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Review Article

The Genus *Jacaranda* (Bignoniaceae): An Updated Review

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ABSTRACT: Genus *Jacaranda* has been traditionally used in treating skin disorders, venereal diseases, leishmaniasis, colds and rheumatism. Additionally, some species have shown diuretic and astringent properties. **Objective:** This review highlights and updates the traditional uses, pharmacology and phytochemistry of the genus *Jacaranda*. **Materials and Methods:** Information was obtained from Google Scholar, Scirus, PubMed and ScienceDirect. **Results:** Phytochemical studies on *Jacaranda* species have shown the presence flavonoids, phenylpropanoids, phenylethanoids, sterols and triterpenes. Extracts of different *Jacaranda* species possess a wide range of pharmacological activities, such as antioxidant antidepressant, antimicrobial, anticancer, anti-leishmanial, anti-protozoal, hypotensive and anti-hypertriglyceridemic activities. **Conclusion:** The genus *Jacaranda* is a natural source of antioxidants and has been widely used in traditional Ethnobotany. Thus, it could be exploited as a potential source for plant-based pharmaceutical products. The present review could form a sound basis for further investigation in the potential discovery of new natural bioactive compounds and could provide preliminary information for future research.

KEYWORDS: Bignoniaceae; Genus *Jacaranda*; Pharmacology; Phytochemistry; Traditional uses.

INTRODUCTION

Family Bignoniaceae includes 120 genera with 800 species mainly distributed within tropical floras of the world, with lesser representation in temperate regions. It consists mainly of woody trees, shrubs and lianas. Some species are used worldwide as ornamentals[1,2].

The genus *Jacaranda* contains 49 species that are native to Central and South America and the Caribbean[3]. Genus *Jacaranda* consists mainly of shrubs and trees with opposite bipinnate leaves; terminal, axillary or cauliflorous, paniculate inflorescence. Fruits are oblong flattened capsules with numerous, winged, hyaline or brownish seeds[4,5]. Traditionally, *Jacaranda* spp. are used for the treatment of tropical diseases, skin problems, venereal infections and for the treatment of colds, rheumatism and gastrointestinal disorders[3].

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The main chemical constituents identified in the family are naphthoquinones, iridoid glucosides, alkaloids, flavones, triterpenes, polyphenols, tannins and seed oils[6]. The main classes of secondary metabolites identified in genus *Jacaranda* are triterpenes, quinones, flavonoids, and acetosides[3].

Bioactive compounds reported from plants of family Bignoniaceae have previously demonstrated a number of pharmacological activities such as molluscicidal, trypanocidal, mosquito larvicidal, antioxidant, antidiabetic, antiplasmodial, anti-inflammatory, immunostimulant, antimicrobial, antidepressant, anti-snake venom, anticancer, antinociceptive, and neurotrophic activities. Similarly, the main pharmacological activities reported for genus *Jacaranda* are antioxidant, antidepressant, antimicrobial, anticancer, anti-leishmanial, anti-protozoal, hypotensive and anti-hypertriglyceridemic activities[7].

Previously, Gachet and Schuhly (2009) have reviewed the chemical and biological aspects of genus *Jacaranda*[3]. In this review, we provide an up-date on the recent pharmacologi-

cal and phytochemical data reported on the genus *Jacaranda*, as a continuation to the previous work, which may be beneficial for research of new drug development in the future.

TRADITIONAL USES

Various medicinal practices are associated with the genus *Jacaranda*. Members of the genus are well known in traditional ethnobotany, especially in the field of tropical diseases and skin problems such as treatment of wounds and ulcerations[3]. The main parts used are leaves and barks, which are applied directly to the wounds or in the form of infusion or decoction, and they are believed to be disinfectant[3]. *Jacaranda* species have also been used traditionally to treat venereal infections, gastrointestinal disorders, leishmaniasis, colds and rheumatism. Some species such as *Jacaranda acutifolia* have shown diuretic and astringent properties[3]. Traditional uses and part used of different *Jacaranda* species are listed in Table 1.

Table 1: Traditional uses reported for *Jacaranda* species

Plant species/References	Part used	Traditional uses
Jacaranda acutifolia [8,9]	Bark	• Skin diseases • Treatmment of venereal diseases • Treatment of rheumatism • Diuretic and astringent
Jacaranda caerulea [10]	Leafy branches	• Skin diseases
Jacaranda caroba [3,11]	Leaves	• Skin diseases • Treatment of venereal disease
Jacaranda caucana ssp. caucana [4,8,12]	Leaves or bark	• Skin diseases • Treatment of venereal disease
	Different parts	• Treatment of colds and rheumatism
Jacaranda copaia [8,9,13–17]	Bark and leaves sap	• Skin diseases • Treatment of leishmaniasis
	Leaves and bark of young trees Bark Leaves	• Treatment of venereal diseases • Treatment of colds • Treatment of rheumatism • For general weakness, fever, mosquito repellant and fish poison
	Tubercles and roots	• Treatment of gastrointestinal disorders
Jacaranda cuspidifolia [18, 19]	Leaves	• Treatment of leishmaniasis • Treatment of venereal disease
Jacaranda decurrens [20]	Leaves, bark and roots	• Skin diseases • Treatmment of venereal diseases
	Roots and leaves	• Treatment of rheumatism
Jacaranda glabra [13]	Leaves	• Skin diseases
	Branches and leaves	• Treatment of leishmaniasis
Jacaranda hesperia [21]	Different parts	• Treatment of leishmaniasis
Jacaranda mimosaefolia [22]	Bark	• Treatment of venereal disease
Jacaranda obtusifolia [9]	Bark	• Skin diseases
Jacaranda puberula [3]	Leaves	• Treatment of colds

PHARMACOLOGICAL ACTIVITIES

Genus *Jacaranda* is interesting for its pharmacological potential and promising activities. Researchers have undertaken various different pharmacological screenings to authenticate the aforementioned traditional uses. A summary of some of the relevant literature is given in Table 2 and discussed in the following section.

Table 2: Pharmacological activities for *Jacaranda* species

Plant species / Reference	Part used / compound	Main pharmacological activity
Jacaranda acutifolia [23]	Flower	(–)DPPH (–)FRAP Antioxidant
Jacaranda caroba [26,32]	Leaves	Antioxidant (–)Monoamine oxidase A Neuroprotective Weak anticholinestrase activity
	Ierobina® (aerial parts)	Anti-hypertriglyceridemic
Jacaranda caucana [24,33,34,12]	Stem	(–)DPPH Antioxidant
	Jacaranone from (twig leaf and stem bark)	Anticancer
	Leaves	(–)Plasmodium falciparum Low cytotoxicity (n)Antileishmanial (n)Antitrypanosomal
Jacaranda copaia [35,36]	Young leaves	Anticancer (–)NF-κB
	Young leaves and internal bark	Weak antiproteases
Jacaranda cuspidifolia [18,19]	Bark	Antimicrobial
	Leaves	(n)Antileishmanial (n)Antitrypanosomal
Jacaranda filicifolia [37]	Stem bark	Moderate antifungal
Jacaranda glabra [28, 38]	Leaves	(n)antimicrobial activity (–)Plasmodium falciparum
	Jacaglabroside A (from leaves)	Cytotoxic (–)Plasmodium falciparum
	Jacaglabrosides B-D (from leaves)	Weak cytotoxic (–)Plasmodium falciparum
Jacaranda mimosaefolia [25,31, 39]	Leaves	(–)DPPH (–)ABTS Antioxidant Antimicrobial Hypothermic Cardiovascular depressive Hypotensive (–)α-adrenergic receptors
Jacaranda obtusifolia [29]	Twigs	Anticancer
	Isoliquiritigenin (from twigs)	Potent anticancer
	Liquiritigenin (from twigs)	Moderate anticancer
Jacaranda puberula [27,30]	Leaves	Antibacterial Bacteriostatic and bactericidal against *S. aureus* Antileishmanial

(–), decrease, inhibit, reduce, down-regulate. (+), increase, activate, up-regulate. (n), no change, no activity.

DPPH: 1,1-Diphenyl-2-picrylhydrazyl; FRAP: Ferric reducing antioxidant power; NF-κB: Nuclear factor Kappa B; ABTS: 2, 2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid; *S. aureus*: *Staphyllococcus aureus.*

Antioxidant activity

The antioxidant activity of different fractions of *Jacaranda acutifolia* flower was evaluated using 1,1-Diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging and ferric ion reducing power. The total phenolic contents were estimated as 17.20 mg/g gallic acid equivalents. The antioxidant activities of all extracts were concentration-dependent and consistent with the total phenolic content. The ethyl acetate fraction possessed the highest antioxidant activities, including effective DPPH radical scavenging (EC_{50} = 0.049 mg/mL) and ferric ion reducing activities (EC_{50} = 0.125 mg/mL)[23].

Extracts from several plants of the family Bignoniaceae from Panama were subjected to a rapid DPPH-TLC test for the detection of radical-scavenging activity, and reported that the methanol extract of the stems of *Jacaranda caucana* showed promising antioxidant activity[24].

The total antioxidant activity of *Jacaranda mimosifolia* leaves was evaluated by both DPPH and ABTS methods. The antioxidant contents were represented in the form of Trolox equivalent antioxidant capacity (TEAC) per gram of extract which ranged between 38 and 134 mg Trolox equivalent/g extract by ABTS (2, 2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid) assay, and between 35 and 146 mg Trolox equivalent/g extract by DPPH assay. Isolated compounds [1,6-Bis(1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetyl)- 3-(para-hydroxybenzeneacetyl)-β-glucopyranoside and jacaranone] show DPPH-TLC radical scavenging activity[25].

Antioxidant and antidepressant (neuroprotective)

Aqueous and hydromethanol leaves extracts of *Jacaranda caroba* (Vell.) A. DC proved to be strong radicals' scavengers and effective monoamine-oxidase A inhibitors, but showed weak protection against cholinesterases activity[26].

Antimicrobial activity

The *in vitro* antimicrobial activity of the hexane (JCHE), methanol (JCME), and chloroform extracts (JCCF) of the bark of *Jacaranda cuspidifolia* Mart. (Bignoniaceae) were evaluated using the disc diffusion method followed by the determination of minimum inhibitory concentration (MIC) values. JCHE was inactive against all bacteria evaluated. JCME presented antibacterial activity against *Streptococcus pyogenes, Staphylococcus aureus* and *Neisseria gonorrhoeae* with MIC values of 16.3 mg/mL, 9.1 mg/mL, and 25.2 mg/mL, respectively. JCCF was mildly active against *Staphylococcus epidermidis, S. aureus, Proteus mirabilis, Serratia marcescens, S. pyogenes, Enterobacter aerogenes, and N. gonorrhoeae* with MIC values of 18.3 mg/mL, 9.3 mg/mL, 6.3 mg/mL, 6.1 mg/mL, 9.2 mg/mL, 6.2 mg/mL, and 25.2 mg/mL, respectively[19].

The antibacterial activity of the hydroalcoholic extracts of leaves from *Jacaranda puberula* Cham. (Bignoniaceae) was investigated by the agar-well method. The results showed a bacteriostatic action against *Staphylococcus aureus*. *J. puberula* also exhibited bactericidal activity towards *S. aureus* at a concentration of 100 mg/mL[27].

Anticancer activity

Four phenylethanoid glucosides, namely jacaglabrosides A−D were identified from *Jacaranda glabra* leaves. The compounds possessed a low cytotoxicity activity toward L-6 cells, with the exception of Jacaglabroside A which was substantially more cytotoxic (IC_{50} was 8.3, >90, 87 and 85 µg/mL for Jacaglabrosides A-D respectively)[28].

The methanol extract of *Jacaranda obtusifolia* H. B. K. ssp. *rhombifolia* Gentry twigs exhibited anticancer activity against NCI-H187 (small cell lung cancer) cell line with an IC_{50} value of 23.2 mg/mL. The isolated compound Isoliquiritigenin exhibited the most potent anticancer activity against NCI-H187 with an IC_{50} of 16.6 mg/mL, while (–)-Liquiritigenin showed moderate anticancer activity against the NCI-H187 (IC_{50} = 30.1 mg/mL). In addition [(–)-Liquiritigenin, (–)-Neoliquiritin, Isoliquiritigenin, Isoliquiritin and formononetin] were non-cytotoxic to Vero cells (African green monkey kidney)[29].

Anti-leishmanial and antiprotozoal activities

The *in vitro* anti-leishmanial activity for a *Jacaranda puberula* leaf methanol extract was reported against *Leishmania amazonensis* promastigotes and amastigotes. The activity against promastigotes was moderate (IC_{50}: 88 µg/mL at 72 h), but against amastigotes was weak (IC_{50}: 359 µg/mL at 24 h). In both cases, at higher concentrations toxicity was observed[30].

Jacaranda glabra has shown promising activity against *Plasmodium falciparum* K1 strain. Subsequently, activity-guided isolation of the dichloromethane extract from the leaves of *J. glabra* afforded four phenylethanoid glucosides, named jacaglabrosides A−D. The compounds were found to be active *in vitro* against the *P. falciparum* K1 strain (IC_{50} of 1.02, 0.56, 0.56 and 0.55 µg/mL, respectively)[28].

Hypotensive activity

The hypotensive properties of an aqueous methanol extract of the leaves of *Jacaranda mimosifolia* were studied. The extract revealed hypothermic (IC_{50} of 100mg/kg; LD_{50}

of 655 mg/kg) and cardiovascular depressive (at 100–400 mg/kg) activities in male Wistar rats. The hypotensive properties reported *in vitro* (evaluated through analysis of contractile tension development) suggest a mode of action via the blockage of α-adrenergic receptors[31].

PHYTOCHEMISTRY

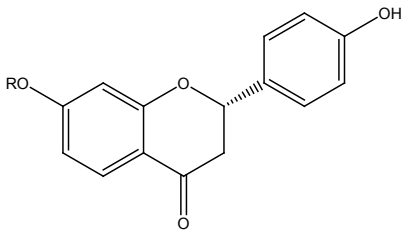
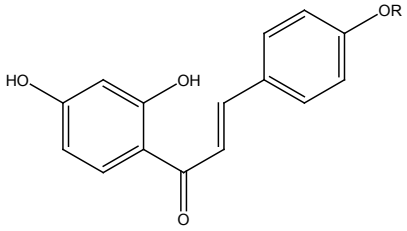
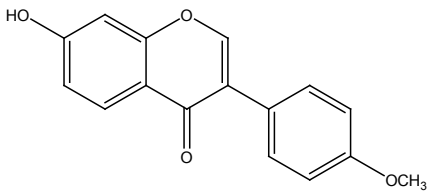
Phytochemicals are the chemical compounds that occur naturally in plants and may have protective or disease preventive properties[40]. Several different classes of phytochemicals have been reported from *Jacaranda* species. These compounds may be classified into several groups: flavonoids, phenylpropanoids, phenylethanoids, quinones, sterols, triterpenes and fatty acids.

Phenolics

The bioassay-guided isolation, structure elucidation and anticancer evaluation of five flavonoids were described, as shown in Table 3, which are (–)-Liquiritigenin, (–)-Neoliquiritin, Isoliquiritigenin, Isoliquiritin and formononetin from the twigs of *Jacaranda obtusifolia* H. B. K. ssp. Rhombifolia (G. F. W. Meijer) Gentry. The structures were elucidated based on ^{1}H, ^{13}C-NMR, comprehensive 2D-NMR, MS analyses and comparison with previously reported spectral data[29].

Recently, *Jacaranda caroba* (Vell.) A. DC was analyzed by HPLC–DAD–ESI/MS and revealed the presence of four dicaffeoyl acid derivatives and nine flavonoids including quercetin, kaempferol and isorhamnetin derivatives. Isorhamnetin-3-*O*-rhmanoside-7,4'-di-*O*-

Table 3. Flavanones, chalcones and isoflavones isolated from *Jacaranda obtusifolia* ssp. Rhombifolia

Compound / Reference	Molecular structure
	
(–)-Liquiritigenin [29] (–)-Neoliquiritin [29]	R = H R = glucosyl
	
Isoliquiritigenin [29] Isoliquiritin [29]	R = H R = glucosyl
Formononetin [29]	

glucoside and quercetin-3-*O*-(2-pentosyl) hexoside were the main metabolites in both the aqueous and hydromethanolic extracts and qualitative and quantitative differences were found between the extracts. The aqueous extract was richer in dicaffeoyl acid derivatives[26].

The total polyphenols and total flavonoids were estimated from different solvent extracts of *Jacaranda mimosifolia* leaves and flowers. It was shown that the butanol fraction of both leaves and flowers contained the majority of the polyphenols in comparison to the other extracts. The total polyphenols were expressed in gallic acid equivalent (GAE) and it ranged from 45.3 to 181.8 mg GAE/g extract. The highest amounts (180.57 mg/g in the leaves and 181.85 mg/g in the flowers) were found in the butanolic extracts. Similarly, the total flavonoids expressed as quercetin equivalent (QE; 4.4–55.4 mg QE/g) were also higher in the butanolic extracts (55.42 mg/g in the leaves and 32.99 mg/g in the flowers)[25]. Table 3 summarizes the different flavanones, chalcones and isoflavones isolated from *Jacaranda* species.

Phenyl propanoids, phenyl ethanoids and quinones

The methanol extract of the stems of *Jacaranda caucana* was analyzed. The extract was partitioned between ethyl acetate, butanol and water. The ethyl acetate fraction afforded two new phenylethanoid glycosides, along with protocatechuic acid, acteoside, and jionoside D. Further purifications yielded isoacteoside and martynoside. The butanol fraction afforded a new rhamnosyl derivative of sisymbrifolin, a neolignan. The structures were determined by means of spectrometric methods, including 1D and 2D-NMR experiments and MS analysis[24].

The dichloromethane extract of the leaves of *J. glabra* was investigated and four phenylethanoid glucosides containing jacaranone-type moieties were identified as jacaglabrosides A−D. Their chemical structures were identified using NMR spectroscopy and MS techniques[28].

The methanol and chloroform extracts of *Jacaranda cuspidifolia* Mart. were analyzed and revealed the presence of saponins, coumarins, flavonoids, tannins, quinones, alkaloids, triterpenes, and steroids. Verbascoside was isolated and identified as a major peak in methanol extract and chloroform fraction high-performance liquid chromatography fingerprints[19].

Four phytoquinoids were isolated from the fresh leaves of *Jacaranda mimosaefolia* which were identified as β-D-glucopyranose 2-benzeneacetate1,6-bis(1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetate), for which the name Jacaranoside was proposed; β-D-glucopyranose 2-(4-hydroxybenzeneacetate) 1,6-bis(1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetate), for which the name Jacarandol was proposed; β-D-glucopyranose 2-benzeneacetate 1-(1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetate) and β-D-glucopyranose 1,6-bis (1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetate)[41].

Two new compounds: 2-(3',4'-dihydroxyphenyl) ethyl-3-*O*-α-L-rhamnopyranosyl-4-*O*-*p*-hydroxy-phenylacetyl-6-*O*-caffeoyl-β-D-glucopyranoside and 2-(3',4'-dihydroxyphenyl) ethyl-3-*O*-α-L-rhamnopyranosyl- 4-*O*-piperidine-3-carboxylic acid-6-*O*-caffeoyl-β-D-glucopyranoside, in addition to isoacetoside were identified from the stem bark of *Jacaranda mimosaefolia*[42].

The isolation of a phenylethanoid glucoside [1,6-Bis(1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetyl)-3-(para-hydroxybenzeneacetyl)-β- glucopyranoside] was reported from the leaves of *Jacaranda mimosifolia* along with jacaranone[25]. Table 4 summarizes the different quinones isolated from *Jacaranda* species.

Triterpenes and sterols

Lupeol, betulinaldehyde, terminic acid, betulinic acid, maslinic acid and β-sitosterol glucoside were isolated and identified from the stem bark of *Jacaranda mimosaefolia* (Table 5)[42].

CONCLUSION

The genus *Jacaranda* has proven to be rich in phytoconstituents, mainly consisting of flavonoids, phenylpropanoids, phenylethanoids, sterols and triterpenes. Also, the genus *Jacaranda* have shown significant pharmacological potential and promising activities such as antioxidant, antidepressant, antimicrobial, anticancer, anti-leishmanial, anti-protozoal, hypotensive and anti-hypertriglyceridemic activities.

These results make the traditional uses rational and highlight the importance of the genus *Jacaranda*. Thus, it may serve as a vital natural bioactive medicinal source and promote a high degree of interest in further studies.

Table 4: Quinones isolated from *Jacaranda* species

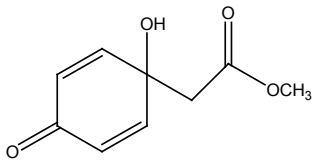
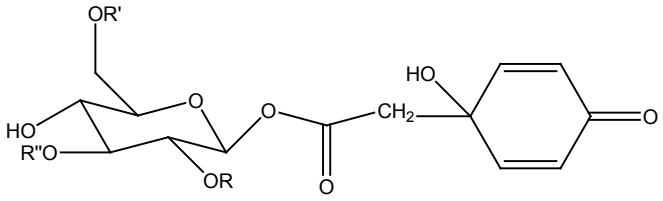
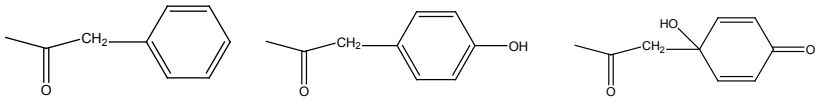
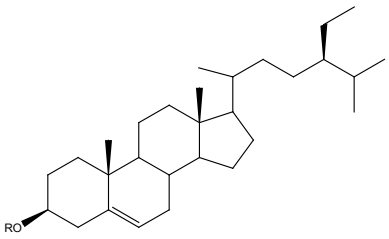
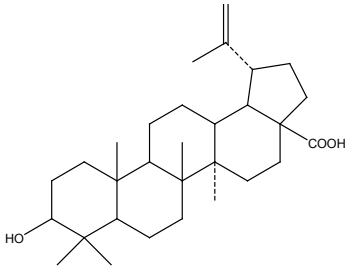
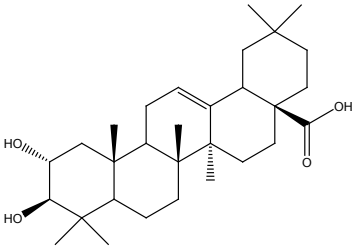
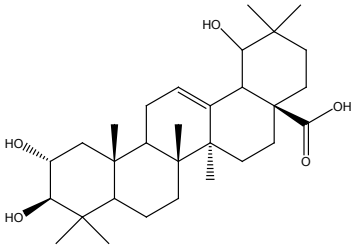
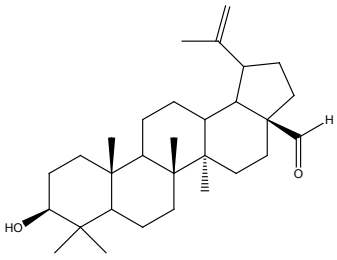
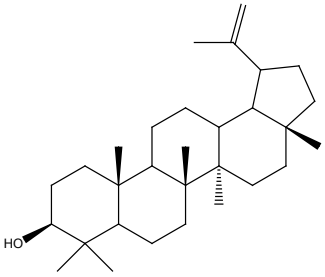
Compound/ Reference	Molecular structure			Plant name
Jacaranone [25].				Jacaranda mimosifolia
				
				
	A	B	C	
	R	**R'**	**R"**	
Jacaranoside (jacaglabroside B) [28, 41].	A	C	H	*Jacaranda glabra, J. mimosifolia*
Jacarandol [25, 41].	B	C	H	*Jacaranda mimosifolia*
β-D-glucopyranose 2-benzeneacetate 1-(1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetate[41].	A	H	H	*Jacaranda mimosifolia*
β-D-glucopyranose 1,6-bis (1-hydroxy-4-oxo-2,5-cyclohexadiene-1-acetate[41].	H	C	H	*Jacaranda mimosifolia*
Jacaglabroside A [28].	A	C	A	*Jacaranda glabra*
Jacaglabroside C [28].	B	C	A	*Jacaranda glabra*
Jacaglabroside D [28].	A	C	B	*Jacaranda glabra*

Table 5: Triterpenes and sterols isolated from *Jacaranda mimosaefolia*

Compound/ Reference	Molecular structure
β-Sitosterol glucoside [42].	 R= β-D-Glucose
Betulinic acid [42].	
Maslinic acid [42].	
Terminic acid [42].	
Betulinaldehyde [42].	
Lupeol [42].	

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