

Review

Chemical Compounds, Pharmacological and Toxicological Activity of *Brugmansia suaveolens*: A Review

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Abstract: This study investigates updated information in different search engines on the distribution, phytochemistry, pharmacology, and toxicology of *Brugmansia suaveolens* (Solanaceae) using the extracts or chemical compounds at present. This plant has been used in traditional medicine in different cultures as a hallucinatory, analgesic, aphrodisiac, nematocide, sleep inducer, and muscle relaxant, as well as a treatment for rheumatism, asthma, and inflammation. The flowers, fruits, stems, and roots of the plant are used, and different chemical compounds have been identified, such as alkaloids, volatile compounds (mainly terpenes), coumarins, flavonoids, steroids, and hydrocarbons. The concentration of the different compounds varies according to the biotic and abiotic factors to which the plant is exposed. The toxic effect of the plant is mainly attributed to atropine and scopolamine, their averages in the flowers are 0.79 ± 0.03 and 0.72 ± 0.05 mg/g of dry plant, respectively. Pharmacological studies have shown that an aqueous extract exhibits the antinociceptive effect, at doses of 100 and 300 mg/kg i.p. in mice. On the other hand, the ethanolic extract at 1000 mg/L, showed a nematocidal activity in vitro of 64% against *Meloidogyne incognita* in 72 h. Likewise, it showed a 100% larvicidal activity at 12.5 mg/L against *Ancylostoma spp.* In another study, the lethal activity of shrimp in brine from an ethanolic extract showed an LC_{50} of 106 $\mu\text{g/mL}$ at double serial concentrations of 1000–0 ($\mu\text{g/mL}$). Although there are pharmacological and phytochemical studies in the plant, they are still scarce, which has potential for the examination of the biological activity of the more than one hundred compounds that have been reported, many of which have not been evaluated.

Keywords: alkaloids; terpenoid; scopolamine; antinociceptive; nematocide; toxicity

1. Introduction

Brugmansia suaveolens (Humb. and Bonpl. ex Willd.) Bercht. and J.Presl is widely distributed in the world both as a spontaneous species and as an ornamental plant [1], mainly in areas with climates ranging from tropical and subtropical to temperate [2]. It belongs to the Solanaceae family, and according to *The Plant List*, 12 are recognized in this genus, including hybrids and a subspecies (*Brugmansia arborea*, *B. × candida*, *B. × cubensis*, *B. × dolichocarpa*, *B. × insignis*, *B. longifolia*, *B. pittieri*, *B. × rubella*, *B. sanguinea*, *B. sanguinea* subsp. *vulcanicola*, *B. suaveolens*, and *B. versicolor*) [1]. The objective

of this review is to present complete and updated information on the current research regarding the distribution, phytochemistry, pharmacology, and toxicology of *B. suaveolens*, in order to identify its therapeutic potential and open new research opportunities. The most salient data were searched using the keyword “*Brugmansia suaveolens*” in Google Scholar, ScienceDirect, Wiley, Taylor and Francis, and PubMed. The synonyms, according to *The Plant List*, of *B. suaveolens* (Humb. and Bonpl. ex Willd.) Bercht. and C. Presl, are *Brugmansia albidoflava* (Lem.) Verschaff. ex Bosse (unresolved), *Datura albidoflava* Lem. (synonym), *Datura arborea* Mart. (synonym), *Datura gardneri* Hook. (synonym), *Datura suaveolens* Humb. and Bonpl. ex Willd. (synonym), *Datura suaveolens* f. *albidoflava* (Lem.) Voss (synonym), *Datura suaveolens* var. *macrocalyx* Sendtn. (synonym), *Pseudodatura suaveolens* Zijp (unresolved), and *Stramonium arboreum* Moench (unresolved) [1].

Brugmansia suaveolens is known by various names in different areas of the world, such as in Mexico (Floripondio or florifundio) [3], (Toloache de castilla) [4], Argentina (Floripón) [5], Peru (Misha Colambo (Snake)) [6], (Floripondio) [7], (Toe, Toe de flor blanca) [8], Brazil (Trombeteira or Cartucheira) [9], (Trompeta de Ángel) [10], Sweden (Angel’s Trumpet) [11], Sri Lanka (Attana) [12], and in Indonesia (Kecubung Bunga Kuning and Kecubung Bunga Putih) [13], (Cubung) [14], Pakistan (Shaitani ganti/Bel Boti) [15], and Butan (Gangmeto) [16]. In many other countries, *B. suaveolens* is better known by the name Angel’s Trumpet.

2. Botany

2.1. Taxonomical Classification

Brugmansia suaveolens, was discovered by Alexander von Humboldt and Aimé Bonpland (Humb. Bonpl. Ex Willd.). It was first formally described by Friederich von Berchtold and Jan Presl, and published in *Hortus suburbanus Londinensis* [1] (Table 1).

Table 1. Taxonomical classification of *Brugmansia suaveolens*.

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Order	Solanales
Family	Solanaceae
Subfamilia	Solanoideae
Tribe	Datureae
Genus	<i>Brugmansia</i>
Species	<i>B. suaveolens</i> [1]

Brugmansia suaveolens belongs to the group of woody plants [17], considered shrubs or small trees (Figure 1), with a length ranging from 1 to 6 m high. The petiole is 2–5 cm long; the leaf lamina, with the widest end below the middle part known as an elliptical 15–30 cm long and 5–12 cm wide; the corolla is formed by a tube with lobes of 25–30 cm long; and the basal half is a narrow tubular shape and abruptly expands to form extended lobes 10–15 cm long. The color of the flower is white or reddish. The fruit is narrow at the end and wide in the middle part, and is 20 cm long with a 2.5 cm diameter. Flowering begins in January and from April to November. It bears fruit from May to June and in October [3].



Figure 1. *Brugmansia suaveolens*.

2.2. Distribution

Brugmansia suaveolens is widely distributed around the world (Figure 2), including in the USA [2], Mexico [18], Honduras, Nicaragua, Panama, El Salvador, Paraguay, and the Antilles [3], Argentina [19], Bolivia [20], Costa Rica [21], Colombia [22], Ecuador [23], Venezuela [24], Peru [6], Chile [25], Brazil [18], Korea [26], Vietnam [27], Taiwan [28], India [29], Indonesia [30], Butan [16], Sri Lanka [12], Pakistan [15], Turkey [31], Australia [32], New Zealand [33], Cameroon, Madagascar, Tanzania [3], Uganda [34], Italy, Bulgaria [35], Netherlands [35], Germany [36], Hungary [37], Greece [38], and Sweden [39].



Figure 2. Global distribution map of *Brugmansia suaveolens*.

2.3. Ethnobotany

Many of these species are mainly appreciated as ornamentals, because of their ease of cultivation and the production of their characteristic flower smell at dusk [3], reaching its maximum peak at 21:00 [22]. *B. suaveolens* is also used in traditional medicine [3], despite being documented in the literature that its greatest use is as a hallucinogenic in shamanic rituals in some populations of Latin America [6], among them being some ethnic groups from the Amazon of Peru and Ecuador [40]. In the Inga people of Colombia, it is used externally to ward off the evil spirits that cause insomnia [41]. However, the first instances of its medicinal use were the Spanish in colonial times, where these plants were used for the treatment of rheumatism, infections, and asthma [42].

It is used to calm toothache [3]; to treat inflammation from trauma [6]; reduce general body inflammation [14]; for sores; to heal wounds without scars [6]; for treating pain in general [9], especially chest pain [43]; to treat abscesses, dermatitis, and fungal infections of the skin [44]; for snake bites; as an aphrodisiac [45]; for diarrhea [15]; gonorrhoea; and for loss of appetite [14]. The flower buds are used to treat eye pain [46] and coughing [4].

3. Phytochemistry

Chemical studies of this medicinal species date back to 1996 [47]. Such studies were the first qualitative on groups of compounds, where they were identified as amines, carbohydrates [48], alkaloids, phenolic compounds, flavonoids, steroids, terpenoids, tannins, anthraquinone glycosides, saponins, and triterpenes. The quantification of the alkaloids (5.903 ± 0.01333 mg/g), phenolic compounds (3.435 ± 0.0110 mg/g), and flavonoids (9.945 ± 0.0256 mg/g) was also carried out from the ethanolic extract of the flowers [49]. The concentrations of such compounds can vary, as in living flowers, they show a continuous change in the profile of their volatile compounds, which depend on intrinsic (genetic) and external factors (light, temperature, and water stress). In the case of the cut flowers, they suffer faster deterioration and a loss of volatile compounds [22]. Other factors that also affect it are attacks from pathogens (viruses, bacteria, fungi, and nematodes) and herbivores. The Marvin program was used to draw the structures of organic chemical compounds [50].

3.1. Alkaloids

Tropane alkaloids have anticancer activity [51]. Therefore, this group should be more studied in this regard. However, chemically, it is one of the most studied, where 59 alkaloids have been identified in the mature flowers, as well as in the immature flowers and fruits, corolla, flowers, roots, and flower nectar (Table 2 and Figure 3).

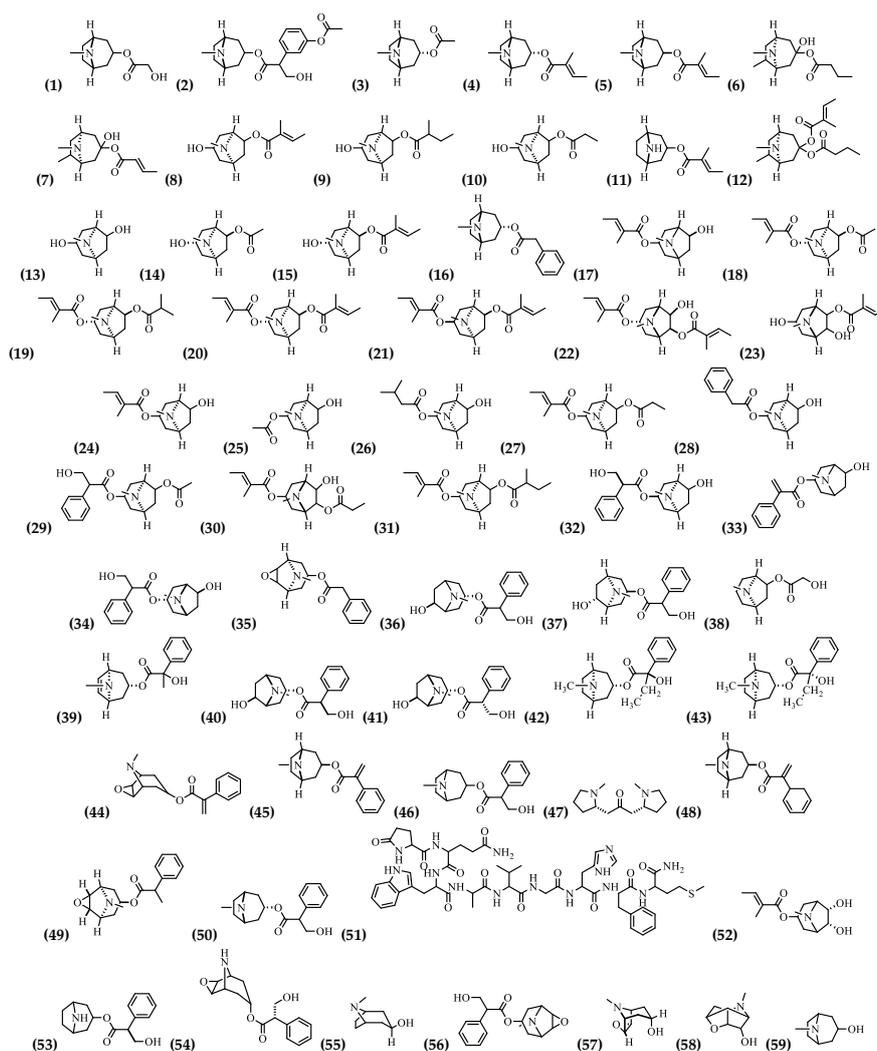


Figure 3. Structure of alkaloids from *Brugmansia suaveolens*.

Table 2. Alkaloids from *Brugmansia suaveolens*.

No.	Compound Name	Parts Used
(1)	3-(Hydroxyacetoxy)-tropane	Roots [35]
(2)	3-(3'Acetoxytropoyloxy)-tropane	Flowers, Roots [35]
(3)	3 α -Acetoxytropane	Root cultivation [36]
(4)	3 α -Tigloyloxytropane	Flowers and Roots [35]
(5)	3 β -Tigloyloxytropane	Flowers [35]
(6)	3-Hydroxy-6-methylbutyryloxy-tropane	Roots [35]
(7)	3-Hydroxy-6-methyl-butenoyl-oxytropane	Flowers [47]
(8)	3-Hydroxy-6-tigloyloxytropane	Root cultivation [36]
(9)	3-Hydroxy-6-(2-methyl butyryloxy)-tropane	Root cultivation [36], Flowers, Roots [35]
(10)	3-Hydroxy-6-propionyl-oxytropane	Flowers [47]
(11)	3-Tigloyloxyntropane	Flowers [35]
(12)	3-Tigloyloxy-6-methylbutyryloxytropane	Flowers, Roots [35]
(13)	3,6-Dihydroxytropane	Flowers [47]
(14)	3 α -Hydroxy-6 β -acetoxytropane	Flowers, Roots [35]
(15)	3 α -Hydroxy-6 β -tigloyloxytropane	Flowers, Roots [35]
(16)	3 α -Phenylacetoxytropane	Roots [35]
(17)	3 α -Tigloyloxy-6 β -hydroxytropane	Flowers, Roots [35]
(18)	3 α -Tigloyloxy-6 β -acetoxytropane	Flowers [35]
(19)	3 α -Tigloyloxy-6 β -isobutyryloxytropane	Flowers, Roots [35]
(20)	3 α ,6 β -Ditigloyloxytropane	Flowers, Roots [35] and Root cultivation [36]
(21)	3 β ,6 β -Ditigloyloxytropane	Roots [35]
(22)	3 α ,6 β -Ditigloyloxy-7 β -hydroxytropane	Flowers [35]
(23)	3,6-dihydroxy-7-tigloyloxytropane	Flowers [35]
(24)	3-Tigloyloxy-6-hydroxytropane	Root cultivation [36]
(25)	3-Acetoxy-6-hydroxytropane	Root cultivation [36]
(26)	3-Isovaleryloxy-6-hydroxytropane	Roots [35]
(27)	3-Tigloyloxy-6-propionyloxytropane	Flowers, and Roots [35]
(28)	3-Phenylacetoxy-6-hydroxytropane	Flowers [35]
(29)	3-Tropoyloxy-6-acetoxytropane	Flowers [35]
(30)	3-Tigloyloxy-6-propionyloxy-7-hydroxytropane	Flowers, Roots [35]
(31)	3-Tigloyloxy-6-(2-methylbutyryloxy)-tropane	Root cultivation [36] and Roots [35]
(32)	7-Hydroxyhyoscyamine	Flowers [35]
(33)	6-Hydroxyapoatropine	Flowers [47], Root cultivation [36], Roots [35]
(34)	6-Hydroxyhyoscyamine	Flowers, Roots [35]
(35)	3-Phenylacetoxy-6,7-epoxytropane	Flowers [52]
(36)	6 β -Hydroxyhyoscyamine	Root cultivation [36]
(37)	7 β -Hydroxyhyoscyamine	Root cultivation [36]
(38)	6-Hydroxyacetoxytropane	Flowers, Roots [35]
(39)	6,7-Dehydronoratopine	Flowers [47]
(40)	6R-Hydroxyhyoscyamine	Flowers [47]
(41)	6S-Hydroxyhyoscyamine	Flowers [47]
(42)	6R-Hydroxynorhyoscyamine	Flowers [47]
(43)	6S-Hydroxynorhyoscyamine	Flowers [47]
(44)	Aposcopolamine	Flowers [47], Root cultivation [36], and Roots [35]
(45)	Apoatropine	Flowers [47], Root cultivation [36], and Roots [35]

Table 3. Volatile Compounds from *Brugmansia suaveolens*.

No.	Compound Name	Parts Used	No.	Compound Name	Parts Used
(60)	Hexanol	Flowers [22]	(85)	α -Tujene	Flowers [22]
(61)	(Z)-3-Hexen-1-ol	Flowers [22]	(86)	Sabinene	Flowers [22]
(62)	Citronellol	Flowers [22]	(87)	<i>trans</i> -Sabinene hydrate	Flowers [22]
(63)	Geraniol	Flowers [22]	(88)	1,8-cineol	Flowers [22]
(64)	(<i>trans, trans</i>)-Farnesol	Flowers [22]	(89)	α -Pinene	Flowers [22]
(65)	Linalool	Flowers [21]	(90)	β -Pinene	Flowers [22]
(66)	(<i>E</i>)-Nerolidol	Flowers [21]	(91)	Theaspirane A	Flowers [21]
(67)	Hexanal	Flowers [22]	(92)	2-Isobutyl-3-methoxypyrazine	Flowers [21]
(68)	Heptanal	Flowers [21]	(93)	Indole	Flowers [22]
(69)	Octanal	Flowers [21]	(94)	Benzyl alcohol	Flowers [22]
(70)	Nonanal	Flowers [22]	(95)	Phenethyl alcohol	Flowers [22]
(71)	Decanal	Flowers [22]	(96)	Benzaldehyde	Flowers [22]
(72)	Neral	Flowers [22]	(97)	Phenylacetaldehyde	Flowers [21]
(73)	Geranial	Flowers [22]	(98)	4-Methoxy benzaldehyde	Flowers [22]
(74)	Citronellal	Flowers [22]	(99)	Methyl benzoate	Flowers [22]
(75)	Farnesal	Flowers [22]	(100)	Methyl salicylate	Flowers [22]
(76)	6-Methyl hept-5-en-2-one	Flowers [22]	(101)	3-phenyl lactic acid	Leaves [29]
(77)	<i>cis</i> - β -Ocimene	Flowers [22]	(102)	Benzyl benzoate	Flowers [22]
(78)	β -Myrcene	Flowers [22]	(103)	Benzyl salicylate	Flowers [22]
(79)	<i>Allo</i> -ocimene	Flowers [22]	(104)	3-(3-indolyl) lactic acid	Leaves [29]
(80)	<i>trans</i> - β -Ocimene	Flowers [22]	(105)	Indole-3-lactic acid methyl ester	Leaves [29]
(81)	Terpinolene	Flowers [22]	(106)	Megastigmatrienone I	Flowers [21]
(82)	γ -Terpinene	Flowers [21]	(107)	Megastigmatrienone II	Flowers [21]
(83)	Terpinen-4-ol	Flowers [22]	(108)	Megastigmatrienone III	Flowers [21]
(84)	α -Terpineol	Flowers [22]	(109)	Megastigmatrienone IV	Flowers [21]

3.3. Phenolic Compounds, Coumarin, and Flavonoids

A glycosylated phenolic compound, a coumarin, and seven flavonoids have been identified, in the flowers and leaves (Table 4 and Figure 5).

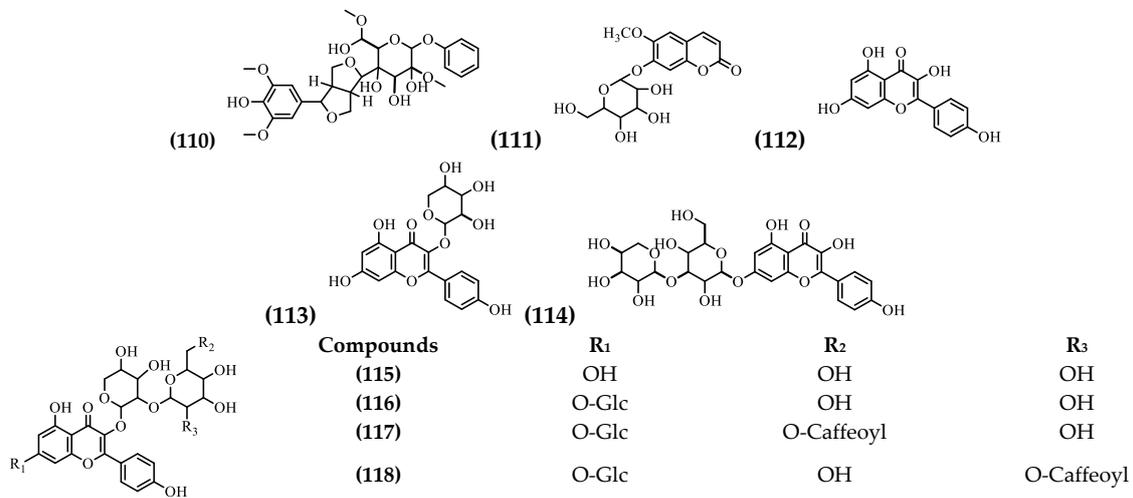


Figure 5. Structure of Phenolic Compounds, Coumarin, and Flavonoids from *Brugmansia suaveolens*.

3.4. Steroids

Three Steroids have been identified in the flowers and leaves (Table 5 and Figure 6).

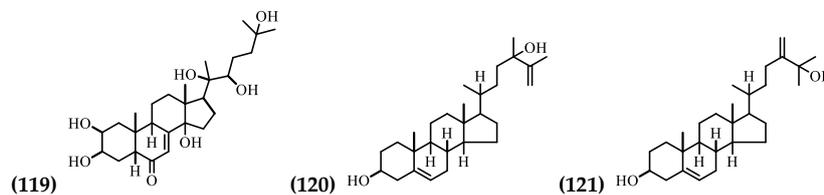


Figure 6. Structure of Steroids from *Brugmansia suaveolens*.

3.5. Hydrocarbons

The presence of four hydrocarbons in *B. suaveolens* has been identified only in the flowers (Table 6 and Figure 7).

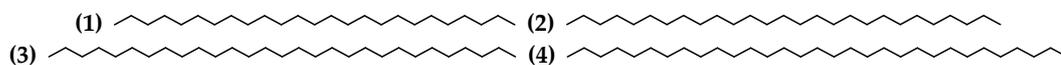


Figure 7. Structure of the hydrocarbons from *Brugmansia suaveolens*.

Table 4. Phenolic Compounds, Coumarin, and Flavonoids from *Brugmansia suaveolens*.

No.	Compound Name	Parts Used
(110)	Acanthoside B	Flowers [55]
(111)	Scopoletin 7-O- β -D-galactopyranoside	Flowers [55]
(112)	Kaempferol	Flowers [55]
(113)	Kaempferol 3-O- α -L-arabinopyranoside	Leaves [29]
(114)	kaempferol 3-O- α -L-arabinopyranosyl-7-O- β -D-glucopyranoside	Leaves [29]
(115)	Kaempferol 3-O- β -D-glucopyranosyl-(1''' \rightarrow 2'')-O- α -L-arabinopyranoside	Leaves [56]
(116)	Kaempferol 3-O- β -D-glucopyranosyl-(1''' \rightarrow 2'')-O- α -L-arabinopyranoside-7-O- β -D-glucopyranoside	Leaves [56]
(117)	Kaempferol 3-O- β -D-[6'''-O-(E-caffeoyl)]-glucopyranosyl-(1''' \rightarrow 2'')-O- α -L-arabinopyranoside-7-O- β -D-glucopyranoside	Leaves [56]
(118)	Kaempferol 3-O- β -D-[2'''-O-(E-caffeoyl)]-glucopyranosyl-(1''' \rightarrow 2'')-O- α -L-arabinopyranoside-7-O- β -D-glucopyranoside	Leaves [56]

Table 5. Steroids from *Brugmansia suaveolens*.

No.	Compound Name	Parts Used
(119)	20-hydroxyecdysone	Flowers [55]
(120)	Physalindicanol A	Leaves [29]
(121)	Physalindicanol B	Leaves [29]

Table 6. Hydrocarbons from *Brugmansia suaveolens*.

No.	Compound Name	Parts Used
(122)	Pentacosane	Flowers [21]
(123)	Heptacosane	Flowers [21]
(124)	Nonacosane	Flowers [21]
(125)	Hentriacontane	Flowers [21]

4. Pharmacological Activity

Brugmansia suaveolens is reported in traditional medicine in many Latin American countries; however, the first studies are from 22 years ago [4]. As there are very few pharmacological investigations of the plant, this is still an opportunity for future investigations.

4.1. Antinociceptive

The aqueous extract of *B. suaveolens* flowers was administered at doses of 100 and 300 mg/kg i.p. They significantly inhibited ($p < 0.05$) the induced contortions and increased the percentage of inhibition by acetic acid to 0.6% (3.0 ± 0.8 and 94.9%, and 0.6 ± 0.5 and 99%, respectively). Diclofenac 5 mg/kg i.p. (43.4 ± 3.5 and 25.8%) was used as a positive control. An increase in the latency time was observed in the formalin test (20 μ L of 2.5%); in the first phase (0–5 min), with a dose of 100 mg/kg (15.6 ± 4.2 s and 63.3%) and 300 mg/kg (0.3 ± 0.3 s and 98.6%) and diclofenac (43.6 ± 7.0 s and 0%), and the second phase (20–25 min) with a dose of 100 mg/kg (7.5 ± 2.8 s and 82.2%) and 300 mg/kg (0.0 ± 0.0 s and 100%) and diclofenac (7.0 ± 2.8 s and 69.6%) in male Swiss albino mice. An increase in the latency time was also observed in the hot plate and tail dip tests [9].

In another study of the aqueous extract of flowers of *B. suaveolens* on the probable antinociceptive mechanism of the 300 mg/kg dose, a mechanism on benzodiazepine receptors was found. Flumazenil (5 mg/kg, i.p.) was used as an antagonist [57].

4.2. Antimicrobial

The antibacterial activity of the aqueous extract of *B. suaveolens* flowers against *Bacillus thurigiensis* was evaluated in one study and showed no activity [58].

4.3. Nematicide

The ethanolic extract of flowers at a concentration of 1000 mg/L, showed a 64% in vitro nematocidal activity against *Meloidogyne incognita* within 72 h. [49]. In another study of the ethanolic extract of aerial parts (flowers, and flowers and stems), a 100% larvicidal activity at a dilution of 12.5 mg against *Ancylostoma* spp was shown [59].

4.4. Cytotoxicity

Studies of the cytotoxic evaluation of the aqueous extract of *B. suaveolens* were carried out in the Brine-shrimp model (*Artemia* sp., Artemiidae) during 24 h, the concentrations of 1000, 500, 250, 125, 62.5, 31.25, and 0 (μ g/mL) were evaluated. An LC_{50} of 106 μ g/mL was obtained [7].

4.5. Muscle Relaxer

Brugmansia suaveolens ethanol extract inhibits rabbit smooth muscle contractility at 100% at a concentration of 75.5 g/mL [4].

5. Toxicity

There are several factors (climatic and seasonal) that can increase or decrease the concentration of the alkaloids associated with the toxicity of the plant. It has been documented that it has been involved in poisoning in many parts of the world, and other species, such as *B. candida*, *B. sanguinea*, and *B. × candida*, are considered toxic in some places like Mexico, especially their seeds. It is documented that an intake of 4 to 5 g of raw leaf, or just a seed, can cause a child to die [3]. Among the most toxic compounds are atropine and scopolamine, and their averages in the flowers are 0.79 ± 0.03 and 0.72 ± 0.05 mg/g of dry plant, respectively; these concentrations will increase if the plant is fertilized with organic fertilizer (6 kg/m² per year) [44]. In another study, a scopolamine concentration of 149.80 ± 6.01 μ g/mL was determined in the flower nectar [37]. The plant parts that are the most involved in poisoning are flowers (77.5%), leaves (13.4%), fruits (4.5%), stem (2.3%), and root (2.3%) [60].

The signs and symptoms of Angel's Trumpet poisoning are mydriasis, dry mouth, delirium, reddened skin [61], dry skin [60], agitation/aggressiveness, reduced bowel sounds [61], ileal paralysis, drowsiness [62], visual hallucinations, tachycardia, urinary retention, fever, increased systolic blood pressure, a Glasgow Coma Scale (GCS) of <12, [61], vertigo [60], decreased temperature and difficulty breathing prior to coma [3].

Unusual poisoning occurred in a five-year-old boy who consumed flowers, and as a consequence, unilateral tonic pupils and Guillain-Barré syndrome were observed [31].

6. Conclusions

This review details the distribution and ethnomedical, phytochemical, pharmacological, and toxicological uses of *B. suaveolens* in the world. The scientific investigations that have been carried out to date are scarce, the analgesic, cytotoxic, nematicidal, and antimicrobial activity has been studied. However, regarding its chemistry, it is important to highlight that 125 compounds have been reported and identified, and a high percentage are not associated with pharmacological activity. Ethnomedical uses reported around the world include its uses to treat pain, insomnia, rheumatism, infections, asthma, inflammation, sores, wounds, abscesses, dermatitis, snakebites, loss of appetite, coughs, and as an aphrodisiac. From this empirical and traditional knowledge in different countries, the scientific validation of this plant species emerges as a great area of opportunity, which provides an opportunity for interdisciplinary collaboration between different research groups.

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References

1. The Plants List. "Brugmansia suaveolens". 2020. Available online: <http://www.theplantlist.org/tpl1.1/record/kew-26840192020> (accessed on 18 August 2020).
2. Chellemi, D.O.; Webster, C.G.; Baker, C.A.; Annamalai, M.; Achor, D.; Adkins, S. Widespread occurrence and low genetic diversity of Colombian datura virus in *Brugmansia* suggest an anthropogenic role in virus selection and spread. *Plant Dis.* **2011**, *95*, 755–761. [CrossRef]
3. Monroy-Ortiz, C.; Monroy, R. *Las Plantas, Compañeras de Siempre: La Experiencia en Morelos*, 1st ed.; UAEM, Centro de Investigaciones Biológicas de la Conabio Conanp: Cuernavaca, Morelos, Mexico, 2006.
4. Encarnación-Dimayuga, R.; Altamirano, L.; Maki, K.A. Screening of medicinal plants from Baja California Sur (Mexico) by their effects on smooth muscle contractility. *Pharm. Biol.* **1998**, *36*, 124–130. [CrossRef]
5. Furlan, V.; Kujawska, M.; Hilgert, N.I.; Pochettino, M.L. To what extent are medicinal plants shared between country home gardens and urban ones? A case study from Misiones, Argentina. *Pharm. Biol.* **2016**, *54*, 1628–1640. [CrossRef] [PubMed]
6. De Feo, V. The ritual use of *Brugmansia* species in traditional Andean medicine in northern Peru. *Econ. Bot.* **2004**, *58*, S221–S229. [CrossRef]
7. Bussmann, R.W.; Malca, G.; Glenn, A.; Sharon, D.; Nilsen, B.; Parris, B.; Dubose, D.; Ruiz, D.; Saleda, J.; Martínez, M.; et al. A townsmith toxicity of medicinal plants used in traditional medicine in Northern Peru. *J. Ethnopharmacol.* **2011**, *137*, 121–140. [CrossRef]
8. Sanz-Biset, J.; Cañigueral, S. Plants as medicinal stressors, the case of depurative practices in Chazuta valley (Peruvian Amazonia). *J. Ethnopharmacol.* **2013**, *145*, 67–76. [CrossRef]

9. Parker, A.; Goulart Peraza, G.; Sena, J.; Sinnott Silva, E.; Flores Soares, M.C.; Cezar Vaz, M.R.; Badiale Furlong, L.; Muccillo-Baisch, A.L. Antinociceptive effects of the aqueous extract of *Brugmansia suaveolens* flowers in mice. *Biol. Res. Nurs.* **2007**, *8*, 234–239. [[CrossRef](#)]
10. Lucinda, N.; Inoue-Nagata, A.K.; Kitajima, E.W.; Nagata, T. Complete genome sequence of *Brugmansia suaveolens* mottle virus, a potyvirus from an ornamental shrub. *Arch. Virol.* **2010**, *155*, 1729–1732. [[CrossRef](#)]
11. Hudák, J.; Walles, B.; Vennigerholz, F. The transmitting tissue in *Brugmansia suaveolens* L.: Ultrastructure of the stylar transmitting tissue. *Ann. Bot.* **1993**, *71*, 177–186. [[CrossRef](#)]
12. Jayawickreme, K.P.; Janaka, K.V.C.; Subasinghe, S. Unknowing ingestion of *Brugmansia suaveolens* leaves presenting with signs of anticholinergic toxicity: A case report. *J. Med. Case Rep.* **2019**, *13*, 1–4. [[CrossRef](#)]
13. Oktavia, A.I.; Indriani, S.; Jati, B. Ethnobotanical study of toxic plants in Ngadiwono Village, Tosari District, Pasuruan Regency, East Java. *Indones. J. Environ. Sustain. Dev.* **2017**, *8*, 83–88. [[CrossRef](#)]
14. Batoro, J.; Siswanto, D. Ethnomedicinal survey of plants used by local society in Poncokusumo district, Malang, East Java Province, Indonesia. *Asian J. Med. Biol. Res.* **2017**, *3*, 158–167. [[CrossRef](#)]
15. Ijazal, F.; Iqbal, Z.; Ur Rahman, I.; Alam, J.; Mulk Khan, S.; Mujtaba Shah, G.; Khang, K.; Afzal, A. Investigation of traditional medicinal floral knowledge of Sarban Hills, Abbottabad, KP, Pakistan. *J. Ethnopharmacol.* **2016**, *179*, 208–233. [[CrossRef](#)] [[PubMed](#)]
16. Chetri, B.K.; Wangdi, P.; Penjor, T. Ethnomedicinal practices in Kilikhar, Mongar. *Asian Plant Res. J.* **2018**, *1*, 1–13. [[CrossRef](#)]
17. Bye, R.; Sosa, V. Molecular phylogeny of the jimsonweed genus *Datura* (Solanaceae). *Syst. Bot.* **2013**, *38*, 818–829. [[CrossRef](#)]
18. Safford, W.E. Synopsis of the genus *Datura*. *J. Washingt. Acad. Sci.* **1921**, *11*, 173–189. Available online: <http://www.jstor.org/stable/24532461> (accessed on 25 March 2020).
19. Kujawska, M. Forms of medical pluralism among the Polish Community in Misiones, Argentina. *Anthropol. Med.* **2016**, *23*, 205–219. [[CrossRef](#)]
20. Hosking, J.R.; Conn, B.J.; Lepschi, B.J.; Barker, C.H. Plant species first recognised as naturalised or naturalising for New South Wales in 2004 and 2005. *Cunninghamia* **2011**, *12*, 85–114.
21. Anthony, S.J.; Zuchowski, W.; Setzer, W.N. Composition of the floral essential oil of *Brugmansia suaveolens*. *Rec. Nat. Prod.* **2009**, *3*, 76.
22. Stashenko, E.E.; Martínez, J.R. Sampling flower scent for chromatographic analysis. *J. Sep. Sci.* **2008**, *31*, 2022–2031. [[CrossRef](#)]
23. Mosquera-Yuqui, F.; Garrido, P.; Flores, F.J. Molecular characterization and complete genome of alstroemeria mosaic virus (AIMV). *Virus Genes* **2020**, *56*, 87–93. [[CrossRef](#)] [[PubMed](#)]
24. Giraldo, C.E.; Barbosa, E.P.; Freitas, A.V.L. Immature stages of *Pagyris cymothoe cymothoe* (Hewitson, 1855) (Lepidoptera, Danainae, Ithomiini). *Trop. Zool.* **2013**, *26*, 145–153. [[CrossRef](#)]
25. Danton, P.; Perrier, C.; de Reyes, G.M. Nouveau catalogue de la flore vasculaire de l'archipel Juan Fernández (Chili) Nuevo catálogo de la flora vascular del Archipiélago Juan Fernández (Chile). *Acta Bot. Gall.* **2006**, *153*, 399–587. [[CrossRef](#)]
26. Zhao, F.; Lim, S.; Yoo, R.H.; Lim, H.S.; Kwon, S.Y.; Lee, S.H.; Moon, J.S. Complete genome sequence of a South Korean isolate of *Brugmansia* mosaic virus. *Arch. Virol.* **2013**, *58*, 2019–2022. [[CrossRef](#)]
27. Mai, N.T. Quantitative analysis of scopolamine in *Brugmansia suaveolens* by HPLC-MS method. *J. Multidiscip. Eng. Sci. Technol.* **2017**, *4*, 8176–8179.
28. Lin, T.J.; Nelson, L.S.; Tsai, J.L.; Hung, D.Z.; Hu, S.C.; Chan, H.M.; Deng, J.F. Common toxidromes of plant poisonings in Taiwan. *Clin. Toxicol.* **2009**, *47*, 161–168. [[CrossRef](#)]
29. Sajeli Begum, A.; Sahai, M.; Fujimoto, Y.; Asai, K.; Schneider, K.; Nicholson, G.; Suessmuth, R. A new kaempferol diglycoside from *Datura suaveolens* Humb. & Bonpl. ex. Willd. *Nat. Prod. Res.* **2006**, *20*, 1231–1236.
30. Suganda, A.G.; Nishiyama, Y.; Yamakawa, T.; Sugiyama, N. Random amplified polymorphic DNA analysis to distinguish *Brugmansia suaveolens*, *B. candida* and *B. versicolor*. *Plant Biotechnol.* **2006**, *23*, 519–520. [[CrossRef](#)]
31. Sevketoglu, E.; Tatli, B.; Tuğcu, B.; Demirelli, Y.; Hatipoglu, S. An unusual cause of fulminant Guillain-Barré syndrome: Angel's trumpet. *Pediatr. Neurol.* **2010**, *43*, 368–370. [[CrossRef](#)]
32. Haegi, L. Taxonomic account of *Datura* L. (Solanaceae) in Australia with a note on *Brugmansia* Pers. *Aust. J. Bot.* **1976**, *24*, 415–435. [[CrossRef](#)]
33. Sykes, W.R. Checklist of dicotyledons naturalised in New Zealand 10. Polemoniales and Boraginaceae. *N. Z. J. Bot.* **1981**, *19*, 311–317. [[CrossRef](#)]

34. Otim, A.S.; Kajobe, R.; Abila, P.P.; Kasangaki, P.; Echodu, R. Important plants for honey production in four agro ecological zones of Uganda. *Bee World* **2019**, *96*, 81–86. [CrossRef]
35. Doncheva, T.; Berkov, S.; Philipov, S. Comparative study of the alkaloids in tribe Datureae and their chemosystematic significance. *Biochem. Syst. Ecol.* **2006**, *34*, 478–488. [CrossRef]
36. Zayed, R.; and Wink, M. Induction of tropane alkaloid formation in transformed root cultures of *Brugmansia suaveolens* (Solanaceae). *Z. Nat. C* **2004**, *59*, 863–867. [CrossRef] [PubMed]
37. Kerchner, A.; Darók, J.; Bacskay, I.; Felinger, A.; Jakab, G. Protein and alkaloid patterns of the floral nectar in some solanaceous species. *Acta Biol. Hung.* **2015**, *66*, 304–315. [CrossRef] [PubMed]
38. Malandraki, I.; Papachristopoulou, M.; Vassilakos, N. First report of potato spindle tuber viroid (PSTVd) in ornamental plants in Greece. *New Dis. Rep.* **2010**, *21*, 9. [CrossRef]
39. Vennigerholz, F. The transmitting tissue in *Brugmansia suaveolens*: Immunocytochemical localization of pectin in the style. *Protoplasma* **1992**, *171*, 117–122. [CrossRef]
40. Bennett, B.C. Hallucinogenic plants of the Shuar and related indigenous groups in Amazonian Ecuador and Peru. *Brittonia* **1992**, *44*, 483–493. [CrossRef]
41. Laferriere, J.E. Medicinal plants of the Lowland Inga people of Colombia. *Int. J. Pharmacogn.* **1994**, *32*, 90–94. [CrossRef]
42. Schultes, E.R.; Plowman, T. The ethnobotany of *Brugmansia*. *J. Ethnopharmacol.* **1979**, *1*, 147–164. [CrossRef]
43. Lalzarzovi, S.T.; Lalramnghinglova, H. Traditional use of medicinal plants found within Aizawl city in Mizoram, India. *Pleione* **2016**, *10*, 269–277.
44. Reis, R.B.; Bragagnolo, F.S.; Gianeti, T.M.R.; Rodrigues, S.A.; Funari, C.S.; Gonçalves, G.G.; Ming, L.C. *Brugmansia suaveolens* leaf productivity and alkaloid contents under different doses of organic fertilizer. *J. Agric. Sci.* **2019**, *11*, 341–349. [CrossRef]
45. Carlini, E.A.; Maia, L.O. Plant and fungal hallucinogens as toxic and therapeutic agents. *Toxinology* **2015**, *1*, 1–44.
46. Rohman, F.; Juma, D.H.; Utomo, S.R.; Arifah, S.N.; Putra, W.E. Plants diversity as a medicinal plants by the Tengger Tribe, Bromo Tengger Semeru National Park, East Java, Indonesia. *EurAsian J. Biosci.* **2019**, *13*, 2293–2298.
47. Freitas, A.V.L.; Trigo, J.R.; Brown, K.S.; Witte, L.; Hartmann, T.; Barata, L.E.S. Tropane and pyrrolizidine alkaloids in the ithomiines *Placidula euryanassa* and *Miraleria cymothoe* (Lepidoptera: Nymphalidae). *Chemoecology* **1996**, *7*, 61–67. [CrossRef]
48. Sakunthala, P.; Charles, A.; Kesavan, D.; Ramani, V.A. Phytochemical screening and adsorption studies of *Brugmansia suaveolens*. *Chem. Sci. Rev. Lett.* **2013**, *29*, 319–322.
49. Nandakumar, A.; Vaganan, M.M.; Sundararaju, P.; Udayakumar, R. Phytochemical analysis and nematocidal activity of ethanolic leaf extracts of *Datura metel*, *Datura innoxia* and *Brugmansia suaveolens* against *Meloidogyne incognita*. *Asian J. Biol.* **2017**, *2*, 1–11. [CrossRef]
50. Marvin, “MarvinSketch 18.04”. 2018. Available online: <http://www.chemaxon.com> (accessed on 25 March 2020).
51. Alam, E.A. In vitro cultures for the production of some anticancer agents. *Life Sci. J.* **2013**, *10*, 297–310.
52. Pinto, C.F.; Salinas, S.; Flores-Prado, L.; Echeverría, J.; Niemeyer, H.M. Sequestration of tropane alkaloids from *Brugmansia suaveolens* (Solanaceae) by the treehopper *Alchisme grossa* (Hemiptera: Membracidae). *Biochem. Syst. Ecol.* **2016**, *66*, 161–165. [CrossRef]
53. Andreola, B.; Piovan, A.; Da Dalt, L.; Filippini, R.; Cappelletti, E. Unilateral mydriasis due to Angel’s Trumpet. *Clin. Toxicol.* **2008**, *46*, 329–331. [CrossRef]
54. Alves, M.N.; Sartoratto, A.; Trigo, J.R. Scopolamine in *Brugmansia suaveolens* (Solanaceae): Defense, allocation, costs, and induced response. *J. Chem. Ecol.* **2007**, *33*, 297–309. [CrossRef] [PubMed]
55. Mai, N.T. Investigation on chemical constituents of the *Brugmansia suaveolens* flowers. *J. Multidiscip. Eng. Sci. Technol.* **2019**, *6*, 10021–10024.
56. Geller, F.; Murillo, R.; Steinhauser, L.; Heinzmann, B.; Albert, K.; Merfort, I.; Laufer, S. Four new flavonol glycosides from the leaves of *Brugmansia suaveolens*. *Molecules* **2014**, *19*, 6727–6736. [CrossRef] [PubMed]
57. Muccillo-Baisch, A.L.; Parker, A.G.; Cardoso, G.P.; Cezar-Vaz, M.R.; Flores Soares, M.C. Evaluation of the analgesic effect of aqueous extract of *Brugmansia suaveolens* flower in mice: Possible mechanism involved. *Biol. Res. Nurs.* **2010**, *11*, 345–350. [CrossRef]

58. Vilani, A.; Lozano, E.R.; Potrich, M.; de Gouvea, A.; Martins Costa Maia, F.; Angeli Alves, L.F.; Dall Agnol de Lima, J. Activity of plant aqueous extracts on *Bacillus thuringiensis* and their interactions on *Anticarsia gemmatalis* (Lepidoptera: Erebiniae). *Semin. Ciências Agrárias* **2017**, *38*, 1051–1057. [[CrossRef](#)]
59. Santos, I.D.; Souza, F.; Akisue, G.; da Coelho, S.F.A.; Coelho, M.D.G. Evaluation of ovicidal and larvicidal activity of ten plant extracts against *Ancylostoma* spp. *Rev. Patol. Trop.* **2013**, *42*, 209–216.
60. Doan, U.V.M.; Wu, L.; Phua, D.H.; Mendez Rojas, B.; Yang, C.C. *Datura* and *Brugmansia* plants related antimuscarinic toxicity: An analysis of poisoning cases reported to the Taiwan poison control center. *Clin. Toxicol.* **2019**, *57*, 246–253. [[CrossRef](#)]
61. Isbister, G.K.; Oakley, P.A.; Dawson, H.; Whyte, I.M. Presumed Angel's trumpet (*Brugmansia*) poisoning: Clinical effects and epidemiology. *Emerg. Med.* **2003**, *15*, 376–382. [[CrossRef](#)]
62. Fuchs, J.; Rauber-Lüthy, C.; Kupferschmidt, H.; Kupper, J.; Kullak-Ublick, G.A.; Ceschi, A. Acute plant poisoning: Analysis of clinical features and circumstances of exposure. *Clin. Toxicol.* **2011**, *49*, 671–680. [[CrossRef](#)]



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