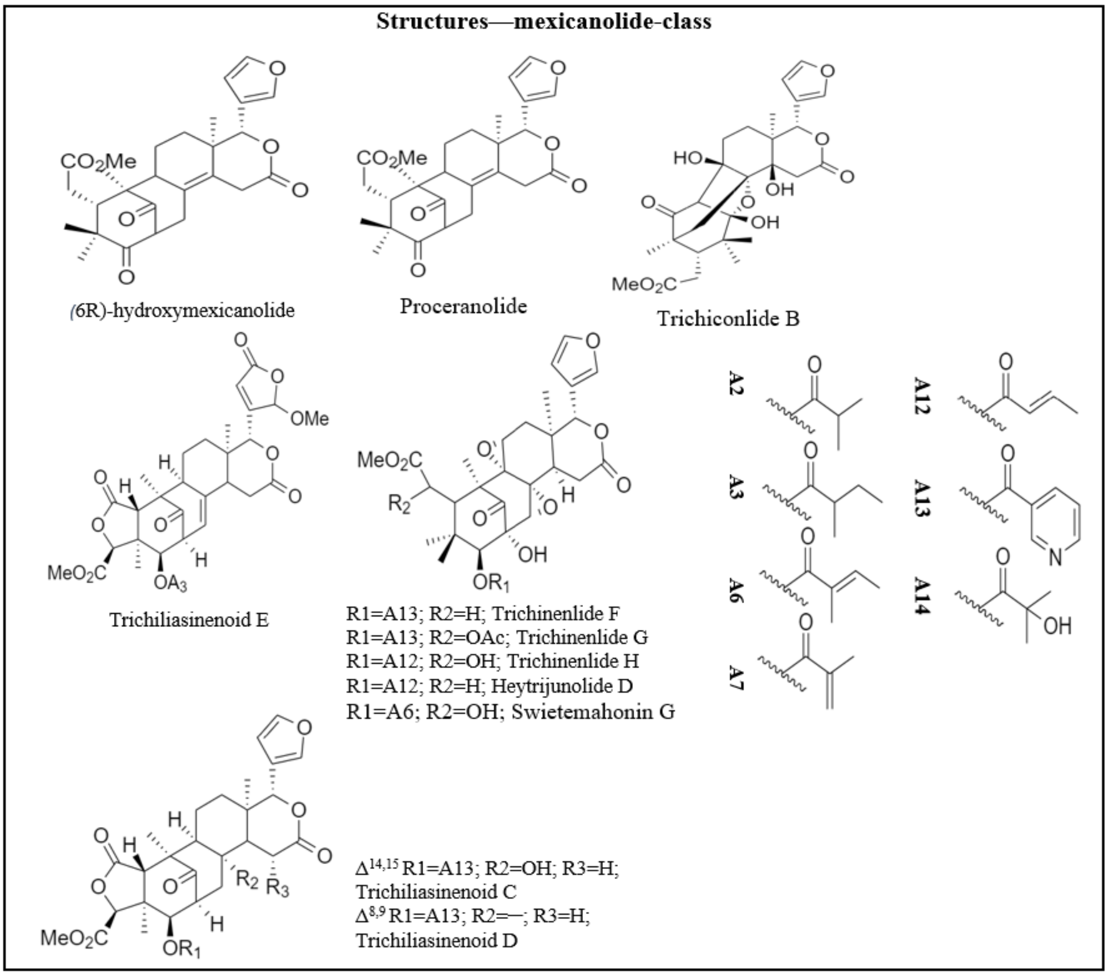


Figure 18. Structures—mexicanolide-class from *Trichilia.*

Table 13. List of Phragmalin-class Compounds from *Trichilia*.

Species	Plant Part	Phragmalin-class Compounds	References
T. connaroides	Leaves	Trichagmalin B Trichagmalin A 1,30-Siacetyltrichagmalin F 30-Acetyltrichagmalin F Trichagmalin F 15-Acetyltrichagmalin E Trichagmalin E Trichagmalin D 1,2-Diacetyltrichagmalin C 15-Acetyltrichagmalin C Trichagmalin C	[103]
T. sinensis	Roots	15-Acetyltrichagmalin C Trisinenmalin I Trisinenmalin H Trisinenmalin G Trisinenmalin F Trisinenmalin E Trisinenmalin D Trisinenmalin C Trisinenmalin B Trisinenmalin A	[104]

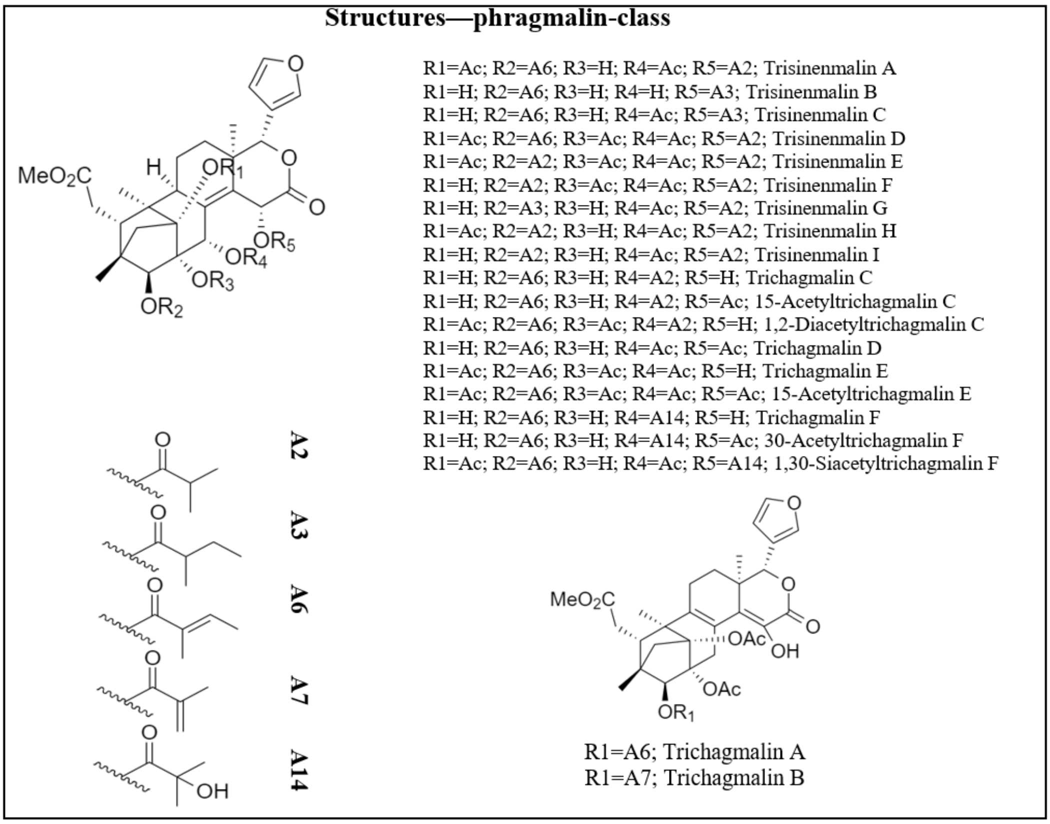
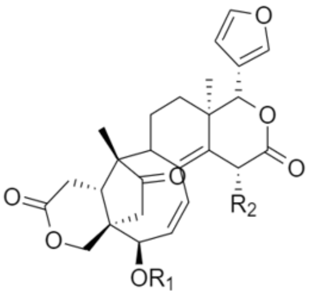


Figure 19. Structures—phragmalin-class from *Trichilia.*

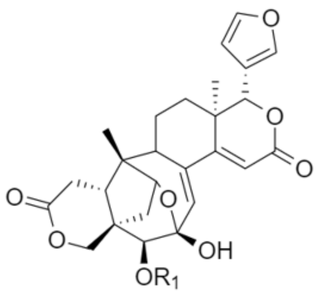
Table 14. Polyoxyphragmalin-class Compounds from *Trichilia.*

Species	Plant part	Polyoxyphragmalin-class Compounds	References
T. sinensis	Roots	Trichisinton D Trichisinton C Trichisinton B Trichisinton A	[104]
T. connaroides	Fruits	Trichiconlide F Trichiconlide E Trichiconlide D Trichiconlide C Trichiconlide B Trichiconlide A	[105]
	Stems and bark	Trichiliton H Trichiliton G	[105]
	Twigs and leaves	Triconoid D	[106]
	Leaves	Trichiliton A	[107]
	Roots	Trichiliton I	[108]

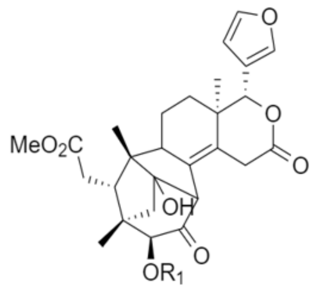
Structures—polyoxyphragmalin-class



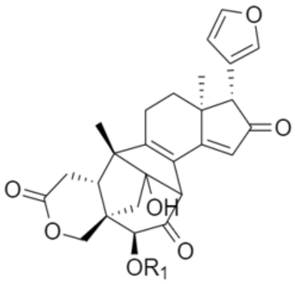
R1=A6; R2=OH; Trichiconlide E
R1=A6; R2=H; Trichiconlide F



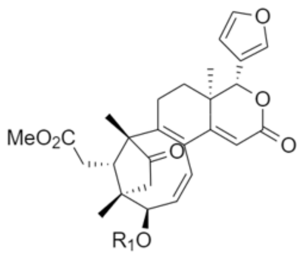
R1=A6; Trichiconlide C
R2=A12; Trichiconlide D



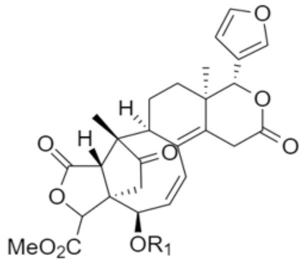
R1=A6; Trichiconlide B



R1=A12; Trichiconlide A

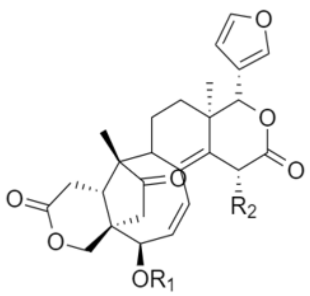


R1=A6; Trichiliton I

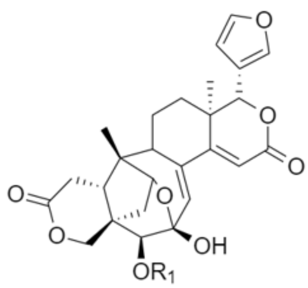


R1=A6; Triconoid D

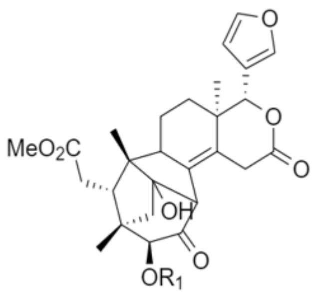
Structures—polyoxyphragmalin-class



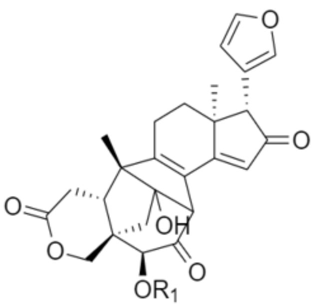
R1=A6; R2=OH; Trichiconlide E
R1=A6; R2=H; Trichiconlide F



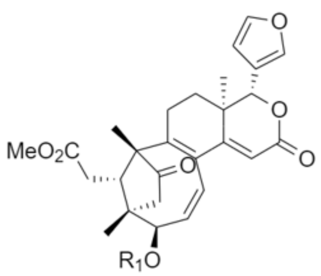
R1=A6; Trichiconlide C
R2=A12; Trichiconlide D



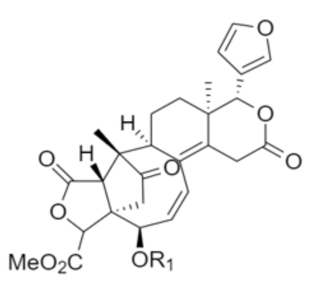
R1=A6; Trichiconlide B



R1=A12; Trichiconlide A



R1=A6; Trichiliton I



R1=A6; Triconoid D

Figure 20. (*Continued*).

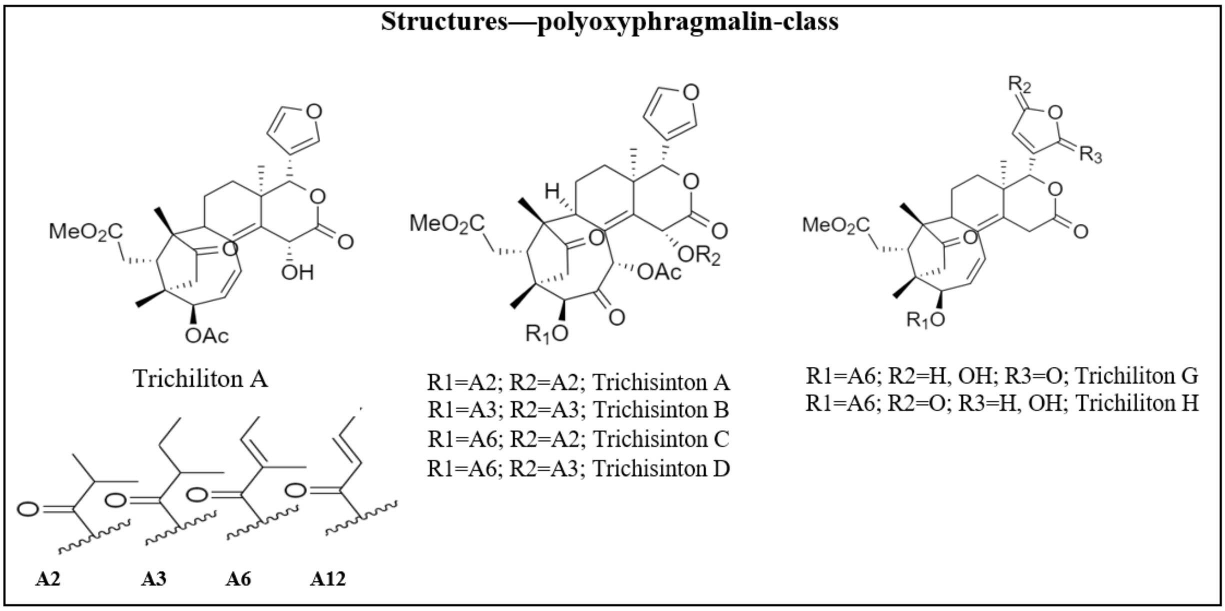


Figure 20. Structures—polyoxyphragmalin-class from *Trichilia*.

Table 15. List of Trijugin-class Compounds of *Trichilia*.

Species	Plant part	Trijugin-class Compounds	References
T. connaroides	Roots	12-Deacetoxyltrijugin A	[108]
	Twigs and leaves	Trijugin H Trijugin G Trijugin F Trijugin E Trijugin D Trijugin C Trichiliton B Trichilin B Trichilin A	[108–110]
	Leaves	Trijugin C	[110]
	Fruits	Spirotrichilin B Spirotrichilin A	[111]

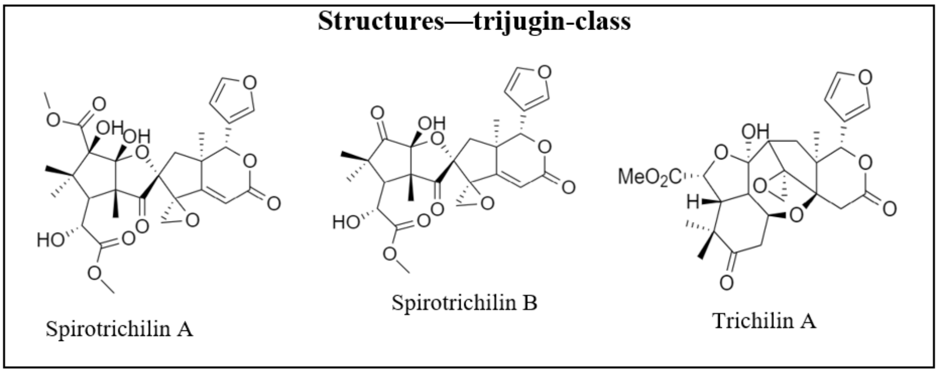


Figure 21. (*Continued*).

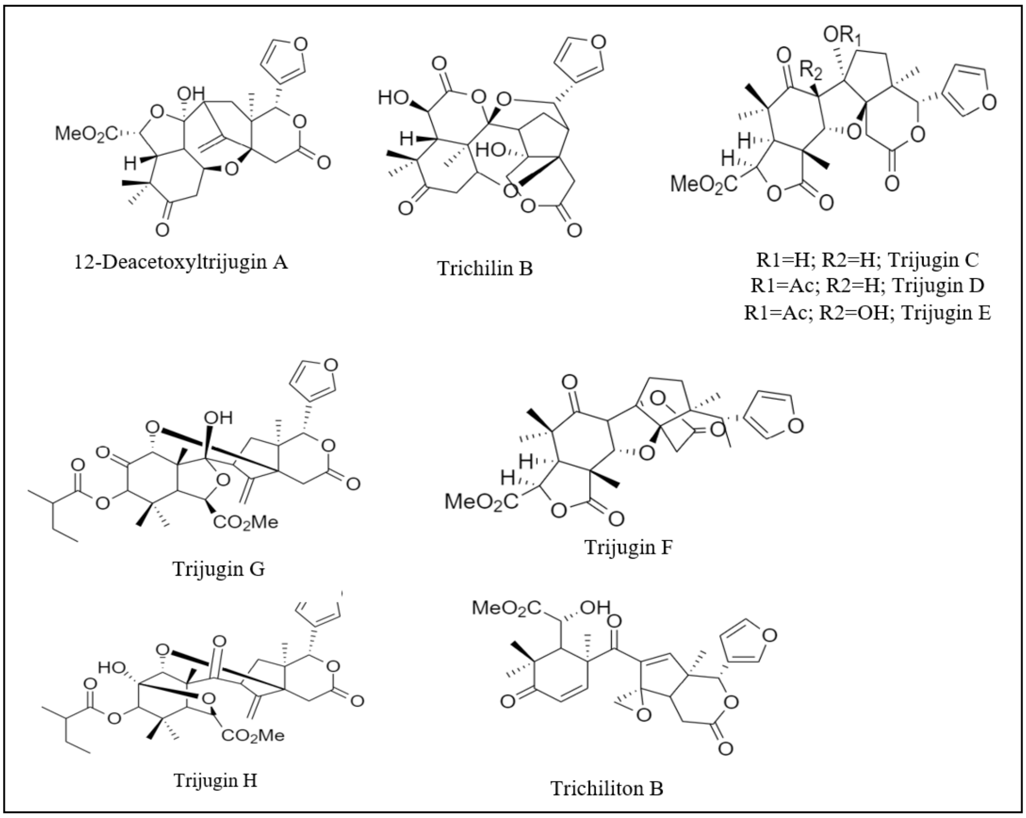


Figure 21. Structures—trijugin-class from *Trichilia.*

a. Flavonoids from *Trichilia*

Catiguanin A, catiguanin B, cinchonain Ia, cinchonain Ib, cinchonain Ic, cinchonain Id were segregated from the stem of *T. catigua*. On the whole found in the seeds of *T. catigua*. Steam and leaves of *T. catigua* contained Catechin and epi-catechin. *T. connaroides* leaves part showed just a single flavonoid that is kaempferol-7-O-glycosyde. Quercetin recognized in *T. pallida*[112–115] (**Table 16** and **Figure 22**).

Table 16. List of Flavonoids from *Trichila.*

Flavonoids	Species
catiguanin A cinchonain Ia catiguanin B cinchonain Ib cinchonain Id cinchonain Ic	*T. catigua* (steam)
epi-catechin Catechin	*T. catigua* (steam and leaves)
kaempferol-7-O-glycosyde	*T. connaroides* (leaves)
Quercetin	*T. pallida* (leaves and seeds)
Quercitrin	*T. pallida* (leaves and wood)
naringenin taxifolin 4'-O-β-D-glucopyranoside elephantorrhizol catechin 3-O-β-D-glucopyranoside eriodictyol 3-O-β-D-glucopyranoside	*Trichilia emetic* (seeds)

b. Glycosylated lignans from *Trichilia*

Every one of the four glycosylated lignans secluded from *Trichilia* were found in the seeds of *T. estipulata.*

1) (−)-isolariciresinol-3α-O-β-D-xylopyranoside,
2) (+)-4’-O-methyl-9’-deoxyisolariciresinol-3α-O-β-D-glucopyranoside
3) (−)-lyoniresinol-3α-L-rhamnopyranoside
4) (−)-lyoniresinol-3α-O-β-D-xylopyranoside[116] (**Figure 23**).

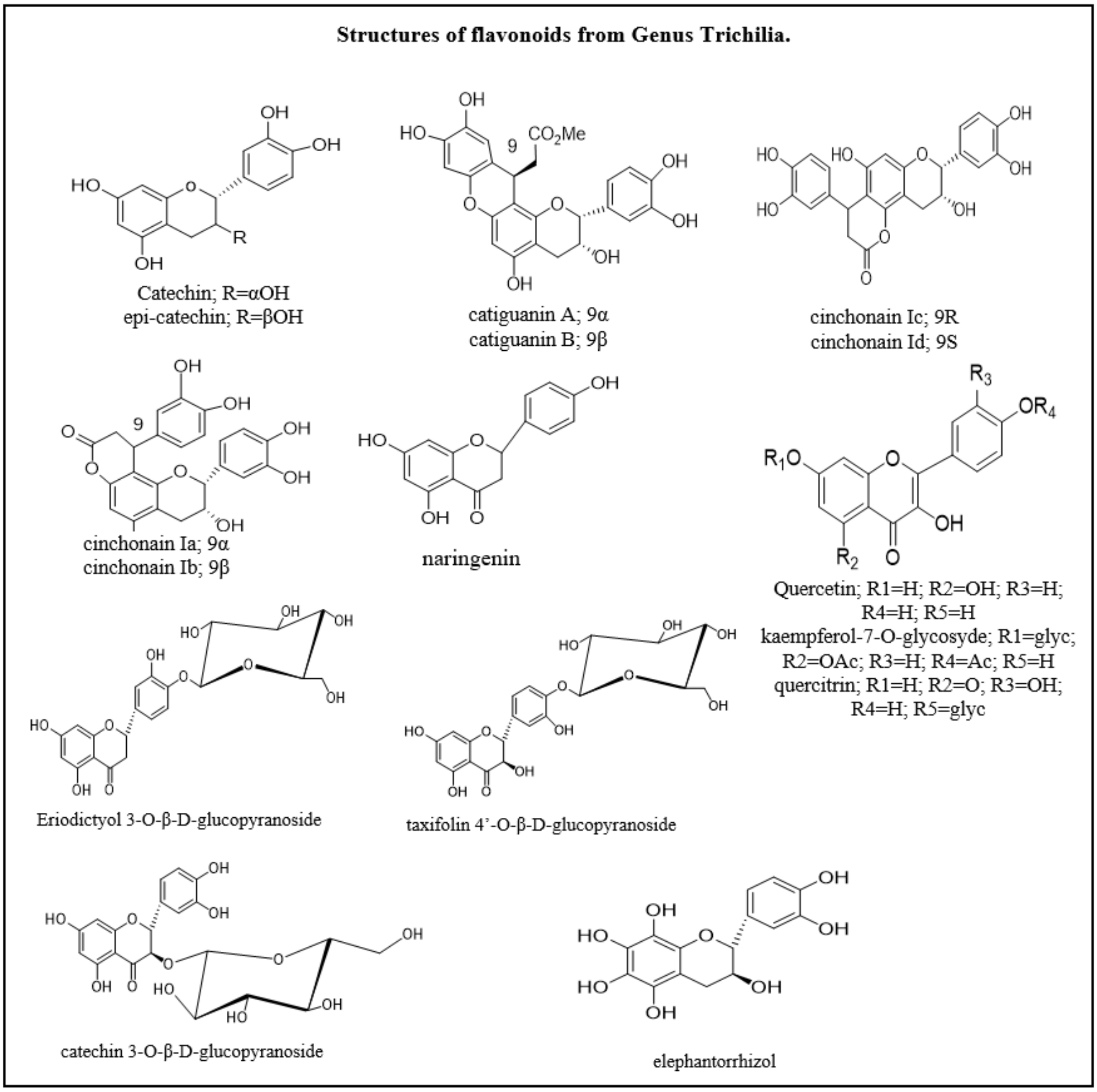


Figure 22. Structures of flavonoids from Genus *Trichilia.*

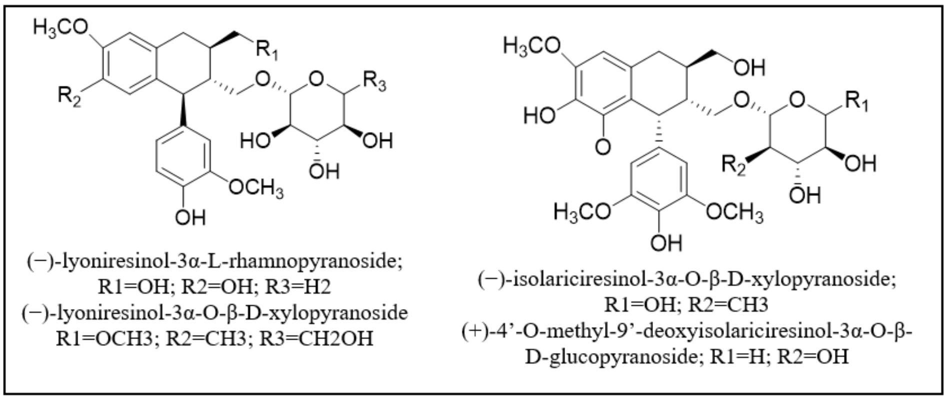


Figure 23. Structures of glycosylated lignans from Genus *Trichilia.*

c. Other compounds from *Trichilia*

Other compounds were also isolated from genus *Trichilia*. The compounds were found from some species of this genus. The species are *T. casaretti, T. claussenii, T. connaroides, T. heudelotti, T. lepidota, T. schomburgkii, T. sp.* Phytol was found from the leaves extract of *T. casaretti* and *T. lepidota*[117].

(2R,3S,4S)-3-hydroxy-4-methyl-2-(13'-phenyl-1'-n-tridecyl)-butanolide, (2R,3S,4S)-3-hydroxy-4-methyl-2-(11'-phenyl-1'-n-undecyl)-butanolide, (2R,3S,4S)-3-hydroxy-4-methyl-2-(1'-n-hexadec-7'(Z)-enyl)-butanolide, (2R,3S,4S)-3-hydroxy-4-methyl-2-(1'-n-tetradecyl)-butanolide, ω-phenyl alkanoic and alkenoic acids, N-methylproline, 4-hydroxy-N-methylproline, α-tocopherol, plastocromenol were isolated from fruits and leaves extract of *T. claussenii*[118]. The stem part of T. connaroides contained palmitic acid, nonacosanol, n-heptacosyl alcohol[119]. *T. heudelotti* leaves was showed four compounds. They were protocatechuic acid, 4-hydroxybenzoic acid, 2-methylprotocatechuic acid, 2-propylonoxy-β-resorcylic acid[120].

α-tocopherol, N-methylproline were also found in leaves part of *T. lepidota*. 3-hydroxy-4-methoxycinamaldeide, 3,5-dimethoxy-4-hydroxycinamaldeide, 4-hydroxy-3,5-dimethoxybenzaldeide, chlorogenic acid were isolated from *T. sp*[121]. 4-hydroxy-N-methylproline was found in *T. schomburgkii*[122] (**Figure 24**).

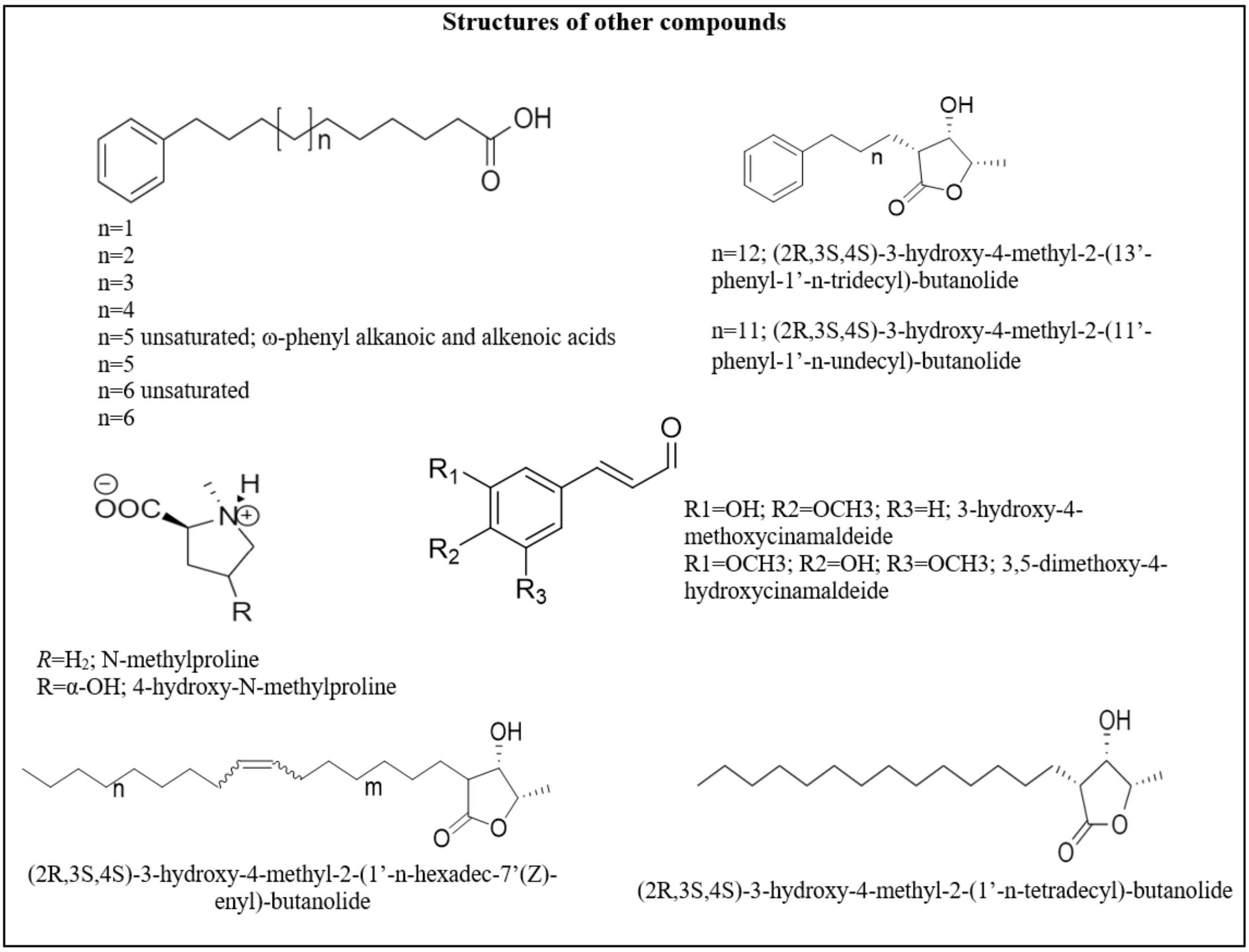


Figure 24. (*Continued*).

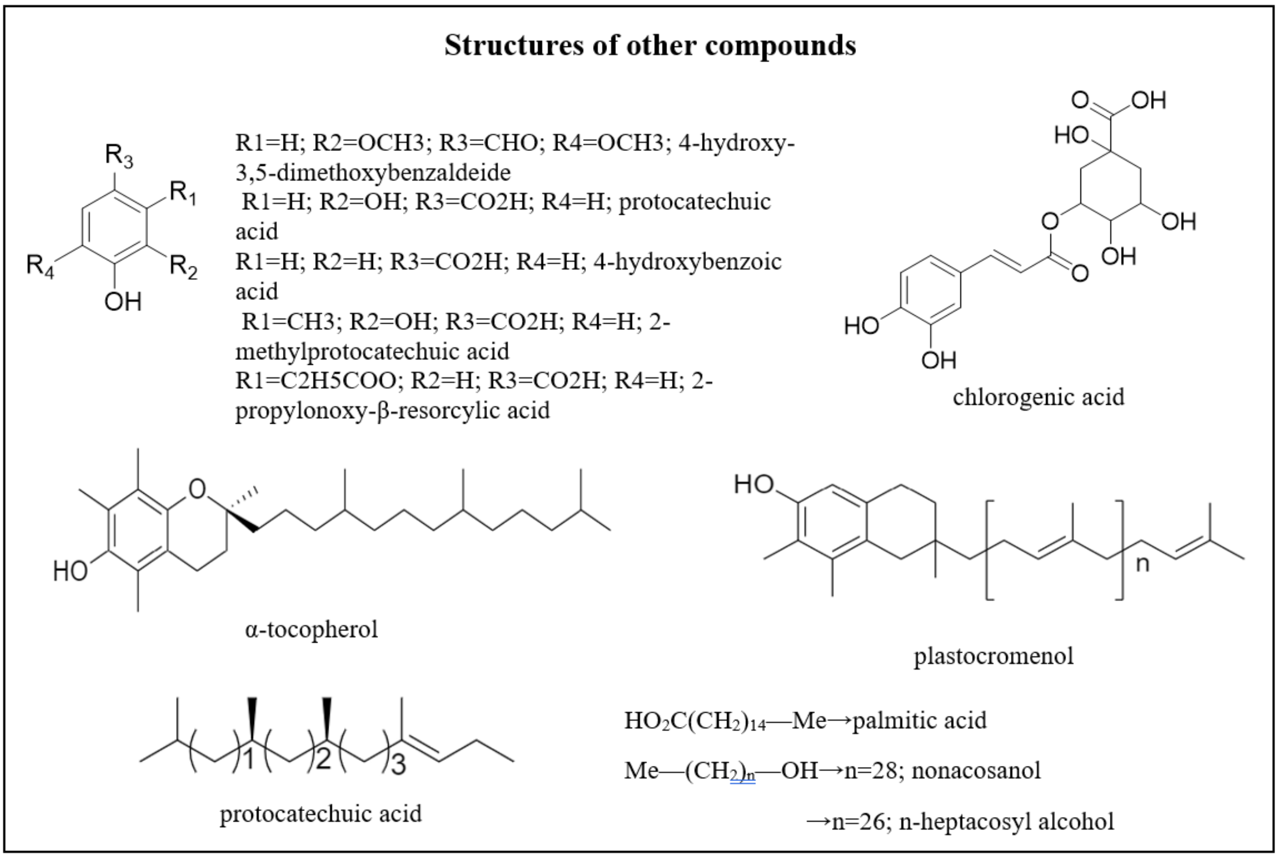


Figure 24. Structures of other forms from Genus *Trichilia*.

6. Result and discussion

The substance of *Trichilia* were segregated and recognized 334 unique mixtures, which are circulated in monoterpenes, diterpenes, sesquiterpenes, triterpenes, limonoids, steroids, coumarins, phenolic acids, flavonoids, phenolic acids and lignans shaping the compound constitution of this *Trichilia* genus. The compound constituents were found at various sum as indicated by the part of the plant of the types of origin. **Figure 25** is addressed the different rate of various synthetic build following leaves, wood, natural products, seeds and roots. We can see that Compounds got from the metabolic pathway of terpenes were huger, addressing 88.1% of the mixtures separated and recognized from different and a few types of plant species. Among the different carbon skeletons of this *Trichilia*, feature the limonoids addressing an aggregate of 31.5% of the mixtures separated from different *Trichilia* species. It very well may be seen that the limonoids, present in lower sums in the leaves of types of this *Trichilia* variety with 17.6% of every single confined compound, are more plentiful in stems and branches, roots, products of the soil[123–127].

stems and branches—19.1%,

roots—58%,

fruits—60%

seeds—82.1%

total—31.5%

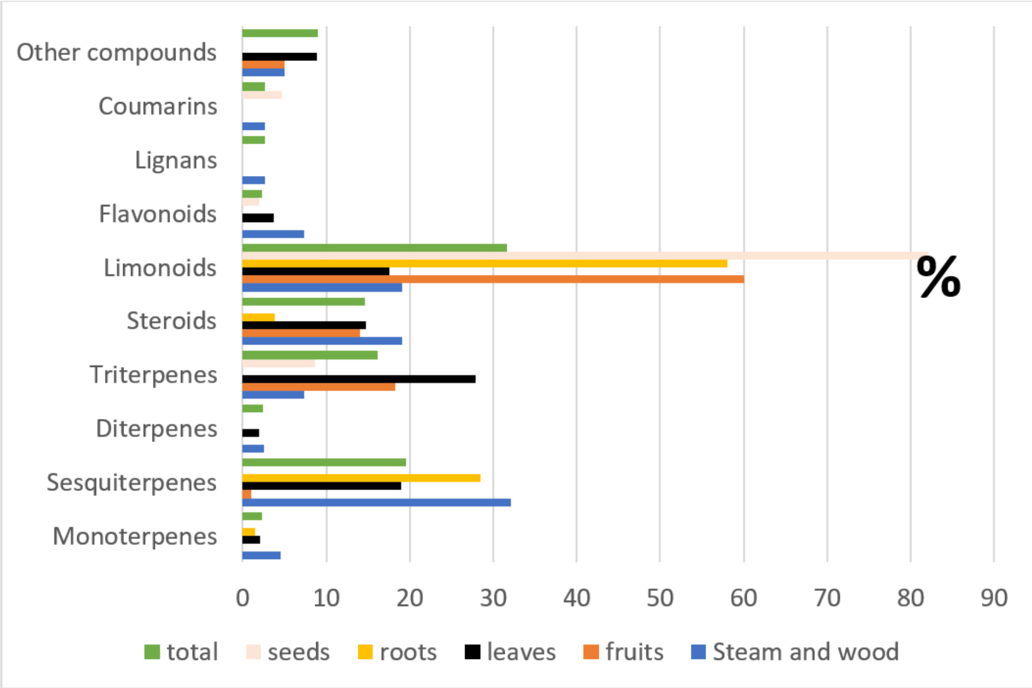


Figure 25. Comparison of different percentage of chemical compound according to their different plant parts.

Forty-seven types of *Trichilia* were found in Brazil, in a time of 15 years just three species were examined in regards to their remedial action (*Trichilia* catigua, *Trichilia* lepidota and *Trichilia* silvatica). Comparing with the impacts of other medicinal plants in terms of activity and toxicity, many species of *Trichilia* family are not still explored and thus, accordingly suggesting further investigations to experimentally approve the activity of its constituents. Restorative plants are significant for the union of new medications. In this specific circumstance, the family *Trichilia* is promising, due to its natural exercises and its secondary metabolites. Nonetheless, we saw that numerous types of this family have diminished quantities of studies. Maybe this reality can be disclosed because of their confined geological area. Dispersing the information procured with regards to these plants is to be sure significant for future examination.

7. Conclusion

About the phytochemical the *Trichilia* gender, many secondary metabolites derived primarily from the biosynthetic route of terpenes were isolated. Several terpenoid classes have been described, among which stand out sesquiterpenes, triterpenes and tetranortriterpenes, which may be related to insecticidal activity. *Trichilia* genus in overall display antimicrobial and cytotoxic activities against some cell's cancer: these activities can be attributed to limonoids, coumarins and triterpens. Also reported was the presence of steroids, coumarins, pregnans, lignans, lactones, flavonoids, limonoids, tannins, fatty acids, vitamin E, amino acids and ω-phenyl alkanoic acids and alkenoics. *Trichilia* species, as we mentioned in this article, still have a lot to give us in terms of fighting and even avoiding diseases like atherosclerosis, diabetes, fungal, neoplastic, bacterial and neurological disorders. Antineoplastic, anti-inflammatory, insecticidal and other properties of *Trichilia limonoids* have been investigated in vitro. Surprisingly, there are little works on the insecticidal action of Meliaceae.

Conflict of interest

The authors declare no conflict of interest.

References

1. The Plant List Version 1. Available online: http://www.theplantlist.org/ (accessed on 1 January 2021).

2. Sytsma, Kenneth J. and Porter, Duncan M. "Sapindales" Encyclopedia Britannica. Available online: https://www.britannica.com/plant/Sapindales (accessed on 23 December 2021).
3. Das GF, Da Silva MF, Gottlieb OR, Dreyer DL. Evolution of limonoids in the Meliaceae. Biochemical Systematics and Ecology. 1984, 12(3): 299-310. doi: 10.1016/0305-1978(84)90053-x
4. Forman LL, Pennington TD, Styles BT. A Generic Monograph of the Meliaceae. Kew Bulletin. 1979, 34(2): 419. doi: 10.2307/4110009
5. Pennington TD. Systematic Treatment of American *Trichilia* (Meliaceae). Phytotaxa. 2016, 259(1): 18. doi: 10.11646/phytotaxa.259.1.5
6. Terra W, Vieira I, Braz-Filho R, et al. Lepidotrichilins A and B, New Protolimonoids with Cytotoxic Activity from Trichilia Lepidota (Meliaceae). Molecules. 2013, 18(10): 12180-12191. doi: 10.3390/molecules181012180
7. del Carmen Ramírez M, Toscano RA, Arnason J, et al. Structure, Conformation and Absolute Configuration of New Antifeedant Dolabellanes from Trichilia trifolia. Tetrahedron. 2000, 56(29): 5085-5091. doi: 10.1016/s0040-4020(00)00423-3
8. Khare S, Singh NB, Singh A, et al. Plant secondary metabolites synthesis and their regulations under biotic and abiotic constraints. Journal of Plant Biology. 2020, 63:203-216. doi: https://doi.org/10.1007/s12374-020-09245-7.
9. Al-Khayri JM, Rashmi R, Toppo V, et al. Plant Secondary Metabolites: The Weapons for Biotic Stress Management. Metabolites. 2023, 13(6), 716.
10. Ali Ghasemzadeh. Flavonoids and phenolic acids: Role and biochemical activity in plants and human. Journal of Medicinal Plants Research. 2011, 5(31). doi: 10.5897/jmpr11.1404
11. Cheynier V, Comte G, Davies KM, et al. Plant phenolics: Recent advances on their biosynthesis, genetics, and ecophysiology. Plant Physiology and Biochemistry. 2013, 72: 1-20. doi: 10.1016/j.plaphy.2013.05.009
12. Gonzalez-Ramirez M, Limachi I, Manner S, et al. Trichilones A–E: New Limonoids from Trichilia adolfi. Molecules. 2021, 26(11): 3070. doi: 10.3390/molecules26113070
13. Campos MM, Fernandes ES, Ferreira J, et al. Antidepressant-like effects of Trichilia catigua (Catuaba) extract: evidence for dopaminergic-mediated mechanisms. Psychopharmacology. 2005, 182(1): 45-53. doi: 10.1007/s00213-005-0052-1
14. Taciany Bonassoli V, Micheli Chassot J, Longhini R, et al. Subchronic administration of Trichilia catigua ethyl-acetate fraction promotes antidepressant-like effects and increases hippocampal cell proliferation in mice. Journal of Ethnopharmacology. 2012, 143(1): 179-184. doi: 10.1016/j.jep.2012.06.021
15. Viana AF, Maciel IS, Motta EM, et al. Antinociceptive Activity ofTrichilia catiguaHydroalcoholic Extract: New Evidence on Its Dopaminergic Effects. Evidence-Based Complementary and Alternative Medicine. 2011, 2011: 1-8. doi: 10.1093/ecam/nep14
16. Truiti MT, Soares L, Longhini R, et al. Trichilia catigua ethyl-acetate fraction protects against cognitive impairments and hippocampal cell death induced by bilateral common carotid occlusion in mice. Journal of Ethnopharmacology. 2015, 172: 232-237. doi: 10.1016/j.jep.2015.05.060
17. Espada S, Faccin-Galhardi L, Rincao V, et al. Antiviral Activity of Trichilia catigua Bark Extracts for Herpesvirus and Poliovirus. Current Pharmaceutical Biotechnology. 2015, 16(8): 724-732. doi: 10.2174/1389201016666150505125235
18. Gomes RM, de Paulo LF, Bonato Panizzon CP do N, et al. Anti-Diabetic Effects of the Ethyl-Acetate Fraction of Trichilia catigua in Streptozo-tocin-Induced Type 1 Diabetic Rats. Cellular Physiology and Biochemistry. 2017, 42(3): 1087-1097. doi: 10.1159/000478761
19. Martins NO, de Brito IM, Araújo SSO, et al. Antioxidant, anticholinesterase and antifatigue effects of Trichilia catigua (catuaba). BMC Complementary and Alternative Medicine. 2018, 18(1). doi: 10.1186/s12906-018-2222-9
20. Ogbole OO, Akinleye TE, Segun PA, et al. In vitro antiviral activity of twenty-seven medicinal plant extracts from Southwest Nigeria against three serotypes of echoviruses. Virology journal. 2018,15:1-8. doi: https://doi.org/10.1186/s12985-018-1022-7
21. Ritter MR, Tempesta de O Marcelo, Makimori RY, et al. Dimeric glycosylated flavan-3-ol and antimicrobial in vitro evaluation of Trichilia catigua extracts. Natural Product Research. 2019, 35(19): 3293-3300. doi: 10.1080/14786419.2019.1698569
22. Germanò MP, D'Angelo V, Sanogo R, et al. Hepatoprotective and antibacterial effects of extracts from Trichilia emetica Vahl. (Meliaceae). Journal of Ethnopharmacology. 2005, 96(1-2): 227-232. doi: 10.1016/j.jep.2004.09.011
23. Eldeen IMS, Elgorashi EE, van Staden J. Antibacterial, anti-inflammatory, anti-cholinesterase and mutagenic effects of extracts obtained from some trees used in South African traditional medicine. Journal of Ethnopharmacology. 2005, 102(3): 457-464. doi: 10.1016/j.jep.2005.08.049
24. Geyid A, Abebe D, Debella A, et al. Screening of some medicinal plants of Ethiopia for their anti-microbial properties and chemical profiles. Journal of Ethnopharmacology. 2005, 97(3): 421-427. doi: 10.1016/j.jep.2004.08.021
25. Sosa EH, Duharte AB, Portuondo D, et al. Immunorestorative in immunosuppressed Balb/c mice and cytotoxic activity of water extract from Trichilia hirta root. Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas. 2010, 9(6): 457-464. https://corpus.co.id/en/lil-644984

26. Sosa EH, Castejón YM, Duharte AB, et al. Leukocyte-Stimulating Effect and Phytochemical Screening ofTrichilia hirtaExtracts. Journal of Medicinal Food. 2011, 14(9): 1057-1059. doi: 10.1089/jmf.2010.0166
27. Hernandez E, González B, Díaz A, et al. Ethnopharmacological evaluation of Trichilia hirta L. as anticancer source in traditional medicine of Santiago de Cuba. Bol. latinoam. Caribe de plantas medicinales y aromáticas. 2013, 12: 176-185. https://corpus.co.id/en/lil-722790.
28. Sosa EH, Mora Gonzalez N, Morris Q, Humberto J. Actividad citotóxica de extractos acuosos de hojas de Trichilia hirta sobre células tumorales humanas. Cuban Journal of Biomedical Research. 2013, 32(1): 93-101. https://corpus.co.id/en/lil-673097
29. Krief S, Huffman MA, Sévenet T, et al. Bioactive properties of plant species ingested by chimpanzees (Pan troglodytes schweinfurthii) in the Kibale National Park, Uganda. American Journal of Primatology. 2006, 68(1): 51-71. doi: 10.1002/ajp.20206
30. Kuglerova M, Halamova K, Kokoska L, et al. Antimicrobial activity of Ugandan Medicinal Plants. Planta Medica. 2007, 73(09). doi: 10.1055/s-2007-986895
31. Eldeen IM, Van Staden J. Antimycobacterial activity of some trees used in South African traditional medicine. South African Journal of Botany. 2007 Apr 1;73(2):248-51.
32. Naidoo D, van Vuuren SF, van Zyl RL, et al. Plants traditionally used individually and in combination to treat sexually transmitted infections in northern Maputaland, South Africa: Antimicrobial activity and cytotoxicity. Journal of Ethnopharmacology. 2013, 149(3): 656-667. doi: 10.1016/j.jep.2013.07.018
33. Opawale B, Oyetayo A, Agbaje R. Phytochemical Screening, Antifungal and Cytotoxic Activities of Trichilia heudelotii Planc (Harm). International Journal of Sciences: Basic and Applied Research. 2015, 24(6): 267-276. https://corpus.co.id/en/56442254
34. Silva LL da, Almeida R de, Silva FT e, et al. Review on the therapeutic activities of the genus Trichilia. Research, Society and Development. 2021, 10(5): e29610514916. doi: 10.33448/rsd-v10i5.14916
35. Da Silva JV, dos Santos RC, Júnior PCO, et al. Anti-inflammatory, Antioxidant and Antiproliferative Activities from Trichilia silvatica (C.DC). Current Pharmaceutical Biotechnology. 2019, 19(12): 973-981. doi: 10.2174/1389201020666181123121817
36. Ben I, Woode E, Koffuor G, et al. Anti-anaphylactic effects of Trichilia monadelpha (Thonn.) J. J. De Wilde extracts on rodent models of anaphylaxis. Research in Pharmaceutical Sciences. 2016, 11(5): 397. doi: 10.4103/1735-5362.192491
37. Subbarao P, Ashok P. Antihyperlipidemic effect of Trichilia connaroides in hypercholesterolemic rats and its possible mechanism. Journal of Pharmacy and Bioallied Sciences. 2011, 3(2): 230. doi: 10.4103/0975-7406.80777
38. Pant AK, Kumar R, Verma G, et al. Head Space GC/MS Analysis of Volatile Constituents of Trichilea connaroides Wight and Arn. Extracts and their in vitro Anti- Plasmodium Activity Against Plasmodium falciparum Isolates. Research Journal of Phytochemistry. 2011, 5(1): 41-47. doi: 10.3923/rjphyto.2011.41.47
39. Tissot AC, Oliveira SL, Duque JEL, et al. Evaluation of the Repellent Effect of the Essential Oil from the Leaves of Trichilia pallida Swartz (Meliaceae) on Aedes aegypti Mosquitoes (Portuguese). In: Proceedings of the 34th Annual Convention of Brazilian Society of Chemistry; 23-26 May 2011; Florianópolis City, Santa Catarina State. CD Data.
40. Traore M, Zhai L, Chen M, et al. Cytotoxic kurubasch aldehyde fromTrichilia emetica. Natural Product Research. 2007, 21(1): 13-17. doi: 10.1080/14786410600921698
41. Garcez WS, Garcez FR, Ramos L, et al. Sesquiterpenes from Trichilia catigua. Fitoterapia. 1997, 68(1): 87-88.
42. Curcino Vieira IJ, da Silva Terra W, dos Santos Gonçalves M, et al. Secondary Metabolites of the Genus Trichilia: Contribution to the Chemistry of Meliaceae Family. American Journal of Analytical Chemistry. 2014, 05(02): 91-121. doi: 10.4236/ajac.2014.52014
43. Senthilkumar N, Murugesan S, Vijayalakshmi KB. GC-MS-MS analysis of Trichilia connaroides (Wight & Arn.) Bentv (Meliaceae): A tree of ethnobotanical records. Asian J Plant Sci Res. 2012;2(2):193-97.
44. Doe M, Shibue T, Haraguchi H, et al. Structures, Biological Activities, and Total Syntheses of 13-Hydroxy- and 13-Acetoxy-14-nordehydrocacalohastine, Novel Modified Furanoeremophilane-Type Sesquiterpenes from Trichilia cuneata. Organic Letters. 2005, 7(9): 1765-1768. doi: 10.1021/ol050346k
45. Nangmo KP, Tsamo TA, Zhen L, Mkounga P, Akone SH, Tsabang N, Müller WE, Marat K, Proksch P, Nkengfack AE. Chemical constituents from leaves and root bark of Trichilia monadelpha (Meliaceae). Phytochemistry Letters. 2018 Feb 1;23:120-6.
46. Paritala V, Chiruvella KK, Thammineni C, et al. Phytochemicals and antimicrobial potentials of mahogany family. Revista Brasileira de Farmacognosia. 2015, 25(1): 61-83.
47. Vieira IJC, Figueiredo ER, Vieira MGC, et al. Two novel cycloartane-type triterpenes from Trichilia casaretti C. DC.(Meliaceae). Molecules. 2018, 23(4): 949.
48. Pupo MT, Adorno MAT, Vieira PC, et al. Terpenoids and Steroids from Trichilia Species. Journal of the Brazilian Chemical Society. 2002, 13(3): 382-388. doi: 10.1590/s0103-50532002000300014
49. Rodrigues VF, Carmo HM, Oliveira RR, et al. Isolation of Terpenoids from Trichilia quadrijuga (Meliaceae) by Droplet Counter-Current Chromatography. Chromatographia. 2009, 70(7-8): 1191-1195. doi: 10.1365/s10337-009-1293-7

50. Benjamin O, Michael O, Modupe AA. Evaluation of bioactivity of stem bark extracts of Lovoa trichiliodes (Harm) and Trichilia heudelotii Planc (Harm). GSC Biological and Pharmaceutical Sciences. 2018, 2(1): 001–008. doi: 10.30574/gscbps.2018.2.1.0019
51. Aladesanmi AJ, Odediran SA. Antimicrobial activity of Trichilia heudelotti leaves. Fitoterapia. 2000, 71(2): 179-182. doi: 10.1016/s0367-326x(99)00143-4
52. Mosqueta IS. Morphology and Development of Fruits, Seeds and Seedlings of Cabralea canjerana Vell. Mart., Guarea Kunthiana A. Juss and Trichilia catigua A. Juss (Meliaceae-Melioideae) (Portuguese) [Master's thesis]. Paulista State University; 1995.
53. Ji KL, Zhang P, Li XN, et al. Cytotoxic limonoids from Trichilia americana leaves. Phytochemistry. 2015, 118: 61-67. doi: 10.1016/j.phytochem.2015.08.014
54. Chan WR, Taylor DR. Hirtin and deacetylhirtin: new "limonoids" from Trichilia hirta. Chem Commun (London). 1966, 0(7): 206-207. doi: 10.1039/c19660000206
55. Cortez DAG, Vieira PC, Fernandes JB, et al. Limonoids from Trichilia hirta. Phytochemistry. 1992, 31(2): 625-628. doi: 10.1016/0031-9422(92)90048-u
56. Simmonds MS, Stevenson PC, Porter EA, Veitch NC. Insect Antifeedant Activity of Three New Tetranortriterpenoids from Trichilia p allida. Journal of Natural Products. 2001 Aug 24;64(8):1117-20.
57. Curcino Vieira MG, Filho RB, Curcino Vieira IvoJ. Curcinomarcoide, a Novel Limonoid from Trichilia hirta (Meliaceae)—Complete 1H and 13C Chemical Shift Assignments. Natural Product Communications. 2019, 14(5): 1934578X1984361. doi: 10.1177/1934578x19843611
58. Longhini R, Lonni AA, Sereia AL, et al. Trichilia catigua: therapeutic and cosmetic values. Revista Brasileira de Farmacognosia. 2017, 27: 254-71.
59. Matos AP, Nebo L, Vieira PC, et al. Constituintes químicos e atividade inseticida dos extratos de frutos de Trichilia elegans E T. catigua (Meliaceae). Química Nova. 2009, 32(6): 1553-1556. doi: 10.1590/s0100-40422009000600037
60. Liu SB, Chen HQ, Feng G, et al. A new insecticidal havanensin-type limonoid from the roots of Trichilia *sinensis* Bentv. Natural Product Research. 2017, 32(23): 2797-2802. doi: 10.1080/14786419.2017.1380016
61. Arenas C, Rodriguez-Hahn L. Limonoids from Trichilia havanensis. Phytochemistry. 1990, 29(9): 2953-2956. doi: 10.1016/0031-9422(90)87113-9
62. Passos MS, Nogueira TS, Azevedo OD, Vieira MG, Terra WD, Braz-Filho R, Vieira IJ. Limonoids from the genus Trichilia and biological activities. Phytochemistry Reviews. 2021 Oct 1:1-32.
63. Rodríguez-Hahn L, Cárdenas J, Arenas C. Trichavensin, a prieurianin derivative from Trichilia havanensis. Phytochemistry. 1996, 43(2): 457-459. doi: 10.1016/0031-9422(96)00245-2
64. Ortego F, López-Olguín J, Ruíz M, et al. Effects of Toxic and Deterrent Terpenoids on Digestive Protease and Detoxication Enzyme Activities of Colorado Potato Beetle Larvae. Pesticide Biochemistry and Physiology. 1999, 63(2): 76-84. doi: 10.1006/pest.1998.2386
65. Taylor DR. New limonoids from Trichilia trifolia. Rev Latinoam Quı´m. 1971, 2: 87–92
66. Kubo I, Klocke JA. An insect growth inhibitor fromTrichilia roka (Meliaceae). Experientia. 1982, 38(6): 639-640. doi: 10.1007/bf01964065
67. Nakatani M, James JC, Nakanishi K. Isolation and structures of trichilins, antifeedants against the Southern army worm. Journal of the American Chemical Society. 1981, 103(5): 1228-1230. doi: 10.1021/ja00395a046
68. Nakatani M, Nakanishi K. Structures of Insect Antifeeding Limonoids, Trichilins F and G, from Trichilia roka. Heterocycles. 1993, 36(4): 725. doi: 10.3987/com-92-6194
69. Germanò MP, D'Angelo V, Biasini T, Sanogo R, De Pasquale R, Catania S. Evaluation of the antioxidant properties and bioavailability of free and bound phenolic acids from Trichilia emetica Vahl. Journal of ethnopharmacology. 2006 May 24;105(3):368-73.
70. Gunatilaka AAL, da Bolzani SV, Dagne E et al (**1998**) Limonoids showing selective toxicity to DNA repair-deficient yeast and other constituents of Trichilia emetica. *J Nat Prod* 61:179–184
71. Liu SB, Mei WL, Chen HQ, et al. Limonoids from the roots of Trichilia sinensis and their cytotoxicities. Archives of Pharmacal Research. 2017, 41(12): 1170-1177. doi: 10.1007/s12272-017-0915-0
72. Nakatani M, Iwashita T, Mizukawa K, et al. Trichilinin, a New Hexacyclic Limonoid from Trichilia roka. Heterocycles. 1987, 26(1): 43. doi: 10.3987/r-1987-01-0043
73. Armelle TT, Pamela NK, Pierre M, et al. Antiplasmodial Limonoids from Trichilia rubescens (Meliaceae). Medicinal Chemistry. 2016, 12(7): 655-661. doi: 10.2174/1573406412666160106154357
74. Tsamo Tontsa A, Mkounga P, Njayou FN, et al. Rubescins A, B and C: new havanensin type limonoids from root bark of Trichilia rubescens (Meliaceae). Chemical and Pharmaceutical Bulletin. 2013, 61(11): 1178-1183. doi: 10.1248/cpb.c13-00506
75. Tsamo AT, Melong R, Mkounga P, et al. Rubescins I and J, further limonoid derivatives from the stem bark of Trichilia rubescens (Meliaceae). Natural Product Research. 2018, 33(2): 196-203. doi: 10.1080/14786419.2018.1443087
76. Krief S, Martin MT, Grellier P, et al. Novel Antimalarial Compounds Isolated in a Survey of Self-Medicative Behavior of Wild Chimpanzees in Uganda. Antimicrobial Agents and Chemotherapy. 2004, 48(8): 3196-3199. doi: 10.1128/aac.48.8.3196-3199.2004

77. Tsamo AT, Pagna JIM, Nangmo PK, et al. Rubescins F–H, new vilasinin-type limonoids from the leaves of Trichilia rubescens (Meliaceae). Zeitschrift für Naturforschung C. 2019, 74(7-8): 175-182. doi: 10.1515/znc-2018-0187
78. deCarvalho ACV, Ndi CP, Tsopmo A, et al. A Novel Natural Product Compound Enhances cAMP-Regulated Chloride Conductance of Cells Expressing CFTRΔF508. Molecular Medicine. 2002, 8(2): 75-87. doi: 10.1007/bf03402077
79. Cortez DAG, Fernandes JB, Vieria PC, et al. Meliacin butenolides from Trichilia estipulata. Phytochemistry. 1998, 49(8): 2493-2496. doi: 10.1016/s0031-9422(98)00234-9
80. Connolly JD, Hill RA. Triterpenoids. Natural Product Reports. 2002;19(4):494-513.
81. Cortez DAG, Fernandes JB, Vieira PC, et al. Separation and purification of meliacin butenolides from Trichilia estipulata by normal-phase HPLC. Journal of Liquid Chromatography & Related Technologies. 2001, 24(3): 415-423. doi: 10.1081/jlc-100001344
82. Kowa TK, Tchokouaha LRY, Cieckiewicz E, et al. Antileishmanial and cytotoxic activities of a new limonoid and a new phenyl alkene from the stem bark of Trichilia gilgiana (Meliaceae). Natural Product Research. 2019, 34(22): 3182-3188. doi: 10.1080/14786419.2018.1553879
83. Chan WR, Gibbs JA, Taylor DR. The limonoids of Trichilia havanensis JACQ: An epoxide rearrangement. Chemical Communications (London). 1967, (14): 720. doi: 10.1039/c19670000720
84. Champagne DE, Koul O, Isman MB, et al. Biological activity of limonoids from the Rutales. Phytochemistry. 1992, 31(2): 377-94.
85. Okorie DA, Taylor DAH. The structure of heudelottin, an extractive from Trichilia heudelottii. Chemical Communications (London). 1967, (2): 83. doi: 10.1039/c19670000083
86. Okorie DA, Taylor DAH. Limonoids from the timber of Trichilia heudelottii Planch. ex Oliv. Journal of the Chemical Society C: Organic. Published online 1968: 1828. doi: 10.1039/j39680001828
87. Mulholland DA, Taylor DAH. Limonoids from the seed of the natal mahogany, Trichilia dregeana. Phytochemistry. 1980, 19(11): 2421-2425. doi: 10.1016/s0031-9422(00)91040-9
88. Komane BM, Olivier EI, Viljoen AM. Trichilia emetica (Meliaceae)–A review of traditional uses, biological activities and phytochemistry. Phytochemistry Letters. 2011, 4(1): 1-9.
89. Musza L, Killar LM, Speight P, et al. Minor limonoids from Trichilia rubra. Phytochemistry. 1995, 39(3): 621-624. doi: 10.1016/0031-9422(94)00959-w
90. Adesida GA, Okorie DA. Heudebolin: A new limonoid from Trichilia heudelotii. Phytochemistry. 1973, 12(12): 3007-3008. doi: 10.1016/0031-9422(73)80532-1
91. Tinto WF, Jagessar PK, Ketwaru P, et al. Constituents of Trichilia schomburgkii. Journal of Natural Products. 1991, 54(4): 972-977. doi: 10.1021/np50076a008
92. Connolly JD, Labbé C, Rycroft DS et al. Tetranortriterpenoids and related compounds. Part 23. Complex tetranortriterpenoids from Trichilia prieuriana and Guarea thompsonii (Meliaceae), and the hydrolysis products of dregeanin, prieurianin, and related compounds. Journal of Chemical Research. 1979, 8: 256–257.
93. Tsamo A, Langat MK, Nkounga P, et al. Limonoids from the West African Trichilia welwitschii (Meliaceae). Biochemical Systematics and Ecology. 2013, 50: 368-370. doi: 10.1016/j.bse.2013.04.011
94. Rodríguez B, Caballero C, Ortego F, Castañera P. A New Tetranortriterpenoid from Trichilia h avanensis. Journal of natural products. 2003, 66(3):452-4.
95. Jolad SD, Hoffmann JJ, Schram KH, et al. Constituents of Trichilia hispida (Meliaceae). 3. Structures of the cytotoxic limonoids: hispidins A, B, and C. The Journal of Organic Chemistry. 1981, 46(3): 641-644. doi: 10.1021/jo00316a035
96. Eldeen IM, Van Heerden FR, Van Staden J. Biological activities of cycloart-23-ene-3, 25-diol isolated from the leaves of Trichilia dregeana. South African Journal of Botany. 2007, 73(3):366-71.
97. Garcez FR, Garcez WS, Tsutsumi MT, et al. Limonoids from Trichilia elegans ssp. elegans. Phytochemistry. 1997, 45(1): 141-148. doi: 10.1016/s0031-9422(96)00737-6
98. Org CG. The Plant List with literature.
99. Nayak S, Chaphekar M, Vaidhun B. Ethnobotanical review of Trichilia catigua A. Juss. Annals of Plant Sciences. 2013, 2(11): 497-502.
100. Wang XN, Fan CQ, Yin S, et al. Structural elucidation of limonoids and steroids from Trichilia connaroides. Phytochemistry. 2008, 69(6): 1319-1327. doi: 10.1016/j.phytochem.2008.01.018
101. Liu CP, Xu JB, Han YS, et al. Trichiconins A–C, Limonoids with New Carbon Skeletons from Trichilia connaroides. Organic Letters. 2014, 16(20): 5478-5481. doi: 10.1021/ol5027552
102. Chen AH, Wen Q, Ma YL, et al. Bioactive mexicanolide-type limonoids from the fruits of Trichilia connaroides. Phytochemistry Letters. 2017, 20: 17-21. doi: 10.1016/j.phytol.2017.03.008
103. Inada A, Konishi M, Murata H, et al. Structures of a New Limonoid and a New Triterpenoid Derivative from Pericarps of Trichilia connaroides. Journal of Natural Products. 1994, 57(10): 1446-1449. doi: 10.1021/np50112a016
104. Wang GC, Fan YY, Shyaula SL, et al. Triconoids A–D, Four Limonoids Possess Two Rearranged Carbon Skeletons from Trichilia connaroides. Organic Letters. 2017, 19(8): 2182-2185. doi: 10.1021/acs.orglett.7b00873

105. Ji KL, Cao DH, Li XF, et al. Two new limonoids from the roots of Trichilia connaroides with inhibitory activity against nitric oxide production in lipopolysaccharide-stimulated RAW 264.7 cells. Phytochemistry Letters. 2015, 14: 234-238. doi: 10.1016/j.phytol.2015.10.020
106. Liu SB, Mei WL, Chen HQ, et al. Mexicanolide-Type Limonoids from the Roots of Trichilia sinensis. Molecules. 2016, 21(9): 1152. doi: 10.3390/molecules21091152
107. Liu SB, Chen HQ, Guo ZK, et al. Phragmalin-type limonoids from the roots of Trichilia sinensis. RSC Advances. 2017, 7(46): 28994-29003. doi: 10.1039/c7ra01785e
108. Zhang Q, Di YT, He HP, et al. Phragmalin- and Mexicanolide-Type Limonoids from the Leaves of Trichilia connaroides. Journal of Natural Products. 2011, 74(2): 152-157. doi: 10.1021/np100428u
109. An FL, Luo J, Wang XB, et al. Trichiconlides A and B: two novel limonoids from the fruits of Trichilia connaroides. Organic & Biomolecular Chemistry. 2016, 14(4): 1231-1235. doi: 10.1039/c5ob02300a
110. An FL, Sun DM, Wang XB, et al. Trichiconlides C F, four new limonoids with 1,2-seco phragmalin-type carbon skeleton from the fruits of Trichilia connaroides. Fitoterapia. 2018, 125: 72-77. doi: 10.1016/j.fitote.2017.12.023
111. Wang HY, Wang JS, Zhang Y, et al. Inhibitory effect of four triterpenoids from Trichilia connaroides on nitric oxide production in lipopolysaccharide-stimulated RAW264.7 cells. Chemical and Pharmaceutical Bulletin. 2013, 61(10): 1075-1080. doi: 10.1248/cpb.c13-00286
112. Fang X, Di Y, Geng Z, et al. Trichiliton A, a Novel Limonoid from Trichilia connaroides. European Journal of Organic Chemistry. 2010, 2010(7): 1381-1387. doi: 10.1002/ejoc.200901245
113. An FL, Luo J, Li RJ, Luo JG, Wang XB, Yang MH, Yang L, Yao HQ, Sun HB, Chen YJ, Kong LY. Spirotrichilins A and B: two rearranged spirocyclic limonoids from Trichilia connaroides. Organic letters. 2016 Apr 15;18(8):1924-7.
114. Geng ZL, Fang X, Di YT, et al. Trichilin B, a novel limonoid with highly rearranged ring system from Trichilia connaroides. Tetrahedron Letters. 2009, 50(18): 2132-2134. doi: 10.1016/j.tetlet.2009.02.147
115. Geng ZL, Fang X, Di YT, et al. A New Limonoid fromTrichilia connaroides. Zeitschrift für Naturforschung B. 2010, 65(6): 762-764. doi: 10.1515/znb-2010-0613
116. Tang W, Hioki H, Harada K, et al. Antioxidant Phenylpropanoid-Substituted Epicatechins from Trichilia catigua. Journal of Natural Products. 2007, 70(12): 2010-2013. doi: 10.1021/np0703895
117. Rocha WC. Search for Bioactive Substances in Amazonian Plants: Adiscanthus fusciflorus (Rutaceae), Trichilia pallida and T. rubra (Meliaceae) (Portuguese) [Master's thesis]. Federal University of São Carlos; 2004.
118. Lagos JB. Comparative Study of the Chemical Composition of the Leaves and Bark of Trichilia catigua A. Juss., Meliaceae (Portuguese) [Master's thesis]. Federal University of Paraná; 2006.
119. Dudecula M, Somasekhar V, Purnima A, Patil S. Isolation, Characterization and Pharmacological Studies of a Flavonol Glucoside from Trichilia connaroides (W & A) Bentilizen. International Journal of Research in Science. 2011, 1(2): 91-101.
120. Beltrame FL, Filho ER, Barros FAP, et al. A validated higher-performance liquid chromatography method for quantification of cinchonain Ib in bark and phytopharmaceuticals of Trichilia catigua used as Catuaba. Journal of Chromatography A. 2006, 1119(1-2): 257-263. doi: 10.1016/j.chroma.2005.10.050
121. Cortez DAG, Fernandes JB, Cass QB, et al. Lignan Glycosides fromTrichilia estipulataBark. Natural Product Letters. 1998, 11(4): 255-262. doi: 10.1080/10575639808044957
122. Figueiredo. Phytochemical study of Trichilia casarettii and Trichilia sylvatica (Portuguese) [PhD thesis]. State University of North Fluminense, Campos dos Goytacazes; 2010.
123. Pupo MT, Vieira PC, Fernandes JB, et al. γ-lactones from Trichilia claussenii. Phytochemistry. 1998, 48(2): 307-310. doi: 10.1016/s0031-9422(97)01089-3
124. Lu H, Li J, Lu X, et al. Chemical Constituents of Trichilia connaroides (Chinese). Chinese Traditional Patent Medicine. 2011, 33: 1194-1196. doi: 10.1007/s10570-010-9464-0
125. Kougan GB, Tabopda T, Kuete V, Verpoorte R. Simple phenols, phenolic acids, and related esters from the medicinal plants of Africa. InMedicinal plant research in Africa 2013 Jan 1 (pp. 225-249). Elsevier.
126. Cazal CM, Alves AR, Matos AP, et al. Chemical Constituents of Trichilia sp (Meliaceae) and Biological Activity of Its Organic Extracts on Spodoptera frugiperda (Portuguese). In: Proceedings of the 31st Annual Convention of Brazilian Society of Chemistry; 26-29 May 2008; Águas de Lindóia City, São Paulo State. CD Data.
127. Tsopgni WD, Happi GM, Stammler HG, et al. Chemical constituents from the bark of the Cameroonian mahogany Trichilia emetica Vahl (Meliaceae). Phytochemistry Letters. 2019, 33:49-54.