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Genus *Cestrum* Therapeutic Potential: An Updated Review of its Phytochemical, Pharmacological, and Morphological Features

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Abstract
One of the most significant Solanaceae genera is *Cestrum* L. which was perceived as a folk remedy. The genus *Cestrum* is recognized for its ornamental usage in the oldest and newest studies. The genus *Cestrum* has interesting isolated compounds and promising *in-vivo* and *in-vitro* biological activities. A number of unique metabolite structures were verified throughout the species represented as saponins, lignans, and flavonoids. Saponins were mainly steroidal saponins (spirostanol and furostanol), phenolic acids, aldehydes, phenyl propanoids, and alkaloids, in addition to non-polar components, which were determined to a much lesser extent. Those phytoconstituents that were characterized in different parts of the species by applying different solvents are crucial for various biological actions, including anti-microbial, anti-cancer, anti-viral, anti - inflammatory, and insecticidal effects. This work has an updated review of the phytochemical, pharmacological, and morphological characterizations.

Keywords:;Jessamines; Traditional medicine; Saponins; Flavonoids; Anti-microbial; Insecticidal.

1. Introduction

Herbal medicine remains the foundation of basic healthcare for approximately 75–80% of the global population, primarily in developing countries, due to their inability to pay for expensive western drugs and healthcare, as well as the fact that traditional treatments are more acceptable from a cultural and spiritual perspective. The chemical components of herbal remedies or plants are thought to be more compatible with the human body since they are part of the physiological processes of live flora. Natural remedies made from plants have been used for centuries to treat a wide range of illnesses [1, 2]. Recently, there has been an increase in interest in using plant-based natural health supplements for both illness prevention and therapy [3]. Traditional medicine has long relied on medicinal plants to effectively treat disease and preserve health. Therefore, there is a lot of opportunity to explore new approaches to the prevention and treatment of disease using medicinal plants [4, 5].

The genus *Cestrum* is found in northern Mexico and southern Florida and comprises about 250 to 300 species. Due to their aromatic flowers, they are sometimes known as *Cestrums* or jessamines (from "jasmine"). They are shrubs that can reach heights of 1-4 m [6].

Cestrum species are well recognized for their use in traditional medicine, chemistry, pharmacology, and ornamental uses [7]. *C. nocturnum* is used by Chinese traditional medicine to cure swellings and burns [8]. *C. parqui* is used as an anti-pyritic and anti-inflammatory. *C. nocturnum* has previously been

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used as an antiepileptic in Chinese traditional medicine [9]. *C. laevigatum* has been used as sedative dressings for wounds, anti-spasmodics, and diuretics. *C. auriculatum* has been used for the cure of allergies, skin infections, pyrexia, and diarrhea [10].

Taxonomically, *Cestrum* is a genus of the family Solanaceae that belongs to the Solanales order then to the class Spermatopsida and Tracheophyta Phylum [7]. According to previous studies, the genus *Cestrum* contains flavonoids, lignans, saponins, phenolics, volatile oils, and alkaloid compounds. The genus has been used in the medical field for pharmacological and ethnopharmacological activities [10]. Recent studies have shown that this genus has promising effects in several areas, the most important of which are anti-microbial [11-13], anti-inflammatory [14, 15], anti-cancer [16-18], insecticidal [19-21], and molluscicidal activities [22]. In this work, we have an updated review of the genus *Cetrum* since it has gained interest and has promising *in-vitro* and *in-vivo* activities. We have collected and updated phytochemical, pharmacological, and morphological characterizations. The aim of this review was to summarize the current state of knowledge regarding the methods and effectiveness of the isolation of active substances from Cestrum L. and their pharmacological activities.

2. *Cestrum* L. Morphology Characterization

There are several different species of *Cestrum*, including trees, shrubs, and vines with sympodial, polyaxial, and monochasial branching. The mature plants are deciduous in nature. In the winter, leaves fall off and are quickly replaced by new growth in the spring. This new growth is supported by side branches with presence of a leaf at each node, giving the illusion of an opposing arrangement of uneven leaves on the surface. It might have monochassial or polyaxial branching. Solitary or clustered blooms with five fused sepals and petals distinguish members of this genus. Flowers may also be almost actinomorphic. Fruits are juicy, succulent berries that birds may readily consume and spread through the deposit of faeces. The blooms stand out and are mostly pollinated by insects. Corollas are long and tubular while anthers are short and longitudinally dehiscent. The berries are few-seeded and the ovary is superior and contained five stamens and two carpels [23].

3. Phytochemical studies

Numerous updated collections of different phytochemical studies from the genus *Cestrum* **(Table 1-2)**

3.1. Saponin compounds

Saponins are steroid or triterpene glycosides that are found in a wide variety of physiologically active compounds in plants and marine animals [24]. The oldest and most recent studies have shown an interest in these compounds since they have promising *in-vivo* and *in-vitro* activities such as anti-hypercholesterolemic, anti-inflammatory, antiallergic, cytotoxic, antitumor, and antiviral activities [25].

Fresh leaves of *C. nocturnum* were extracted with methanol to produce a novel steroidal saponin **(1)** [26] . Diurnoside I **(2)** has been detected in leaf extract of *C. diurnum* by Ahmad et al [27]. Also, a new monodesmosidic spirostanol glycoside **(3)** has been isolated from *C. nocturnum* leaves [28]**.** From *C. sendtenerianum*, Haraguchi and his coworkers have isolated have isolated seven spirostanol sapogenin **(4)** and saponins **(5-10)** [29, 30]

A phytochemical study by Mimaki et al. [18] resulted in the isolation of 7 steroidal saponins **(11-17**) from *C. nocturnum*. Moreover, cesdiurins I–III **(18-20)** were isolated by Fouad et al; 2008 [31]. As well as compounds **21** and **22** have been detected in *C. hediundinum* [32]. The fruits of *C. ruizteranianum* were extracted with aqueous methanol, and seven spirostane and furostane-type glycosides **(23-29)** were isolated in the study done by Galarraga et al. [33]. Spirostanol and furostanol steroidal saponins **(30-44)** have been isolated from *C. laevigatum* [34, 35]**.**

Other 2 spirostanol saponins **(45, 46)** have been isolated and elucidated from 80% ethanolic extract of the leaves of *C. schlechtendahlii* [36].

In a phytochemical analysis study of a methanolic extract of leaves from *C. parqui*, 4 steroidal saponins **(47-50)** have been detected in the leaf extract of *C. parqui* [37]. In addition, the phytochemical study done by Iguchi et al. [38] resulted in the isolation of 10 steroidal glycosides from *C. newelli* **(51-60)**.

Structures of saponin compounds reported in *Cestrum* species are illustrated in **Figure 1**.

3.2. Alkaloid compounds

The different species of *Cestrum* contained alkaloid in considerable amounts as previously mentioned. In *C. diurnm* and *C. nocturnum* leaf extract, 4 alkaloids **(61-64)** have been reported by Halim et al. [39]. Also, 1-carbamoylpyrrolidin-2 -one **(65)** has been detected in *C. nocturnum* [40]. Moreover, solanidine and solasodine **(66, 67)** have been isolated from *C. purpureum* [10]. cestrumines A and B **(68, 69)** have been identified in *C. hediundinum* **[32].** Structures of alkaloids reported in *Cestrum* species are illustrated in **Figure. 2**

3.3. Flavonoid and their glycosides

As presented in **Table 1** and **Figure 3,** methoxylated **(70, 71)** and non-methoxylated **(72- 77)** flavonol glycosides have been isolated from *C. nocturnum* and *C. hediundinum* [13, 15, 29].

3.4. Lignan compounds

Lignans are extensively dispersed across the plant world and have a long history as natural products [41]. Fiorentino and his coworkers have isolated 18 lignan compounds **(78-95)** from *C. parqui* [42]. Additionally, seven glycosides **(96-102)** have been isolated from the methanolic leaf extract of *C. diurnum* [43]. The structures of lignan compounds reported in *Cestrum* species are illustrated in **Figure 4.**

3.5. Miscellanous phenolic compounds

Phenolic compounds detected in *Cestrum* species have a wide variety of structures and functional characteristics [44]. According to previous studies, phenolic ~~compounds~~ acids, aldehydes, have a variety of promising activities, including anti-ageing, anti-inflammatory, antioxidant, and anti-proliferative agents [45]. **Table 1** and **Figure 5** describe 16 phenolic compounds **(103-118)** isolated from *C. parqui* [46].

3.6. Volatile oil, fixed oil and fatty acid compounds

The production of essential oils is considered as one of the most important characteristics of different species of *Cestrum* [12]. **Table 2** describes the volatile constituents present in *Cestrum*.

3.7. Vitamin D_3.

Day jasmine, or *C. diurnum* contains a calcinogenic glycoside known as 1, 25-dihydroxycholecalciferol or 1, 25-dihydroxyvitamin D3 [10].

Table 1: Phytochemical constituents of several *Cestrum* species

No.	Compounds name	Species	Ref.
	Saponins		
1	Nocturnoside A	*C. nocturnum*	[26]
2	Diurnoside I	*C. diurnum*	[27]
3	Nocturnoside B	*C. nocturnum*	[28]
4	spirosta-5,25 (27)-diene-1β, 2α, 3β, 12β-tetrol	*C. sendtenerianum*	[29]
5	1β, 2α, 12β-trihydroxyspirosta-5, 25 (27)-diene-3β-yl *O*- β- D-galactopyranoside	*C. sendtenerianum*	[29]
6	spirosta-5,25(27)-dien-1β,2α,3β--triol 3-O-α- L-rhamnopyranosyl -(1→2)-β- D-galactopyranoside	*C. sendtenerianum*	[30]
7	(25*R*)-spirost-5-en-1β,2α,3β-triol 3-O-α-L-rhamnopyranosyl-(1→2)-β- D-galactopyranoside	*C. sendtenerianum*	[30]
8	5α-spirost-25(27)-en-1β,2α,3β-triol 3-O-α-L-rhamnopyranosyl-(1→2)-β- D-galactopyranoside	*C. sendtenerianum*	[30]

9	(25*R*)-5*α*-spirostan-1*β*,2*α*,3*β*-triol 3-O-*α*-L -rhamnopyranosyl-(1→2)-*β*-D-galactopyranoside	*C. sendtenerianum*	[30]
10	spirosta-5,25(27)-dien-1*β*,2*α*,3*β*-triol 3-O-*α*-L-rhamnopyranosyl-(1→2)-O-[*β*-D-glucopyranosyl-(1→4)]-*β*- D-galactopyranoside	*C. sendtenerianum*	[30]
11	(25*R*)-spirost-5-en-2*α*,3*β*-diol 3-O-*β*- D-glucopyranosyl-(1→2)-O- [*β*- D-xylopyranosyl-(1→ 3)]-O-*β*- D-glucopyranosyl-(1→4)-*β*-D-galactopyranosid	*C. nocturnum*	[18]
12	(25*R*)-spirost-5-en-2*α*,3*β*,17*α*-triol 3-O-*β*-D-glucopyranosyl-(1→2)-O- [*β*-D-xylopyranosyl-(1→ 3)] -O-*β*-D-glucopyranosyl-(1→4)-*β*-D-galactopyranosid	*C. nocturnum*	[18]
13	(25*R*)-spirost-5-en-2*α*,3*β*-diol 3-O-*β*-D-glucopyranosyl-(1→3)-O-*β*-D-glucopyranosyl-(1→2)-O-[*β*-D-xylopyranosyl-(1→3)]-O-*β*-D-glucopyranosyl-(1→4)-*β*- D-galactopyranoside	*C. nocturnum*	[18]
14	(25*R*)-spirost-5-en-2*α*,3*β*,15-triol 3-O-*β*-D-glucopyranosyl-(1→3)-O-*β*-D-glucopyranosyl-(1→2)-O- [*β*- D -xylopyranosyl-(1→3)]-O-*β*-D-glucopyranosyl-(1→4)-*β*-D-galactopyranoside	*C. nocturnum*	[18]
15	(25*R*)-spirost-5-en-2*α*,3*β*,17*α*-triol 3-O-*β*-D- glucopyranosyl-(1→3)-O-*β*-D-glucopyranosyl-(1→2)-O- [*β*- D -xylopyranosyl-(1→3)]-O-*β*- D-glucopyranosyl-(1→4)-*β*-D-galactopyranoside	*C. nocturnum*	[18]
16	(25*R*)-spirost-5-en-3*β*-ol 3-O-*α*-L-rhamnopyranosyl-(1→2)-O-[O-*α*-*L*-rhamnopyranosyl-(1→4)-*α*-L- rhamnopyranosyl- (1→ 4)]-*β*-D-glucopyranoside	*C. nocturnum*	[18]
17	(25*R*)-spirost-5-en-2*α*,3*β*-diol 3-O-*α*- L-rhamnopyranosyl-(1→2)-O- [O-*α*-L-rhamnopyranosyl-(1→4)-*α*- L-rhamnopyranosyl- (1→ 4)]-*β*- *D*-glucopyranoside	*C. nocturnum*	[18]
18	Cesdiurin I	*C. diurnum*	[31]
19	Cesdiurin II	*C. diurnum*	[31]
20	Cesdiurin III	*C. diurnum*	[31]
21	Cestruside A	*C. hediundinum*	[32]
22	Cestruside B	*C. hediundinum*	[32]
23	Pennogenin 3-O-*β*-chacotrioside	*C. ruizteranianum*	[33]
24	(25*R*,26*R*)-spirost-5-ene-3*β*,17*α*,26 -triol 3-*O*-*β*-chacotrioside	*C. ruizteranianum*	[33]
25	Methyl protodioscin	*C. ruizteranianum*	[33]
26	Protodioscin	*C. ruizteranianum*	[33]
27	26-O-*β*-D-glucopyranosyl-(25 *R*)-furost-5-ene-3*β*,17*α*,22,26-tetrol 3- O-*β*-chacotrioside.	*C. ruizteranianum*	[33]
28	26-O-*β*-D-glucopyranosyl-22- methoxy-(25*R*)-furost-5-ene-3*β*,26-diol-3-O-*α*-L-rhamnopyranosyl-(1→4)-*α*-L-rhamnopyranosyl-(1→4)-[*α*-L-rhamnopyranosyl-(1→2)]-*β*- D-glucopyranoside	*C. ruizteranianum*	[33]
29	26-O- *β* – D -glucopyranosyl-(25*R*)-furost-5-ene-3*β*,22,26-triol-3-O-*α*-Lrhamnopyranosyl-(1→4)-*α*- L rhamnopyranosyl-(1→4)-[*α*-Lrhamnopyranosyl-(1→2)]-*β*- D -glucopyranoside	*C. ruizteranianum*	[33]
30	(25 *R*)-spirost-5-ene-3*β*,26*β*-diol 3-O-*α*- L -rhamnopyranosyl-(1→4)-*α*-L-rhamnopyranosyl-(1→4)-[(1→2)-*α*-L-rhamnopyranosyl]-*β*- D -glucopyranoside	*C. laevigatum*	[33]
31	(25 *R*)-spirost-6- ene-3*β*,5*β*-diol 3-O-*α*- *L*-rhamnopyranosyl-(1→ 4)-*α*- L-rhamnopyranosyl-(1→4)-[(1→2)-*α*-L-rhamnopyranosyl]-*β*-D-glucopyranosid	*C. laevigatum*	[35]
32	Chonglouoside SL-5	*C. laevigatum*	[35]

33	Formosanin C	*C. laevigatum*	[35]
34	Diosgenin O-*α*- L-rhamnopyranosyl-(1 → 4)-*α*-L-rhamnopyranosyl-(1 → 4)-β-D-glucopyranosid	*C. laevigatum*	[35]
35	26-O-*β*- D -Glucopyranosyl-(25 S)-5*α*-furost-20-ene,2*α*,3*β*-diol 3-O-*β*-D-galactopyranoside	*C. laevigatum*	[34]
36	26-O-*β*-D-Glucopyranosyl-(25*R*)-5*α*-furost-20-ene,2*α*,3*β*-diol 3-O-*β*-D-galactopyranoside	*C. laevigatum*	[34]
37	26-O-*β*- D-Glucopyranosyl-(25 S)-5*α*-furost-20-ene,2*α*,3*β*-diol 3-O-*β*-D galactopyranosyl-(1→4)-*β*- D -galactopyranoside	*C. laevigatum*	[34]
38	26-O-*β*-D-Glucopyranosyl-(25*R*)-5*α*-furost-20-ene,2*α*,3*β*-diol 3-O-*β*-D galactopyranosyl-(1→4)-*β*- D- galactopyranoside	*C. laevigatum*	[34]
39	(25 *S*)-5*α*-spirostan-2*α*,3*β*-diol-3-O-*β*- D- galactopyranoside	*C. laevigatum*	[34]
40	(25 *R*)-5*α*-spirostan-2*α*,3*β*-diol-3-O-*β*- D-galactopyranoside	*C. laevigatum*	[34]
41	(25 *S*)-5*α*-Spirostan-2*α*,3*β*-diol 3-O-*β*- D- glucopyranosyl-(1→2)-*α*-L-rhamnopyranosyl-(1→4)-*β*- D -galactopyranoside	*C. laevigatum*	[34]
42	(25 *R*)-5*α*-Spirostan-2*α*,3*β*-diol 3-O-*β*- D-glucopyranosyl-(1→2)-*α*-L-rhamnopyranosyl-(1→4)-*β*- D-galactopyranoside	*C. laevigatum*	[34]
43	(25 *S*)-5*α*-Spirostan-2*α*,3*β*-diol 3-O-*β*- D-glucopyranosyl-(1→4)-*β*-D galactopyranosyl -(1→4)-*β*- D-galactopyranoside	*C. laevigatum*	[34]
44	(25 *R*)-5*α*-Spirostan-2*α*,3*β*-diol 3-O-*β*- D-glucopyranosyl-(1→4)-*β*-D galactopyranosyl -(1→4)-*β*- D-galactopyranoside	*C. laevigatum*	[34]
45	(25 *R*)–5*α*–spirostan–1*β*,2*α,*3*β*-triol 3-O-*β*–D–galactopyranoside	*C. schlechtendahlii*	[34]
46	(25 *R*)–5*α*–spirostan–1*β*,2*α,*3*β*-triol 3-O-*α*–L–rhamnopyranosyl–(1→2)–*β*–D–galactopyranoside	*C. schlechtendahlii*	[34]
47	Parquispiroside	*C. parqui*	[37]
48	Parquifuroside	*C. parqui*	[37]
49	Capsicoside D	*C. parqui*	[37]
50	22-OMe-capsicoside D	*C. parqui*	[37]
51	(24*S*,25*S*)-spirost-5-en-2*α*,3*β,*12*β*,24-tetrol 3-O-*β*-D-glucopyranosyl-(1→4)-*β*-D-galactopyranoside	*C. newelli*	[38]
52	(24*S*)-spirosta-5,25(27)-dien-2*α*,3*β,*12*β*,24-tetrol 3-O-*β*-Dglucopyranosyl-(1→4)-*β*-D-galactopyranoside	*C. newelli*	[38]
53	spirosta-5,25(27)-dien-2*α,*3*β*-diol 3-O-*β*-D-glucopyranosyl-(1→4)-*β*-Dgalactopyranoside	*C. newelli*	[38]
54	26- [(*β*- D-glucopyranosyl)oxy]-2*α*-hydroxy-22*α*-methoxyfurosta-5,25(27)-dien-3*β*-yl-O-*β*-D-glucopyranosyl-(1→4)-*β*-D-galactopyranoside	*C. newelli*	[38]
55	26- [(*β*- D-glucopyranosyl)oxy]-2*α*-hydroxy-22*α*-methoxyfurosta-5,25(27)-dien-3*β*-yl-O-*α*-L-rhamnopyranosyl-(1→2)-O-[*α*-L-rhamnopyranosyl-(1→4)]-*β*- D-glucopyranoside	*C. newelli*	[38]
56	26- [(*β*- D-glucopyranosyl)oxy]-2*α*-hydroxyfurosta-5,20(22),25(27)-trien-3*β*-ylO-*β*- D-glucopyranosyl-(1→4)-*β*-D-galactopyranoside	*C. newelli*	[38]
57	26- [(*β*- D-glucopyranosyl)oxy]-2*α*-hydroxyfurosta-5,20(22),25(27)-trien-3*β*-ylO-*α*- L-rhamnopyranosyl-(1→2)-O-[*α*-L-rhamnopyranosyl-(1→4)]-*β*- D-glucopyranoside	*C. newelli*	[38]
58	(22*S*)-25- [(*β*- D-glucopyranosyl)oxy]-22-hydroxycholest-5-en-3*β*-yl-O-*α*-Lrhamnopyranosyl-(1→2)-O-[*α*-L-rhamnopyranosyl-(1→4)]-*β*-Dglucopyranoside	*C. newelli*	[38]
59	(22S,25*R*)-26-[(*β*-D-glucopyranosyl) oxy]-22-hydroxycholest-5-	*C. newelli*	[38]

60	en-3*β*-y- O-*α*L-rhamnopyranosyl-(1→2)-O-[*α*-L-rhamnopyranosyl-(1→4)]-*β*- D-glucopyranoside (22S,25*R*)-26 *β*- D-glucopyranosyl) oxy]-16,22-dihydroxycholest-5-en-3*β*-ylO-*α*-L-rhamnopyranosyl- (1→2)-O-[*α*-*L*-rhamnopyranosyl- (1→4)]-*β*-D glucopyranoside	*C. newelli*	[38]
	Alkaloids		
61	Nicotine	*C. nocturnum, C. diurnum*	[39]
62	Nornicotine	*C. nocturnum, C. diurnum*	[39]
63	Cotinine	*C. nocturnum, C. diurnum*	[39]
64	Myosmine	*C. nocturnum, C. diurnum*	[39]
65	1-Carbamoyl pyrrolidin-2-one	*C. nocturnum*	[39]
66	Solanidine	*C. purpureum*	[10]
67	Solasodine	*C. purpureum*	[10]
68	Cestrumine A	*C. hediundinum*	[32]
69	Cestrumine B	*C. hediundinum*	[32]
	Flavonoids		
70	4′,5-dihydroxy-7-methoxyflavonol 3-O- [6-O-(E)-3,5-dimethoxy-4-hydroxycinnamoyl-β-D-glucopyranosyl] -(1→2)-O-[α-L-rhamnopyranosyl-(1→6)]-*β*-D-glucopyranoside	*C. nocturnum*	[18]
71	4′,5- dihydroxy-7-methoxyflavonol 3-O-β-D-xylopyranosyl-(1→2)-O-[*α* -L-rhamnopyranosyl-(1→6)]-*β*-D-glucopyranoside	*C. nocturnum*	[18]
72	Nicotiflorin	*C. hediundinum*	[32]
73	Rutin	*C. hediundinum*	[32]
74	Kaempferol	*C. nocturnum*	[16]
75	Kaempferol 3-O-*α*-rhamnoside	*C. nocturnum*	[16]
76	Kaempferol 3-O-*β*-glucoside-7-O-*α*-rhamnoside	*C. nocturnum*	[16]
77	Kaempferol 3,7-di-O-*α*-rhamnoside	*C. nocturnum*	[16]
	Lignans		
78	(+)-pinoresinol	*C. parqui*	[42]
89	(+)-mediaresinol	*C. parqui*	[42]
80	(+)-syringaresinol	*C. parqui*	[42]
81	Syringaresinol 4-O-*β*-D-glucopyranoside	*C. parqui*	[42]
82	(+)-lariciresinol	*C. parqui*	[42]
83	(+)-Justiciresinol	*C. parqui*	[42]
84	5′-methoxylariciresinol	*C. parqui*	[42]
85	(-)-berchemol	*C. parqui*	[42]
86	Cis-dehydrodiconiferyl alcohol	*C. parqui*	[42]
87	Trans-dehydrodiconiferyl alcohol	*C. parqui*	[42]
88	(-)-simulanol	*C. parqui*	[42]
89	Cis- herpetotriol	*C. parqui*	[42]
90	Trans- herpetotriol	*C. parqui*	[42]
91	Dimethyl (7′E)-3,3′-dimethoxy-4,4′-oxyneolign-7′-ene-9,9′-dioate	*C. parqui*	[42]
92	9′-nor-3′,4,4′-trihydroxy-3,5-dimethoxylign-7-eno-9,7′-lactone	*C. parqui*	[42]
93	*threo*-4′,4″,7″,9″-tetrahydroxy-3,3′,3″,5′-tetramethoxy-4,8″-oxy-7,9′:7′,9-diepoxylignan	*C. parqui*	[42]

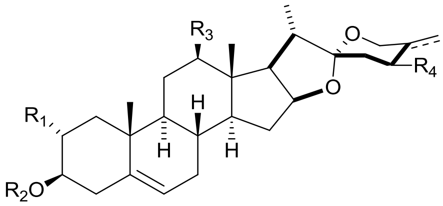
94	*erythro*-4′,4″,7″,9″-tetrahydroxy-3,3′,3″,5′-tetramethoxy-4,8″-oxy-7,9′:7′,9-diepoxylignan	*C. parqui*	[42]
95	*erythro*-4′,4″,7″,9″-tetrahydroxy-3,5,3′,3″,5′-pentamethoxy-4,8″-oxy-7,9′:7′,9-diepoxylignan	*C. parqui*	[42]
96	Cestrumoside.	*C. diurnum*	[43]
97	Berchemol-4'-O-*β*-glucopyranoside.	*C. diurnum*	[43]
98	Liriodendrin	*C. diurnum*	[43]
99	Dehydrodiconiferyl alcohol-4-O-*β*-glucopyranoside.	*C. diurnum*	[43]
100	(–)-Lyoniresinol 3a-O-*β*-glucopyranoside.	*C. diurnum*	[43]
101	(+)-Lyoniresinol 3a-O-*β*-glucopyranoside.	*C. diurnum*	[43]
102	Citroside B	*C. diurnum*	[43]
	Other phenolic		
103	4-hydroxybenzaldehyde	*C. parqui*	[46]
104	3,5-Dimethoxybenzaldehyde	*C. parqui*	[46]
105	4-hydroxybenzoic acid	*C. parqui*	[46]
106	methyl 4-hydroxybenzoate	*C. parqui*	[46]
107	Vanillic acid	*C. parqui*	[46]
108	Syringic acid	*C. parqui*	[46]
109	Methyl vanillate	*C. parqui*	[46]
110	Methyl syringate	*C. parqui*	[46]
111	Tirosol	*C. parqui*	[46]
112	3′,5′-dimethoxy-4′-hydroxy-(2-hydroxy) acetophenone	*C. parqui*	[46]
113	*p*-coumaric acid	*C. parqui*	[46]
114	Caffeic acid	*C. parqui*	[46]
115	methyl ester caffeic acid	*C. parqui*	[46]
116	methyl ferulate	*C. parqui*	[46]
117	*N*-(*p*-carboxymethylphenyl)-*p*-hydroxybenzamide	*C. parqui*	[46]
118	Rosmarinic acid	*C. parqui*	[46]

Table 2: Volatile constituents of different *Cestrum* species

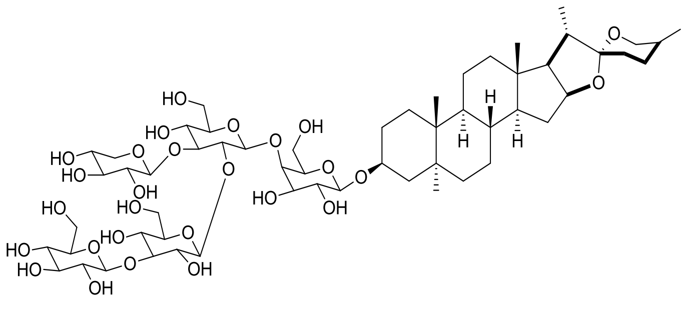
No.	Compunds name	Species	Ref.
1	Linalool	*C. nocturnum*	[47]
2	Benzaldehyde	*C. nocturnum*	[47]
3	benzyl alcohol	*C. nocturnum*	[47]
4	phenylacetaldehyde	*C. nocturnum*	[47]
5	cis-jasmone	*C. nocturnum*	[47]
6	benzyl acetate	*C. nocturnum*	[47]
7	methyl jasmonate	*C. nocturnum*	[47]
8	palmitic acid	*C. diurnum*	[13]
9	stearic acid	*C. diurnum*	[13]
10	oleic acid	*C. diurnum*	[13]
11	trans-2-Hexenal	*C. diurnum* *C. nocturnum*	[10]
12	*cis*-3-hexenyl acetate	*C. diurnum* *C. nocturnum*	[10]
13	*cis*-3-hexenol	*C. diurnum* *C. nocturnum*	[10]
14	*trans*-2-hexenol	*C. diurnum* *C. nocturnum*	[10]
15	L-arabinitol	*C. nocturnum*	[48]
16	trans-Z-α-bisabolene epoxide	*C. nocturnum*	[48]

17	isoeugenol	*C. nocturnum*	[48]
18	tetradecynoic acid	*C. nocturnum*	[48]
19	D-mannitol	*C. nocturnum*	[48]
20	Methoxyeugenol	*C. nocturnum*	[48]
21	heneicosane	*C. nocturnum*	[48]
22	Phytol	*C. diurnum*	[49]
23	Octadecyl acetate	*C. diurnum*	[49]
24	Tricosane	*C. diurnum*	[49]

	R_1	R_2
18	H	S1
54	OH	S1
55	OH	S2



	R_1	R_2	R_3	R_4	
1	OH	S4	H	H	
3	H	S5	H	H	
51	OH	S1	OH	OH	
52	OH	S1	OH	OH	$\Delta^{25(27)}$
53	OH	S1	H	H	$\Delta^{25(27)}$



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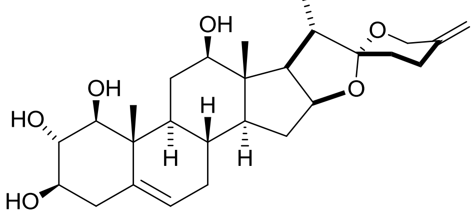

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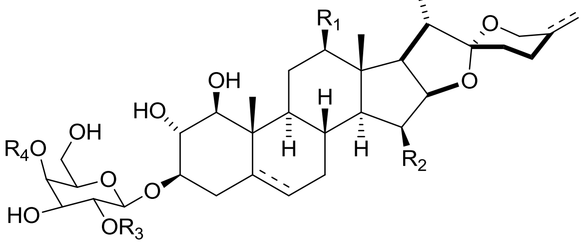
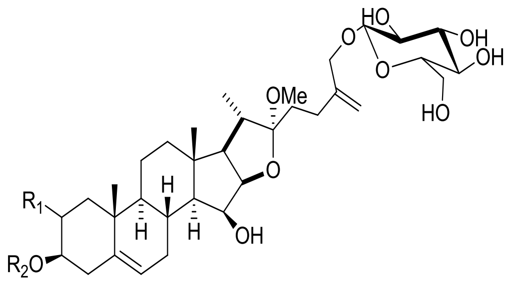
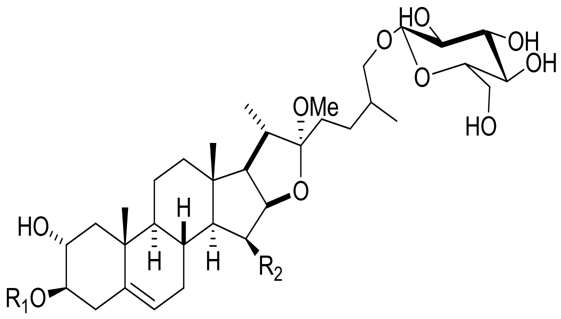
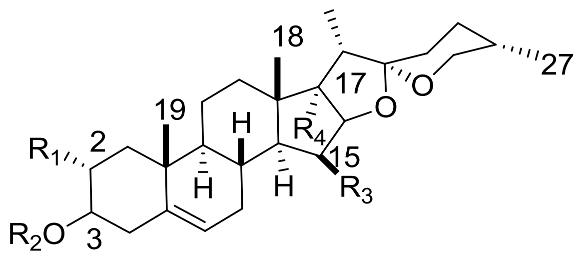


	R_1	R_2	R_3	R_4	
5	OH	H	H	H	$\Delta^{5,25(27)}$
6	H	H	Rha	H	$\Delta^{5,25(27)}$
7	H	H	Rha	H	Δ^{5}
8	H	H	Rha	H	$\Delta^{5, 25(27)}$
9	H	H	Rha	H	
10	H	H	Rha	β-D-Glc	$\Delta^{5, 25(27)}$
21	OH	H	Rha	H	$\Delta^{25(27)}$
22	OH	H	Rha	H	$\Delta^{5,25(27)}$
45	H	OH	H	H	
46	H	OH	Rha	H	

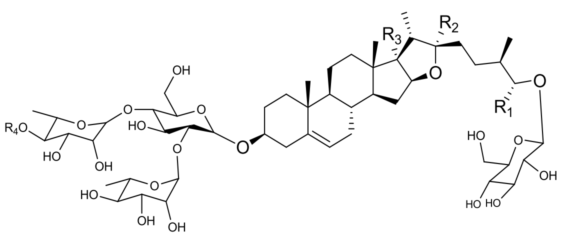


	R_1	R_2
19	S1	H
20	S1	OH

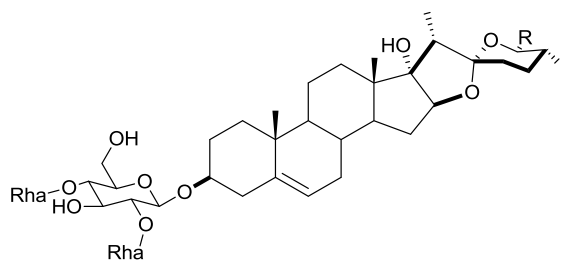




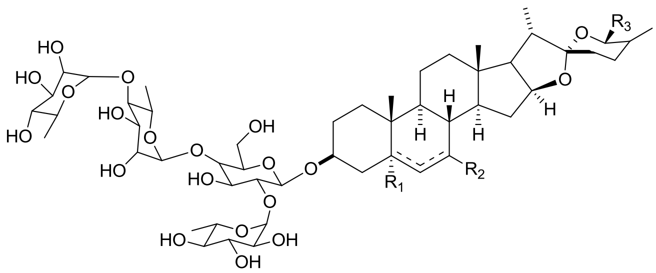
	R_1	R_2	R_3	R_4
11	OH	S1	H	H
12	OH	S1	H	OH
13	OH	S2	H	H
14	OH	S2	OH	H
15	OH	S2	H	OH
16	H	S3	H	H
17	OH	S3	H	H



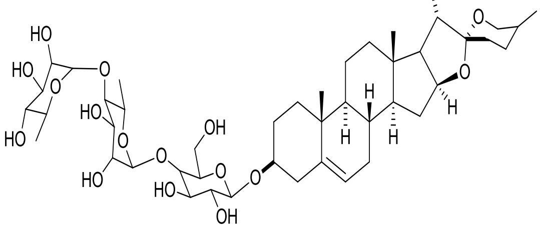
	R_1	R_2	R_3	R_4
25	H	OH	H	H
26	H	OCH_3	H	H
27	OH	OH	H	H
28	OH	OCH_3	OH	Rha
29	OH	OH	H	Rha



	R
23	H
24	OH



	R_1	R_2	R_3	
30	-	H	OH	Δ^5
31	OH	H	H	Δ^6
32	-	=O	H	Δ^5
33	-	H	H	Δ^5



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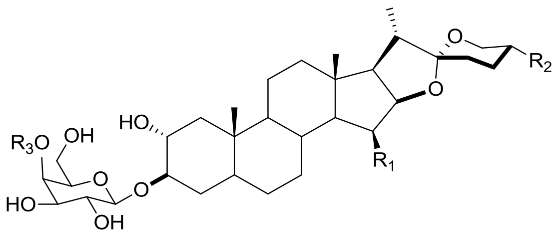
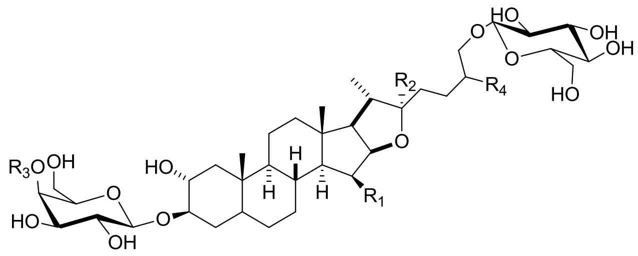
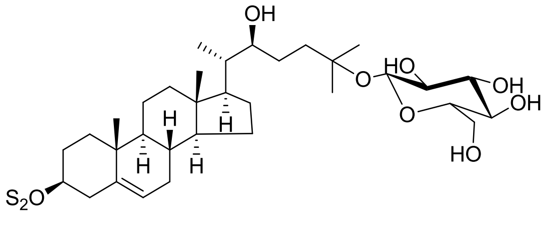
	R_1	R_2	R_3
39	H	β-CH_3	H
40	H	α-CH_3	H
41	H	β-CH_3	Glc 1-2 Gal
42	H	α-CH_3	Glc 1-2 Gal
43	H	β-CH_3	Glc 1-2 Rha
44	H	α-CH_3	Glc 1-2 Rha
47	OH	α-CH_3	S3





No.	R_1	R_2	R_3	R_4
35	H	H	H	β-CH_3
36	H	H	H	α-CH_3
37	H	H	Gal	β-CH_3
38	H	H	Gal	α-CH_3
48	OH	OH	S3	α-CH_3
49	H	OH	S3	α-CH_3
50	H	OMe	S3	α-CH_3



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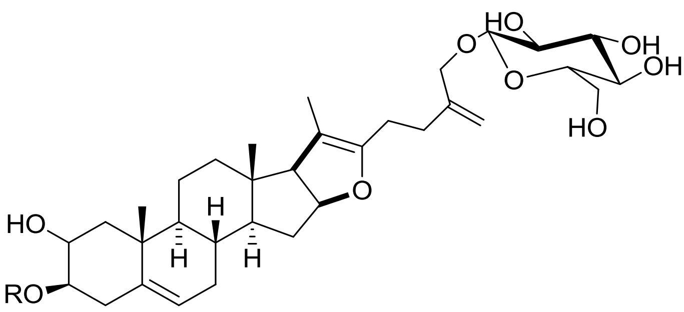
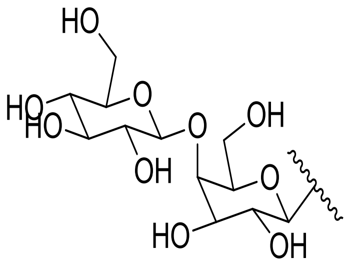
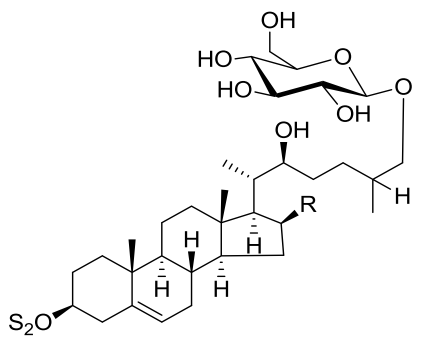


	R
56	S1
57	S2

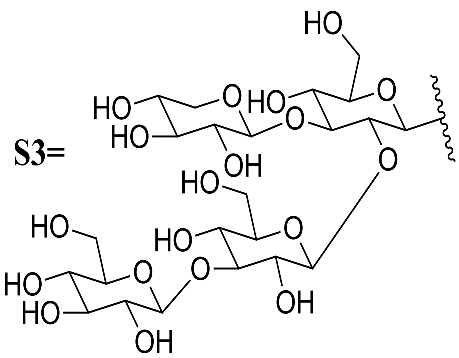
S1=





	R
59	H
60	OH

S3=



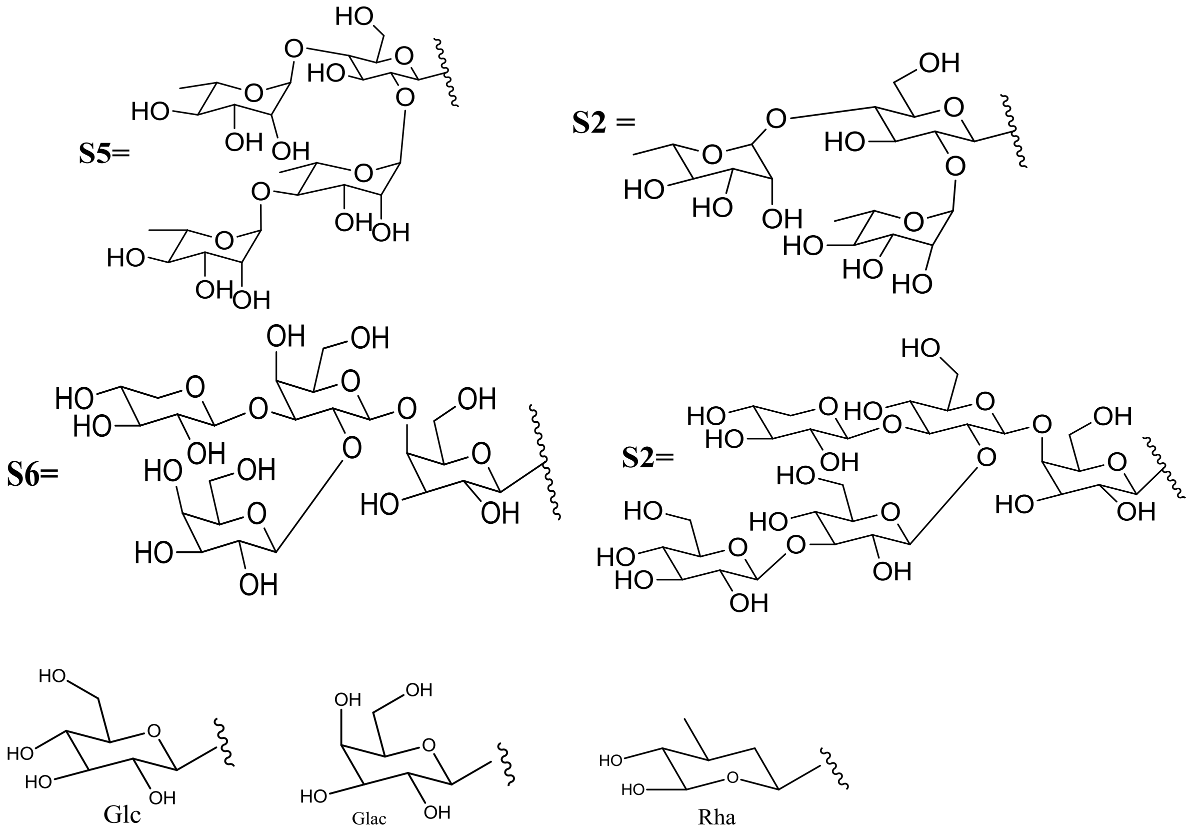


Figure 1: Structure of saponins reported in *Cestrum* species.

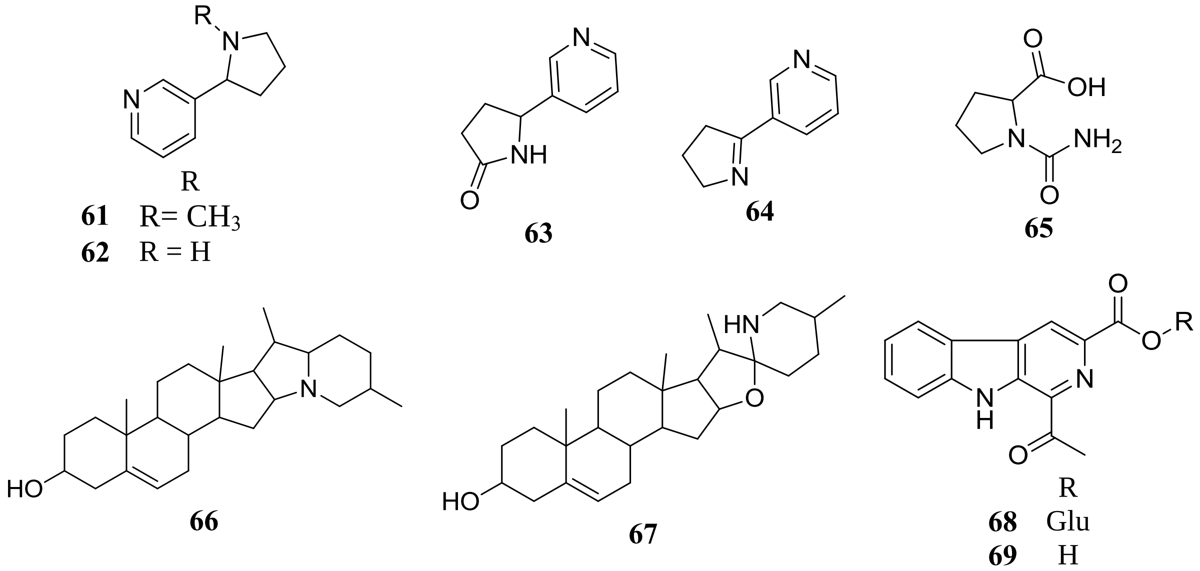
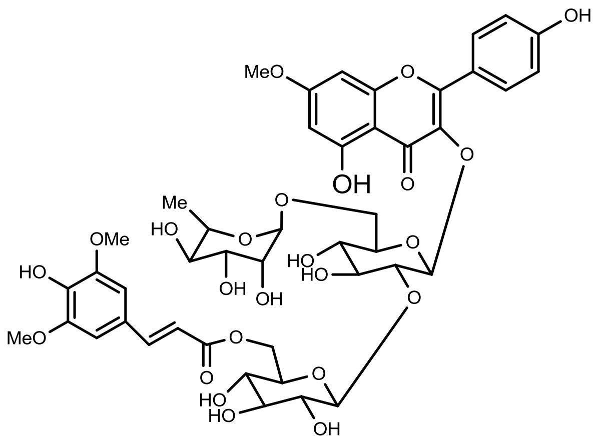


Figure 2: Structure of alkaloids reported in *Cestrum* species.



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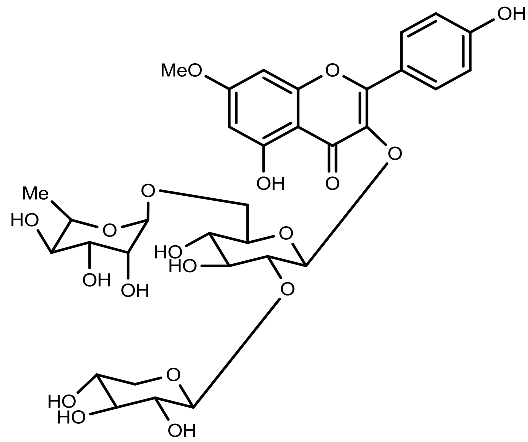

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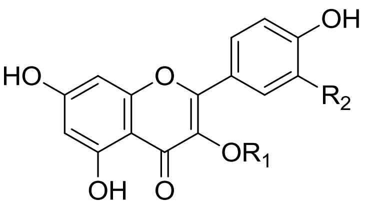
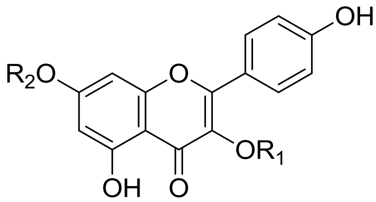
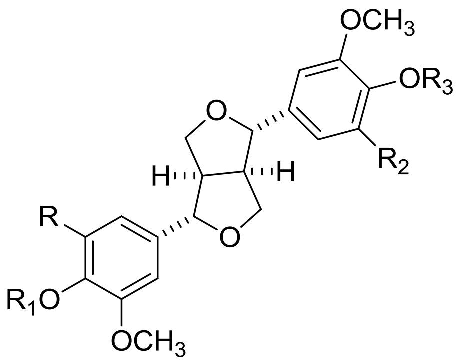


	R_1	R_2
72	Glc-Rha	H
73	Glc-Rha	OH

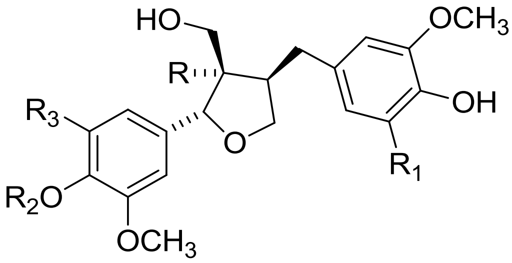


	R_1	R_2
74	H	H
75	Rha	H
76	Rha	Rha
77	Glc	Rha

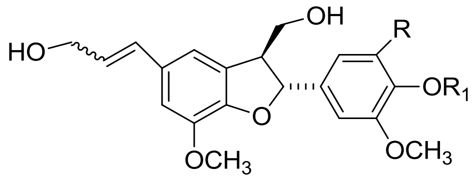
Figure 3: Structure of flavonoids reported in *Cestrum* species.



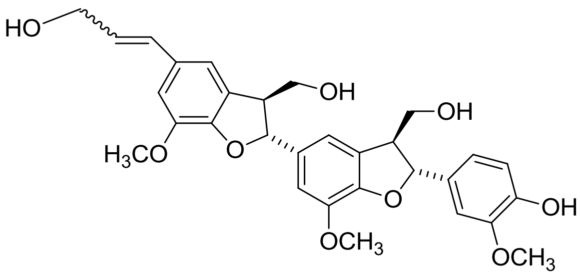
	R	**R_1**	**R_2**	**R_3**
78	H	H	H	H
79	H	H	OCH_3	H
80	OCH_3	H	OCH_3	H
81	OCH_3	H	OCH_3	Glc.
98	OCH_3	Glc	OCH_3	Glc.



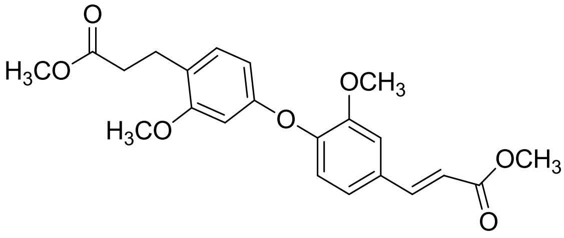
	R	**R_1**	**R_2**	**R_3**
82	H	H	H	H
83	H	OCH_3	H	H
84	H	H	H	OCH_3
85	OH	H	H	H
97	OH	H	Glc	H



	R	R_1	
86	H	H	*cis*
87	H	H	*trans*
88	OCH_3	H	*trans*
99	H	Glc	*trans*



89 *cis*
90 *trans*



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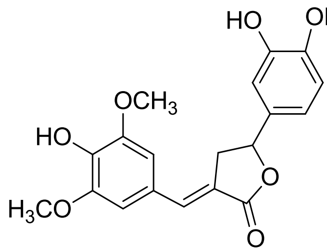

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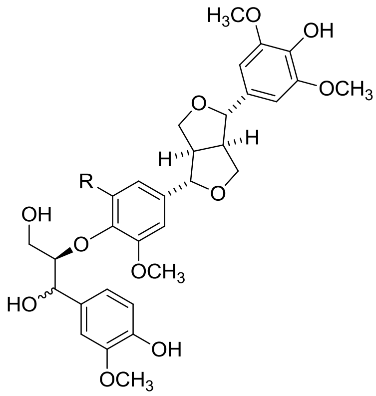
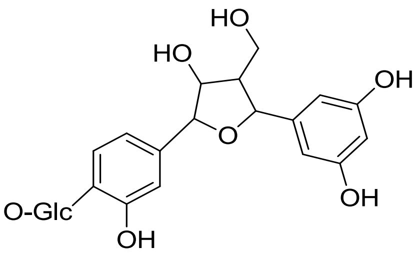


	R	
93	H	*threo*
94	H	*erythro*
95	OCH_3	*erythro*



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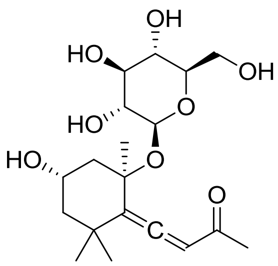

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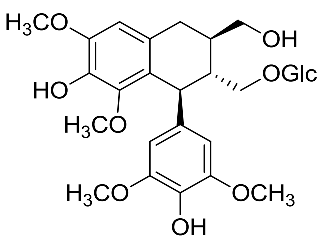

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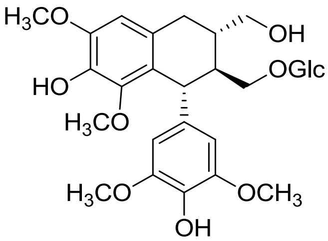

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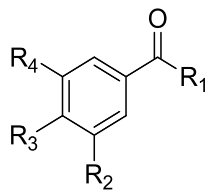
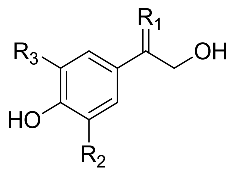
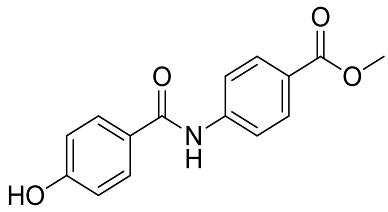
Figure 4: Structure of lignans reported in *Cestrum* species.



	R1	R2	R3	R4
103	H	OMe	H	OMe
104	H	H	OH	H
105	OH	H	OH	H
106	OMe	H	OH	H
107	OH	OMe	OH	H
108	H	OMe	OH	OMe
109	OMe	OMe	OH	H
110	OMe	OMe	OH	OMe



	R1	R2	R3
111	H, H	H	H
112	O	OMe	OMe



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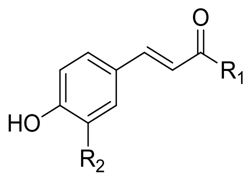

	R1	R2
113	OH	H
114	OH	OH
115	OMe	OMe
116	OMe	OH

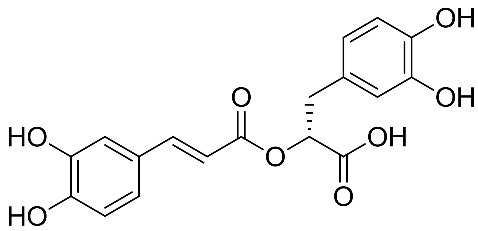

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Figure 5: Structure of other phenolic compounds reported in *Cestrum* species.

Pharamacological activities

Genus *cestrum* has showed promising pharmacological activities such as analgesic, anti-inflammatory [50] and anti-diabetic [51]. The saponin content of the *Cestrum* L. species may be connected to several important biological activities., whether it is the saponin rich fraction or the pure separated components [52] (**Table 3)**

4.1. Anti-microbial activity

A methanolic extract of *C. nocturnum* has anti-microbial activity against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans*, and *Aspergillus niger*. On the other hand, the n-butanol extract showed stronger activity against the previous organisms. In addition, the water and *n*-butanol extracts of the leaves of *C. elegans* revealed noticeable anti-microbial activity against the same strains [11].

Different fractions (*n*-hexane, chloroform, ethyl acetate, methanol, and essential oil) of the flowers of *C. nocturnum* have been tested on eleven food-borne pathogenic bacteria and showed antibacterial activity against. The oil had a strong inhibitory activity against *S. aureus*, *Listeria monocytogenes*, *Bacillus subtilis*, *Salmonella typhimurium*, and *Escherichia coli* with inhibition zones that ranged in diameter from 9.8-18.2 mm. When compared to the conventional antibiotic streptomycin, methanol extract had the highest antibacterial efficacy against

S. aureus, *L. monocytogenes*, and *B. subtilis*, with corresponding width zones of inhibition of 18.1, 18.4, and 17.0 mm [12].

Screening the antimicrobial activity of the essential oil of *C. diurnum* leaves against pathogenic strains of G+ve (*S. aureus* and *B. subtilis*) and G-ve (*E. coli* and *P. aeruginosa*) bacteria were conducted and showed strong *in-vitro* effects against *P. aeruginosa* and *S. aureus* [13].

4.1. Anti-inflammatory activity

C. diurnum n-hexane and methanol extracts contain ursolic acid, a pentacyclic triterpenoid with anti-inflammatory properties. It works as an immunomodulator by decreasing THelper-1 (T-h1) cytokines such as IL-1, IFN-, and TNF- (pro-inflammatory cytokines) and raising THelper-2 (T-h2) cytokines (anti-inflammatory agents), explaining its usage in arthritis [53].

Additionally, the *C. parqui* methanol: water (1:1) extract of the aerial parts revealed significant inhibition of the carrageenan-induced rat paw oedema [14].

4.3. Anticancer activity

The aerial parts of *C. nocturnum* were successively extracted with chloroform, ethyl acetate, and water then screened against MCF-7 (breast adenocarcinoma), NCI-H460 (non-small cell lung cancer, HCT-15 (colon carcinoma), HeLa (cervical carcinoma), and HepG2 (hepatocellular carcinoma) cell lines. The chloroform fraction demonstrated the maximum cytotoxicity against NCI-H460, HCT-15, and HepG2 cell lines. On the other hand, the ethyl acetate fraction showed the greatest cytotoxicity against cervical cancer cell lines [16].

The methanol extract of *C. diurnum* L. has been evaluated for cytotoxic activity using the brine shrimp lethality bioassay. The extract had LC_{50} values of 0.074 g/ml and LC_{90} values of 4.85 g/ml after 2 hours, and all shrimp died after 4 hours at the same dose [17].

The isolated compounds from *C. nocturnum* were investigated for their cytotoxic effects on normal human gingival fibroblasts and HSC-2 oral squamous cell carcinoma. Saponins showed remarkable activity against HSC-2 cells (human oral squamous cell carcinoma) but were weakly active against normal human gingival fibroblasts [18].

4.4. Insecticidal activity

C. nocturnum water and ethanol extracts of the leaves have been tested against *Tribolium confusum* and *Tribolium castaneum*. The alcoholic extract has much higher insecticidal efficacy against *Tribolium* sp [19].

C. parqui has been demonstrated to have substantial toxicity to neonate larvae, reducing population growth at concentrations over 0.6%. the aqueous extract reduces the reproductive capacity of adults, signaling a major impact on progeny [20].

The different fractions of *C. diurnum* have been assayed for biocontrol of the larval form of *Anopheles stephensi*. The chloroform: methanol (1:1 in v/v) extract had the greatest effectiveness as a biocontrol agent against the larval stages [21].

4.5. Anti-viral

The isolated compounds of *C. elegans*, including saponins and flavonoids, were evaluated against the Hepatitis A virus. One of the isolated steroidal saponin and flavonoid showed the highest antiviral activities with 34.3% and 25% antiviral activity, respectively. Mechanistically, the compounds interfered with the virus envelope glycoproteins, blocking the binding and fusion processes during virus-cell contacts, which is how the virus spreads [54]. The essential oil extracted from *C. diurnum* by different methods, including steam distillation, hydrodistillation, and microwave-assisted hydro-distillation, were assayed against HCoV-229E. The steam distillation extracted EO showed a promising antiviral activity with IC_{50} of 10.93 µg/mL, whereas, the other oil samples showed a moderate activity with IC_{50} values of 119.9 and 148.2 µg/mL, respectively [49]. And Alrabayah et al; 2022 have tested alcoholic leaf extract and zinc oxide nanoparticles and found promising anti-viral activities against HCoV-229E with IC_{50} of 61.15 µg/mL, 7.01 µg/mL and 2.41 µg/mL for combinations. [55]

Species	Tested sample	Reference
	Anti-microbial activity	
C. nocturnum	Methanolic extract and *n*-butanol extract of the leaves	[8]
C. nocturnum	*n*-Hexane, chloroform, ethyl acetate, methanol, and essential oil of the flower.	[9]
C. diurnum	Essential oil of leaves extracted using hydro-distillation.	[10]
	Anti-inflammatory activity	
C. diurnum	*n*-Hexane and methanol of the leaves	[50]
C. parqui	methanol: water (1:1) of the aerial parts	[11]
	Anticancer activity	
C. nocturnum	Chloroform and ethyl acetate fractions from 80 % methanol extract of the aerial parts	[13]
C. diurnum	Methanol extract of the aerial parts	[14]
C. nocturnum	Flavonol glycosides and saponins	[15]
	Insecticidal activity	
C. nocturnum	Water and ethanol extract of the leaves	[16]
C. parqui	*n*-Hexane, acetone, methanol/water (80:20), and aqueous extracts of the leaves.	[17]
C. diurnum	Pet. ether, hexane, ethyl acetate, (1:1 in v/v) $CHCl_3$: methanol, acetone and absolute alcohol extract of the leaves	[18]
	Anti-viral	
C. elegans	Dried flowers 85% MeOH	[51]
C. diurnum	Essential oil	[52]

Table 3: Pharmacological activities of different *Cestrum* species

4. Conclusion

The phytochemical, pharmacological, and morphological information on the genus *Cestrum* is reviewed and collected. A review of the literature confirms the presence of volatile oils, lignans, phenols, and steroidal saponins as well as alkaloids. In the near future, we hope to see more and more progress in studies on this genus because of its promising isolated chemical compounds and pharmacological activities.

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