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Chemical constituents and biological activities of species of *Justicia* - a review

Geone M. Corrêa,*[*,1,2] Antônio F. de C. Alcântara[1]

[1]Departamento de Química, ICEx, Universidade Federal de Minas Gerais, Brazil, [2]Instituto de Ciências Exatas e Tecnologia, Universidade Federal do Amazonas, Brazil.

Review

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Abstract: The Acanthaceae family is an important source of therapeutic drugs, and the ethnopharmacological knowledge of this family requires urgent documentation as several of its species are near extinction. *Justicia* is the largest genus of Acanthaceae, with approximately 600 species. The present work provides a review addressing the chemistry and pharmacology of the genus *Justicia*. In addition, the biological activities of compounds isolated from the genus are also covered. The chemical and pharmacological information in the present work may inspire new biomedical applications for the species of *Justicia*, considering atom economy, the synthesis of environmentally benign products without producing toxic by-products, the use of renewable sources of raw materials, and the search for processes with maximal efficiency of energy.

Introduction

The Acanthaceae family, order Scrophulariales, superorder Lamiiflorae (sensu Dahlgren), comprises almost 250 genera with 2500 species. Its species are widespread in tropical regions of the world (Wasshausen & Wood, 2004) and are poorly represented in temperate regions (Mabberley, 1997). *Justicia* is the largest genus of Acanthaceae, with approximately 600 species that are found in pantropical and tropical regions (Durkee, 1986).

The species of *Justicia* are described as erect or scandent perennial herbs or subshrubs. Leaves present cystoliths and are petiolate with a leaf margin that is usually entire. Inflorescences are in spikes or panicles cimas, and the species rarely has solitary, terminal, or axillary flowers. The bracts and bracteoles are usually conspicuous and imbricate. The species of *Justicia* can be easily recognized by their bilabial corolla, with a posterior lip that is generally two-lobed, an anterior lip that is three-lobed, two stamens, a capsule with four seeds, and a basal sterile portion (Graham, 1990; Braz et al, 2002).

Table 1 shows the vegetal species of the genus *Justicia* with previous chemical and/or biological studies, indicating their botanical synonymy, popular name, and geographical distribution. Few species of *Justicia* have been studied (36 species of approximately 600 cataloged species), with fifteen species found in the Americas, thirteen species in Asia, and eight species in Africa. Among the studied species, 31 species have ethnopharmacological/pharmacological information, 23 species were chemically investigated, and only eighteen species were chemically and biologically studied, mainly in the last decade. The most studied species are *Justicia pectoralis* Jacq., *Justicia procumbens* L., *Justicia gendarussa* Burm. f., and *Justicia anselliana* (Nees) T. Anderson. Consequently, the phytochemical and biological potential of other species of *Justicia* have yet to be fully explored.

Material and Methods

An extensive search in original and review articles was carried out in this work. The keywords used for this review were *Justicia,* Acanhaceae and Medicinal Plants. The search was performed accessing SciFinder, ScienceDirect, Web of Science, and Scielo web sites, updated to May 2011. From the literature search, all plants/herbal of *Justicia* preparations that are used ethnomedically were included in this review. More than 90% of the references obtained were later consulted.

Ethnopharmacological information for the species of *Justicia*

Several species of *Justicia* are widely used in folk medicine (as shown in Table 2) for the treatment of respiratory and gastrointestinal diseases (thirteen and ten occurrences, respectively) as well as inflammation (ten occurrences, including applications in rheumatism and arthritis). The plants are also utilized for their effects on the central nervous system as hallucinogens, somniferous agents, sedatives, depressors, and treatments for epilepsy and other mental disorders, with eleven occurrences. Other species are popularly used in the treatment of headache and fever (eight occurrences, which may be associated with their sedative and analgesic properties), cancer (seven occurrences), diabetes (three occurrences), and HIV (two occurrences).

Whole plant and aerial parts are usually used in folk medicine. Extracts made from only the leaves are the most used (nineteen occurrences), followed by those extracts made from only the roots (five occurrences). Some species are used as mixtures (three occurrences). For example, traditional physicians around Kotagiri village near Ootacamund use a mixture of the powdered roots of *Cassia occidentalis* L., Caesalpineae, *Derris brevipes* var. *coriacea*, Papillionaceae, and *Justicia simplex* D. Don, Acanthaceae, to control fertility. Administration of this mixture for a few days after menstruation prevents conception without any toxic effects. The number of pregnancies among treated women was significantly less than that of the control group. These results indicate the abortifacient nature of the roots of these plants (Badami et al., 2003). The species *Justicia pectoralis* Jacq. is used as the major component in a mixture to treat various diseases. Moreover, *Justicia insularis* T. Anderson is used as an infusion mixed with the leaves of *Ambrosia maritime* L., Compositae.

Pharmacological tests of species of *Justicia*

Table 3 shows the pharmacological activities of the species of *Justicia* described in the literature. Some species show antitumoral activity against different cancer cell lines (seven occurrences). An ethanol extract of *Justicia neesii* Ramamoorthy (Acanthaceae) exhibited anticancer activity against P388 lymphocytic leukemia in mice. A methanol extract of the whole plant of *Justicia procumbens* L. showed significant inhibitory activity *in vivo* against P-388 lymphocytic leukemia growth and *in vitro* cytotoxicity in the 9-KB (human nasopharyngeal carcinoma) cell culture assay (Chen et al., 1995). Some species also showed inhibition of human cancer cell lines, mainly toward human cervical carcinoma (*Justicia ciliata* Jaqc.), T 47D and HeLa human cell lines (*Justicia spicigera* Schltdl.), and human ovarian cancer cell line (*Justicia rhodoptera* Baker), as well as prevention of some tumoral cell growth (*Justicia patentiflora* Hemsl.). The activity of popularly used whole-plant extracts of *J. procumbens* and *J. nesii* and leaf extracts of *J. specigera* as anticancer agents (Table 2) was confirmed by employing the same parts of the plant, as seen in Table 3. However, the anticancer properties of *Justicia adhatoda* L. have not yet been confirmed pharmacologically.

The whole-plant extract of *J. spicigera* contains cytotoxic factors for leukemic cells and has no proliferative activity on normal hematopoietic progenitor cells. The plant extract induces apoptosis in the human leukemia cell line TF-1, but not in the bcl-2 transfectant cell line TB-1. These data suggest a strong correlation between the cytotoxic effect and cell proliferation. The results indicate that the infusion of the aerial parts of *J. spicigera* does not contain any hematopoietic activity, induces apoptosis inhibited by bcl-2, and is linked to cell proliferation.

Some species show antiviral activity (five occurrences, *i.e., Justicia extensa* T. Anderson, *Justicia gendarussa* Burm. f., *J. procumbens, Justicia reptans* Sw., and *Justicia valida* Ridl.) against *in vitro* HIV type 1 reverse transcriptase, HIV replication, and vesicular stomatitis virus (Table 3). However, the species popularly used as antiviral agents, *Justicia betonica* L. and *Justicia flav*a (Vahl) Vahl (see Table 2), were either not included in pharmacological studies, or were tested but did not show antiviral activity. Crude water extracts of the aerial parts of *J. gendarussa* proved to be strongly active against *in vitro* HIV type 1 reverse transcriptase (as shown in Table 3). Based on these observations, this species might be further explored for its antiviral indications.

J. pectoralis showed high antibacterial activity against *E. coli, E. faecalis,* and *S. epidermidis.* Moreover, this species shows positive antimosquito tests, which were observed on the growth and development of IV-stage larvae of *Aedes aegypt*i mosquitoes. A brief exposure to concentrations of 0.05 to 0.50 mg/mL of the plant extract is required to produce 100% larvicidal activity. The extracts of *J. pectoralis* were found to be the most toxic larvicide among the species of *Justicia* extracts tested. Extracts of *J. pectoralis* have estrogenic, progestagenic, and anti-inflammatory effects, explaining the plant's traditional use in menopause and PMS therapies.

The methanol extract of the whole plant of *J. procumbens* exhibited 50% inhibitory activity toward the arachidonic acid-induced aggregation of rabbit platelets (Chen et al., 1995; Chen et al., 1996). The antiplatelet aggregation activity can be related to the popular use of extracts obtained from *Justicia*

anselliana (Nees) T. Anderson in the treatment of heart disease (Table 2).

The ethanol extract of the leaves of *J. gendarussa* showed a higher paw edema inhibition than aspirin-treated rats in the FCA-induced and the collagen-induced arthritic models (Table 3). These pharmacological results align with the popular use of *J. gendarussa* in the treatment of arthritis and rheumatism (see Table 2). The species *J. spicigera* is popularly used as an anti-inflammatory agent (Table 2), and this activity was also pharmacologically confirmed (see Table 3).

The popular use of *J. pectoralis* in the treatment of epilepsy and anxiety (as shown in Table 2) was confirmed with the ethanol extract of the leaves (Table 3). The ethanol extracts of *J. pectoralis, Justicia aurea* Schltdl., and *Justicia albobracteata* Leonard were tested *in vitro* for their ability to inhibit GABA-transaminase (GABA-T) or to bind to the GABAA-benzodiazepine receptor, two principal drug targets in epilepsy and anxiety. A significant positive correlation between GABA-T inhibition and the relative frequency of use for epilepsy was observed. Moreover, an even stronger correlation between GABAA binding and the relative frequency of use for shock was observed. Thus the Q'eqchi' traditional knowledge of *J. pectoralis, J. aurea*, and *J. albobracteata* is associated with the plant's antiepileptic and anxiolytic activities.

The pharmacological studies of some species were not based on their use in folk medicine. Extracts of the whole plant of *Justicia prostrata* Gamble showed antiulcer activity (Table 3). The aqueous extract was more active than the alcoholic extract when tests were made using the aspirin-induced pylorus ligated rat model. The antiulcerogenic activities of both extracts were compared with the drug Rantidine, an H2-receptor antagonist. Alcoholic extracts of *J. anselliana* showed allelopathic properties (Table 3). The aerial part of the plant produced more significant effects on the growth parameters of the cowpea plant (*Vigna unguiculata* (L.) Walp., Leguminosae), such as germination, elongation, and the weight, than extracts of the root (Ahanchede et al., 2004). Likewise, the popular use of the leaves of *Justicia schimperiana* (Hochst. ex Nees) T. Anderson in the treatment of liver disease (Table 2) may be related to the hepatoprotective activity of the leaf extracts of the plant (Table 3). However, the hepatoprotective activity of *J. adhatoda* (Table 3) was not studied despide its popular use. In addition, some other species, such as *J. betonica, Justicia calycina* (Nees) V.A.W.Graham, *Justicia diffusa* Willd., *Justicia dumetorum* Morong, *J. flava, Justicia ghiesbreghtiana* Lem., *Justicia ideogenes, J. insularis, Justicia plectrantus, Justicia purpurea* L., *Justicia secunda* Vahl, *Justicia sericea* Ruiz & Pav., and *J. simplex*, showed a variety of popular uses and have no yet been studied pharmacologically.

Compounds isolated from species of *Justicia*

A great diversity of chemical classes is found in the species of *Justicia*, mainly alkaloids, lignans, flavonoids, and terpenoids (iridods, diterpenoids, and triterpenoids). Other chemical classes have been isolated from species of *Justicia*, such as essential oils, vitamins, fatty acids (docosanoic acid), and salicylic acid (Angonese et al., 1992; Al-Juaid & Abdel-Mojib, 2004). The steroids campesterol, stigmasterol, sitosterol, and sitosterol-D-glucoside were isolated from the leaves and roots of *J. flava, J. spicigera*, and *J. gendarussa* (Olaniyi, 1980; Wahi et al., 1974; Domínguez et al., 1990; Amborabé et al., 2002; Deepak et al., 2002; Rajakumar & Shivana, 2009). The literature describes the allelopathy effect of the sterols and triterpenes. Both of the chemical classes isolated from the alcoholic extract of the aerial parts of *J. anselliana* showed allelopathic effects on cowpea plants (Kpoviessi et al., 2006). The allelopathic effects of the leaf and root extracts of *J. anselliana* have also been described, as shown in Table 3.

Table 4 shows a coumarin, flavonoids, alkaloids, and triterpenoidal glycosides isolated from the species of *Justicia*. Only one coumarin, umbeliferone (**1**), and a small variety of flavonoids (**2-5**), alkaloids (**6-13**), and triterpenoidal glycosides (**14-21**) were identified.

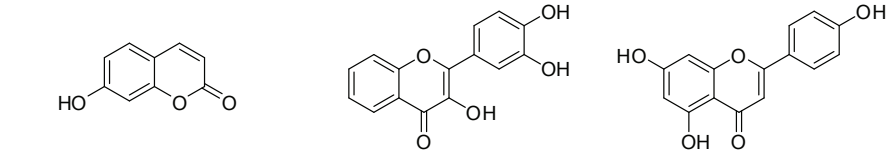
Leaf extracts from *J. reptans* display a clear virucidal effect on HIV, which was attributed to two glycosylated flavonoids that have not yet been identified (Bedoya, 2008). Compounds of this chemical class have been previously reported to display anti-HIV properties including reverse transcriptase or integrase inhibition, but this is the first time that they are described as virucides (Kumar et al., 2005). Pharmacological tests using the ethanol extract from *J. reptans* indicated inhibition of HIV replication (Table 3).

A large variety of lignans has been isolated from species of *Justicia* (Table 5). Lignans are a large group of natural products that show diverse biological effects. Lignans may serve as lead compounds for the development of new therapeutic agents with cytotoxic activity (Fukamiya & Lee, 1986; Hui et al., 1986). For example, lignans obtained from *J. pectoralis* are cytotoxic to leukemia and solid tumor cell lines (Hui et al., 1986).

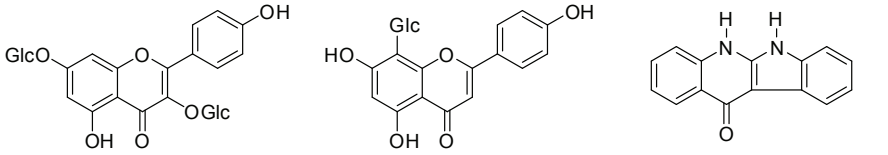
Lignans also show antiangiogenic, antileishmanial, antifungal, hypolipidemic, antiasthmatic (Vasilev & Ionkova, 2005), antiviral (Asano et al., 1996), antineoplastic (Gordaliza et al., 2000), antifeedant (Bedoya et al., 2008), insecticidal, cardiotonic, antidepressant (Ghosal et al., 1979), analgesic, antiplatelet (Chen et al., 1996), and anti-inflammatory (Navarro et al., 2004)

indications, as well as activity as lipid peroxidation inhibitors. Potent anti-inflammatory activities were described for lignan glycosides isolated from *J. ciliata* (Day et al., 2000) and phenolic compounds isolated from *J. prostrata* (Sanmugapriya et al., 2005b).

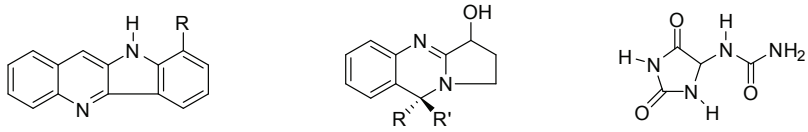
Many lignans contain an arylnaphthalide skeleton (**22-54**) and are found in relatively high proportions (Rajasekhar & Subbaraju, 2000). For example, jusmicranthin (**22**) was isolated from a chloroform extract of *J. neesii*, giving a mass yield of 0.025%. The dry leaves of *J. extensa* contain approximately 1% of justicidin P (**47**), which exists at



1 **2** **3**



4 **5** **6**

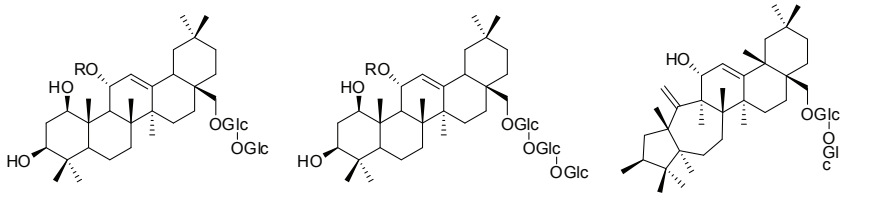


7 R=H
8 R=OGlc

9 R=R'=H
10 R and R'=O

11

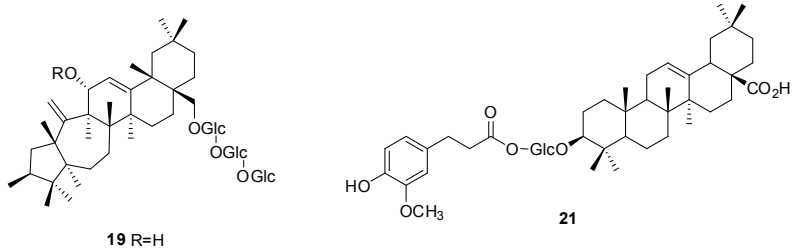
12 **13**



14 R=H
15 R=Me

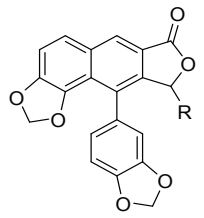
16 R=H
17 R=Me

18

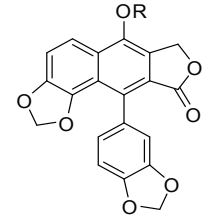


19 R=H
20 R=Me

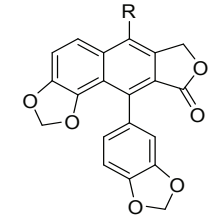
21



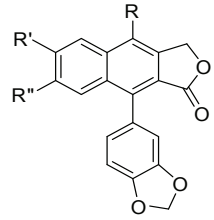
22 R=OMe
23 R=OH
24 R=H



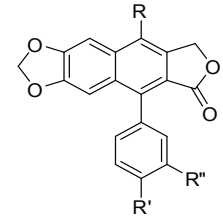
25 R=H
26 R=Me



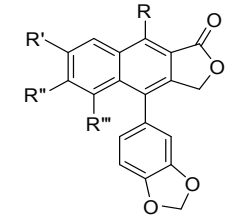
27 R=H
28 R=OMe



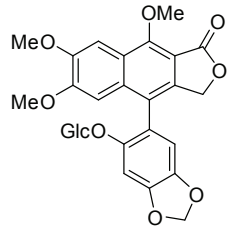
29 R=H; R'=R"=OMe
30 R=OH; R'=R"=OMe
31 R=R'=R"=OMe
32 R=OGlc; R'=R"=OMe
33 R=OGlc-OGlc; Me; R'=R"=OMe
34 R=OGlc-OGlc; Me; R'=R"=OMe
35 R=OGlc; Me; R'=R"=OMe
36 R=OGlc; Me; R'=R"=OMe
37 R=*O*-D-apiofuranosyl; Me; R'=R"=OMe



38 R=H; R'=R"=OMe
39 R=OMe; R'=OH; R"=OGlc
40 R=R"=OMe; R'=OH
41 R=OH; R'=R"=OMe



42 R=R'=H; R"=OH; R"'=OGlc
43 R=R'=R"OMe; R"'=H



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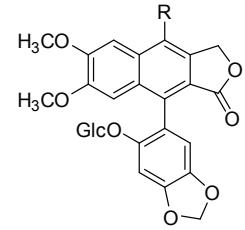
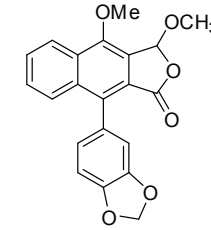


45 R=H
46 R=OMe



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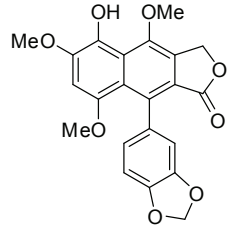

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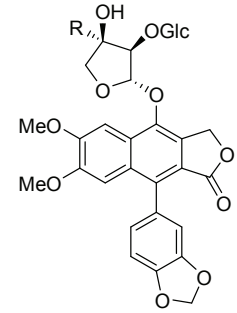
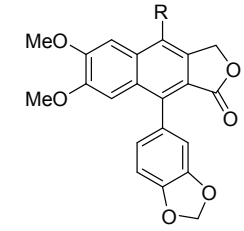
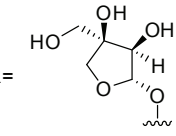


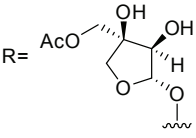
49 R=CH_2-*O*-β-D-xylopyranosyl
50 R=CH_2OH

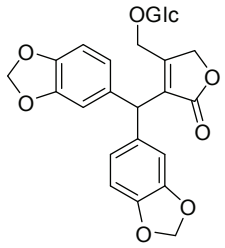


53 R=



54 R=





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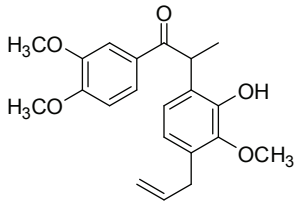

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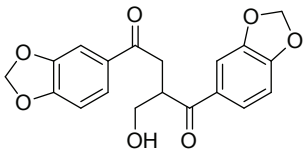

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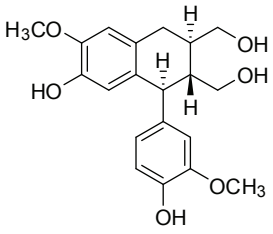

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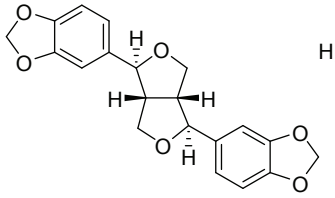

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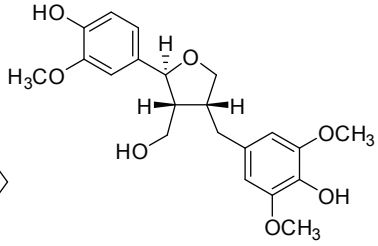

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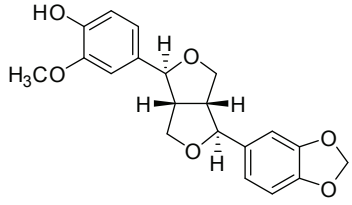

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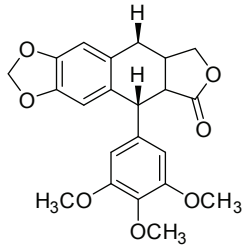

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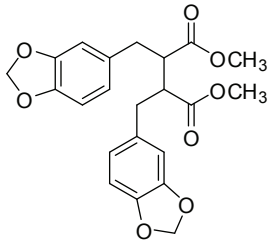

63

25 °C as two rotamers (Wang & Ripka, 1983). Some arylnaphthalide lignans are glycosylated derivatives (**32-37**, **39**, **42**, and **49**). Other miscellaneous-type lignans are also found in species of *Justicia* (**55-63**).

Biological activity of compounds isolated from species of *Justicia*

Some compounds show biological activities related to those observed in the species from which they are isolated. Coumarin umbeliferone (**1**), isolated from hydroalcoholic extract of the leaves of *J. pectoralis* (Table 4), showed anti-inflammatory, antinociceptive, and bronchodilator activities, which are related to the estrogenic, progestogenic, and anti-inflammatory activities of this species (Table 3) and its popular use in the treatment of bronchitis (Table 2). This species is also popularly used in the treatment of respiratory diseases (Table 2). The vasodilator activity of the flavonoid **2** is related to the anti-hypertensive activity of the *Justicia cataractae* Leonard, as shown in Table 3. Apigenin (**3**) has been reported to exert anti-inflammatory effects such as lowering oxidative stress and forestalling the expression of several inflammatory factors (Sawatzky et al., 2006). The flavonoid vitexin (**5**) is a potent anti-inflammatory agent, inhibiting the 5-lipoxygenase pathway, which, together with the COX-2 pathway, is very important in producing and maintaining inflammation (Sridhar et al., 2006). Compounds **3** and **5** were isolated from the ethanol extract of *J. gendarussa*, which is used in the treatment of inflammation, rheumatism, and arthritis in folk medicine (see Table 2). The antimicrobial and anti-inflammatory activities of flavonoid **4** (Table 4), as well as its effects on macrophage regulation and reduction in blood glucose levels are related to the popular uses of *J. spicigera* in giardicidal, anti-inflammatory, anticancer, and antidiabetes therapies (Tables 2 and 3). Alkaloid **11,** also isolated from *J. spicigera*, is used as an anti-inflammatory agent (Table 2).

Alkaloids **9**, **10**, and **13** show bronchodilator activity (Table 4) and were isolated from *J. adhatoda,* which is popularly used in the treatment of bronchitis (Table 2). The antifertility activity of triterpenoidal glycoside **21** (Table 4) is related to the popular use of *J. simplex* as an abortifacient and to control fertility (Table

2). Alkaloids **7** and **8** show antitumor activity (Table 4) and were isolated from *J. betonica*, however, this species is popularly used in the treatment of diarrhea, inflammations, and HIV/AIDS (Table 2), not toward cancer.

Elenoside (**42**), isolated from *Justicia hyssopifolia* L., is the most pharmacologically studied arylnaphthalene lignan in the genus *Justicia*. This compound shows sedative, muscle relaxant, cytotoxic, antiviral, insecticidal, cardiotonic, analgesic, lipid peroxidation inhibitory, anti-inflammatory, and stimulant activities and exhibits significant central nervous system depressant properties in rats. Its anxiolytic action, inducing sedation and muscle relaxation (Navarro et al., 2001a), is similar to other tranquilizer drugs (Irwin, 1968) such as the action of sedative-hypnotic barbiturates (Navarro et al., 2004). The cytotoxic activity of **42** was verified in human cancer cell lines in a range of concentrations from 10^{-5} to 10^{-4} M, with an LD50 of 305 mg/kg in mice and central depressive properties at doses of 25, 50, and 100 mg/kg. No lethality was observed for five days following administration of this compound (Alonso et al., 1997). As a consequence, this compound behaves as a sedative with broad-spectrum cytotoxicity (Navarro et al., 2001b), also showing cytotoxic effects toward leukemia cell lines (Navarro et al., 2001a).

Other lignans isolated from species of *Justicia* show a smaller spectrum of biological activity. The antiplatelet aggregation activity of lignans **25**, **26**, **28**, **29**, **38**, **40**, and **52** are related to the pharmacological tests of the methanol extract of *J. procumbens* (Table 3). Lignans **29**, **30**, **31**, **53**, and **54** showed strong antiviral activity against vesicular stomatitis virus and low cytotoxicity against cultured rabbit lung cells (RL-33) (Asano et al., 1996). Lignans **29** and **43** showed inhibition of secondary aggregation induced by adrenaline (Wu et al., 2007). Moreover, these compounds showed an inhibitory effect on cyclooxygenase-1 (COX-1), with an antiplatelet effect partially due to the suppression of COX-1 activity and reduced thromboxane formation.

Lignan **24** inhibits human hepatitis B viral replication. This compound is isolated from *J. flava*, which is popularly used in the treatment of HIV/AIDS in Uganda. Lignans **29**, **30**, **31**, **44**, **45**, **46**, **53**, and **54** show antiviral activities. These compounds were isolated from *J. extensa, J. betonica*, and *J. procumbens,* and also show the same biological activities (Tables 2 and 3). Conversely, lignans **29**, **30**, **31**, **35**, **36**, and **42** show antiviral activity, but were isolated from species that did not show this activity (Tables 2 and 3). A larger investigation of the extracts of these species is required to explore their antiviral activities.

The antitumor activity of lignans 2**5**, **27**, **29**, **30**, **31**, **35**, **36**, **37**, **50**, **51**, **53**, and **54** are related to the popular uses of *J. procumbens, J. ciliata, J. rhodoptera,* and *J. patentiflora* as anticancer therapies (Tables 2 and 3). Lignans **30**, **31**, and **37**, isolated from *J. ciliata*, showed significant citotoxic effects toward a number of cancer cell types (human hepatomacellular carcinoma, human cervical carcinoma, human colorectal adenocarcinoma, human colorectal carcinoma, and human breast cancer) (Day et al., 2002). Lignan **31** also displayed potent cytotoxic effects against T-24, CaSki, SiHa, HT-3, PLC/PRF/5, and 212 cells *in vitro* (Day et al., 1999). Lignan **60** exhibited low cytotoxicity against three human tumor cell lines: A-549 (human lung carcinoma), MCF-7 (human breast carcinoma), and HT-29 (human colon adenocarcinoma) (Subbaraju et al., 1991). Lignan **62** is included in a wide variety of cancer chemotherapy protocols and was used as a precursor for the semi-synthesis of anticancer therapeutics (Canel et al., 2000). Lignans **24**, **26**, **29**, **30**, **31**, **32**, **37**, **42**, **51**, **60**, **61**, and **62** show antitumoral activity, but they were isolated from species that did not show this activity (see Tables 2, 3, and 5). The data warrant a larger exploration of the extracts of these species for their anticancer properties.

Conclusion

Although the genus *Justicia* contains only a few species that have been chemically and biologically studied, a broad range of biological applications was observed. Lignans are the major components of the active extracts of the species of *Justicia*, exhibiting important pharmacological properties, such as antiviral, antitumoral, anti-inflamatory, and

Table 1. Synonymy, popular name, and geographical distribution of the species of *Justicia* with previous chemical and biological information.

Species	Synonymy (local name)	Geographical distribution	Chemical information	Biological information	Reference
*J. adhatod*a L.	*Adhatoda vasica* Ness (malabar nut and vasaka)	Nepal, India, and Pakistan	Yes	Yes	Aswal et al., 1984; Kumar et al., 2005; Rajakumar & Shivanna, 2009
J. albobracteata L.	(No reported)	Guatemala	No	Yes	Awad et al., 2009
J. anselliana	*Adhatoda anseliana* Ness (damandojé)	Tropical Africa (Mali, Guinea, Liberia, Ghana, Nigeria, Togo, and Benin)	Yes	Yes	Kpoviessi et al., 2006

J. aurea Schltdl.	*Cyrtanthera aurea* Schltdl., *Jacobina aurea* Schltdl., and *Justicia umbrosa* Benth. (yellow justicia and yellow jacobina)	Guatemala	No	Yes	Awad et al., 2009
J. betonica	*Nicoteba betonica* (white shrimp plant)	Northeast of Thailand	Yes	Yes	Day et al., 1999; Kanchanapoom et al., 2004; Subbaraju et al., 2004
J. calycina Nees	*J. acuminatissim*a (sara-tudo)	Suriname	No	Yes	Ruysschaert et al., 2009
J. cataractae	(No reported)	Venezuela	Yes	Yes	Jiménez et al., 2001
J. ciliata	*Dianthera ciliate*	Taiwan	Yes	Yes	Day et al., 1999; Day et al., 2000
J. comata L.	(Marsh water-willow)	Peru	No	Yes	McKenna et al., 2011
J. diffusa Willd	*J. procumbens* L.	India	No	Yes	Ignacimuthu et al., 2008
J. dumetorum Morong	*Justicia squalida*	Bolivia	No	Yes	Bourdy et al., 2004
J. extensa	*Justicia talbotii* (castellana Hiern)	Gabon	Yes	Yes	Wang & Ripka, 1983; Ibrahim et al., 2000
J. flava Vahl	*Adhatoda flava* (yellow justicia)	Tropical and Southern Africa	Yes	Yes	Olaniyi, 1980
J. gendarussa Burm F	*Gendarussa vulgaris* Ness (daun rusa and gandarusa)	China, India, Sri Lanka, and Malaysia	Yes	Yes	Wahi et al., 1974; Hadi & Bremner, 2001; Sridhar et al., 2006; Mruthunjaya & Hukkeri, 2007
J. ghiesbreghtiana	*J. spicigera* (muitle, muicle, and mexican honeysuckle)	Mexico	Yes	No	Euler & Alam, 1982; Ismail et al., 1998
J. glauca	(Glaucous justicia)	Mexico	Yes	No	Subbaraju et al., 1991; Vega-Avila et al., 2009
J. hayatai	*Justicia procumbens* L. var. hayatai Yamamoto	Taiwan	Yes	No	Fukamiya & Lee, 1986
J. heterocarpa T. Anders.	*J. dinteri* S. Moore	Angola, Namibia, Malawi, Mozambique, Zambia, Zimbabwe, and South Africa	Yes	No	Al-Juaid & Abdel-Mojib, 2004; Ssegawa & Kasenene, 2007
J. hyssopifolia L.	(Mataprieta)	Canary Islands	Yes	No	Navarro et al., 2001a; Woradulayapinij et al., 2005
J. ideogenes	(No reported)	Brazil	No	Yes	Schultes, 1993; Adams et al., 2007
J. insularis	(Mmeme, kpahunmarogu)	Nigeria	No	Yes	Ajibesin et al., 2008
J. neesii Ramamoorthy	*J. micrantha* Wall	India	Yes	Yes	Chariandy et al., 1999; Rajasekhar & Subbaraju, 2000
J. patentiflora Hemsl.	*Mananthes patentiflora* Bremek.	North Vietnam	Yes	Yes	Susplugas et al., 2005
J. pectoralis Jacq.	(Tilia, chambá, and papa uwii)	Tropical America	Yes	Yes	Moreno et al., 1994; Lino et al., 1997; Leal et al., 2000; Cano & Volpato, 2004
J. plectrantus	(No reported)	Brazil	No	Yes	Leão et al., 2007
J. procumbens L.	(Ramakrishna theertham)	Taiwan and India	Yes	Yes	Chen et al., 1995; Chen et al., 1996; Asano et al., 1996; Savithramma et al., 2007
J. prostrata Gamble	(No reported)	India	Yes	Yes	Sanmugapriya et al., 2005a; Sanmugapriya et al., 2005b
J. purpurea L.	*Justicia carnea*	India	Yes	Yes	Kavitha et al., 2003
J. reptans Swatz	(Mutuquinha)	Brazil	Yes	Yes	Rodrigues et al., 2010
J. rhodoptera	(No reported)	Madagascar	Yes	Yes	Williams et al., 2003
J. schimperiana	(Sensel, simiza, timisa, and dumoga)	Ethiopia	No	Yes	Umer et al., 2010

J. secunda	(Brudu uwíi)	Suriname	No	Yes	Teklehaymanot, 2009
J. sericea	(Inca queen)	Peru	No	Yes	Rojas et al., 2003
J. simplex	(No reported)	India	Yes	Yes	Badami et al., 2003
J. spicigera	(Mohintli)	Mexico	Yes	Yes	Meckes et al., 2004
J. valida	(No reported)	Taiwan	No	Yes	Woradulayapinij et al., 2005

Table 2. Ethnopharmacological informations of the species of *Justicia.*

Species	Part used	Popular use	Preparation/ Adminstration	Region	Reference
J. adhatoda	Root	Bronchitis	Teaspoonful of root paste	India	Aswal et al., 1984; Joshi & Joshi, 2000
	Flower, fruit, and root	Cold, whooping cough, asthma, and helminthic	Juice	India	Joshi & Joshi, 2000; Kumar et al., 2005
	Leaf	Diarrhoea, dysentery, and glandular tumor	Juice	India	Kumar et al., 2005
	Leaf and root	Expectorant, tuberculosis, abortificient, antimicrobial, antitussive, and anticancer		India	Roja et al., 2011
J. anselliana	Leaf	Heart diseases	Decoction	Benin	Kpoviéssi et al., 2008
	Root	Heart diseases and testicles inflammation	Decoction	Benin	Kpoviéssi et al., 2008
J. betonica	Aerial part	Diarrhoea and inflammation		India	Kanchanapoon et al., 2004
	Leaf	HIV/AIDS		Uganda	Lamorde et al., 2010
J. calycina	Whole plant	Stimulant	Decoction	Suriname	Ruysschaert et al., 2009
J. ciliata	Whole plant	Fever and pain		China	Day et al., 2000
J. diffusa	Leaf	Skin disease	Paste	India	Ignacimuthu et al., 2008
J. dumetorum	Leaf and flower	Eye infection	Juice	Bolivia	Bourdy et al., 2004
J. extensa	Whole plant	Ichthyotoxic (affect the fish respiratory system by paralysis)	Crushed bark, leaf, and fruit	Gabon	Ibrahim et al., 2000
J. flava	Seed	Smeared on gingival, teeth pain, and nausea	Powder	Sudan	El-Kamali, 2009
	Leaf and flower	Haemorrhoids and stomach disorders		Ghana	Agbovie et al., 2002
	Leaf	HIV/AIDS		Uganda	Lamorde et al., 2010
J. gendarussa	Leaf	Fever, hemiplegia, rheumatism, arthritis, headache, earache, muscle pain, respiratory disorders, and digestive troubles	Decoction	China and India	Ratnasooriya et al., 2007
		Muscle pain and treatment of fractured bone	Paste warmed applied on the affected area	Malaysia	Ahmad & Holdsworth, 2003
		Rheumatism and arthritis	Poultice	Vietnam	Ahmad & Holdsworth, 2003
		Analgesic to treat hemiplegia, rheumatism, arthritis, headache, and earache	Decoction	Sri Lanka	Ratnasooriya et al., 2007
	Twig	Herbal bath during childbirth	Decoction	Malaysia	Ahmad & Holdsworth, 2003
	Whole plant	Haemorrhoids and fever	Decoction	India	Gurib-Fakin et al., 1996
	Whole plant	Fever and pains	Decoction	Brazil	De Albuquerque et al., 2007
J. ghiesbreghtiana	Leaf	Stimulant and dysentery	Decoction	Mexico	Euler & Alam, 1982
J. ideogenes	Whole plant	Treatment of limb trembling	Warm decoctions	South America	Schultes, 1993; Adams et al., 2007

J. insularis	Leaf	Tooth ache, digestive, weaning agent, and laxative	Cooked as soup	Nigeria	Ajibesin et al., 2008
	Leaf	Antimalarial	Infusion mixed with leaves of *Ambrosia maritima*	Uganda	Adjanohoun et al., 1993; Tabuti, 2008
J. neesii	Whole plant	Anticancer	Ethanolic extract	India	Chariandy et al., 1999; Rajasekhar & Subbaraju, 2000
J. pectoralis	Leaf	Asthmas, cough, bronchitis, and expectorant	Syrup	Brazil	Agra et al., 2007
	Leaf	Menstruation pain, diuretic, cold, and cough	Aqueous infusion	Ecuador	Tene et al., 2007
		Skin rash	Crushed	Caribbean Region	Longuefosse & Nossin, 1996
	Aerial part	Catarrh, allergic eruptions, somniferous, nervousness, sedative, and hypotensive	Infusion, major component of mixtures	Cuba	Moreno et al., 1994; Cano & Volpato, 2004
		Pulmonary infections and hallucinogenic snuff		South America	MacRae & Towers, 1984
	Whole plant	Asthmas	Crushed and sap	Suriname	Teklehaymanot, 2009
		Epilepsy		Belize	Awad et al., 2009
	Leaf and stem	Diabetes, smooth muscle relaxant in respiratory diseases, prostate diseases, antibacterial, and sedative		Colombia	Lizcano et al., 2010
J. plectrantus	Leaf	Headache	Bath	Brazil	Leão et al., 2007
J. procumbens	Leaf	Asthmas	Decoction	India	Savithramma et al., 2007
	Root	Fever due to typhoid	Decoction	Nepal	Joshi & Joshi, 2000
	Aerial part	Fish-killing material	Juice	Taiwan	Fukumiya & Lee, 1986; Chen et al., 1996
	Whole plant	Fever, pain due to pharyngolaryngeal swelling, and cancer	Juice	Taiwan	Chen et al., 1996
		Laryngeal disease and cancer		China	Asano et al., 1996
J. purpurea	Root	Insanity and other mental disorders		India	Kavitha et al., 2003
J. reptans	Leaf	Colic	Infusion		Rodrigues et al., 2010
J. schimperiana	Leaf	Diarrhoea, dysentery, and other stomach disorders	Juice of crushed fresh leaf	Ethiopia	Teklehaymanot, 2009
	Leaf	Liver diseases		Ethiopia	Umer et al., 2010
J. secunda	Leaf	Depression and anaemia	Infusion	Ghana	N'Guessan et al., 2010
	Whole plant	Anaemia	Decoction	Suriname and Congo	Teklehaymanot, 2009
J. sericea	Aerial part	Vaginitis and inflammation		Peru	Rojas et al., 2003
J. simplex	Root	Control fertility and abortifacient	Mixture of powdered roots of different plants	India	Badami et al., 2003
J. spicigera	Leaf	Stimulant, colic, inflammation, acabies (skin infection caused by the itch mite), gastrointestinal disorders, and source of blue dye	Decoction	Mexico	Meckes et al., 2004
	Aerial part	Kidney infection, stimulant, dysentery, menstruation, uterine cancer and diabetes	Decoction	Mexico	Vega-Avila et al., 2009; Alonso-Castro et al., 2011
	Leaf	diabetes	Infusion	Mexico	Andrade-Cetto & Heinrich, 2005

Table 3. Pharmacological activities of the species of *Justicia.*

Species	Tested Part	Biological Activity	Extract	Reference
J. albobracteata	Leaf	Epilepsy and anxiety	EtOH	Awad et al., 2009
J. adhatoda	Leaf	Hepatoprotective	Aqueous	Bhattacharyya et al., 2005
J. anselliana	Leaf and root	Allellopathy	EtOH	Ahanchede et al., 2004
J. aurea	Leaf	Epilepsy and anxiety	EtOH	Awad et al., 2009
J. cataractae	Whole plant	Anti-hypertensive	EtOH	Jiménez et al., 2001
J. ciliata	Whole plant	Inhibition of human cervical carcinoma	MeOH	Day et al., 1999
J. comata	Whole plant	Cognitive deficits	Aqueous	McKenna et al., 2011
J. extensa	Leaf	Insecticidal and antiviral	EtOH	Wang & Ripka, 1983
J. gendarussa	Leaf	Anti-arthritic	EtOH	Paval et al., 2009
	Aerial part	Inhibition of HIV type 1 reverse transcriptase	Aqueous	Sridhar et al., 2006
	Leaf	Antinociceptive and antioxidant	Aqueous	Ratnasooriya et al., 2007
	Leaf	Immunosuppressive	MeOH	Arokiyaraj et al., 2007
J. neesii	Whole plant	Inhibition of P388 lymphocytic leukaemia in mice	EtOH	Chariandy et al., 1999; Rajasekhar & Subbaraju, 2000
J. patentiflora	Leaf and stem	Inhibition of tumoral cell growth	EtOAc	Susplugas et al., 2005
J. pectoralis	Leaf	Bactericidal and larvicidal	EtOAc	Chariandy et al., 1999
	Aerial part	Estrogenic, progestogenic, and anti-inflammatory	MeOH	Lockleara et al., 2010
	Leaf	Epilepsy and anxiety	EtOH	Awad et al., 2009
J. procumbens	Whole plant	Inhibition of tumoral cell growth and aggregation of rabbit platelets	MeOH	Fukamiya & Lee, 1986; Chen et al., 1996
	Aerial part	Inhibition of vesicular stomatitis virus (VSV).	MeOH	Asano et al., 1996
J. prostrata	Whole plant	Anti-inflammatory, antiulcerogenic, and anti-depressant	Aqueous and EtOH	Stevenson, 1995; Sanmugapriya et al., 2005a
J. reptans	Leaf	Inhibition of HIV replication	EtOH	Bedoya et al., 2008
J. rhodoptera	Leaf	Inhibition of human ovarian cancer cell line		Williams et al., 2003
J. schimperiana	Leaf	Hepatoprotective	Hydroalcoholic	Umer et al., 2010
J. spicigera	Leaf	Inhibition of edema	Hexane, $CHCl_3$, and MeOH	Meckes et al., 2004
	Leaf	Antitumor	Aqueous	Cáceres-Cortés et al., 2001
	Aerial part	Inhibition of human cancer cell lines	Aqueous and EtOH	Vega-Avila et al., 2009; Alonso-Castro et al., 2011
	Aerial part	Giardicidal	MeOH	Peraza-Sanches et al., 2005
J. valida	Aerial part	Inhibition of HIV type 1 reverse transcriptase *in vitro*	Aqueous	Woradulayapinij et al., 2005

Table 4. Biological activity of coumarin (**1**), flavonoids (**2-5**), alkaloids (**6-13**), and triterpenes (**14-21**) isolated from the species of *Justicia.*

Compound	Biological Activity	Species	Extract	Reference
Umbeliferone (**1**)	Anti-inflammatory, antinociceptive, and bronchodilator	*J. pectoralis*	EtOH	Lino et al., 1997; Leal et al., 2000
3´,4´-Dihydroxyflavonol (**2**)	Antioxidant, prevents diabetes, and vasodilator	*J. cataractae*	EtOH	Jiménez et al., 2001; Wang et al., 2004; Woodman et al., 2005; Woodman & Malakul, 2009
Apigenin (**3**)	Anti-inflammatory and antitumor	*J. gendarussa*	EtOH	Wahi et al., 1974; Sawatzky et al., 2006; Cai et al., 2011
Kaempferitrin (**4**)	Antimicrobial, anti-inflammatory, regulators of macrophages, and reduce the blood glucose level	*J. spicigera*	$CHCl_3$	Dominguez et al., 1990; Abdel-Ghani et al., 2001; Fang et al., 2005; Cazarolli et al., 2006
Vitexin (**5**)	Anti-inflammatory and antinociceptive	*J. gendarussa*	EtOH	Wahi et al., 1974; Sridhar et al., 2006; Gorzalczany et al., 2011

5*H*,6*H*-Quinindolin-11-one (**6**)		*J. betonica*	EtOAc	Subbaraju et al., 2004
10*H*-Quindoline (**7**)	Antitumor	*J. betonica*	EtOAc	Caprio et al., 2000; Subbaraju et al., 2004
Jusbetonin (**8**)	Antitumor	*J. betonica*	MeOH	Caprio et al., 2000; Subbaraju et al., 2004
Vasicine (**9**)	Bronchodilator, uterotonic, and anti-inflammatory	*J. adhatoda*	EtOH	Amin & Mehta, 1959; Mehta et al., 1963; Ikram & Huq, 1966; Bhalla et al., 1982; Chakravarthy et al., 1982; Jindal et al., 1988; Ismail et al., 1998; Lorenz et al., 1999; Claeson et al., 2000; Shevyakov et al., 2006; Rachana et al., 2011
Vasicinone (**10**)	Bronchodilator	*J. adhatoda*	EtOH	Amin & Mehta, 1959; Mehta et al., 1963; Ikram & Huq, 1966; Bhalla et al., 1982; Chakravarthy et al., 1982; Ismail et al., 1998; Jindal et al., 1998; Lorenz et al., 1999; Rachana et al., 2011
Allantoin (**11**)	Anti-inflammatory and anti-ulcer	*J. spicigera*		Dominguez et al., 1990; Niu et al., 2010
6*H*-Quinindoline (**12**)		*J. betonica*	EtOAc	Subbaraju et al., 2004
Vasicinol (**13**)	Bronchodilator	*J. adhatoda*	EtOH	Amin & Mehta, 1959; Mehta et al., 1963; Ikram & Huq, 1966; Bhalla et al., 1982; Chakravarthy et al., 1982; Ismail et al., 1998; Jindal et al., 1998; Lorenz et al., 1999; Rachana et al., 2011
Justicioside A (**14**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2004
Justicioside C (**15**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2004
Justicioside B (**16**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2004
Justicioside D (**17**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2004
Justicioside E (**18**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2005
Justicioside F (**19**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2005
Justicioside G (**20**)		*J. betonica*	EtOH/H_2O	Kanchanapoom et al., 2005
Justicisaponin (**21**)	Antifertility	*J. simplex*	MeOH	Ghosal et al., 1981; Badami et al., 2003

Table 5. Lignans isolates from the species of *Justicia.*

Compound	Biological Activity	Species	Extract	Reference
Jusmicranthin (**22**)		*J. neesii*	EtOH	Rajasekhar & Subbaraju, 2000
Jusmicranthin methyl ether (**23**)		*J. neesii*	EtOH	Rajasekhar & Subbaraju, 2000
Helioxanthin (**24**)	Inhibition human hepatitis B viral replication and antitumor	*J. flava*	ETOH	Chang et al., 2000; Tseng et al., 2008;
Taiwanin E (**25**)	Antiplatelet aggregation and antitumor	*J. procumbens*	EtOH	Chen et al., 1996; Chang et al., 2000
Taiwanin E methyl ether (**26**)	Antiplatelet aggregation and cytotoxicity against human cervical carcinoma	*J. purpurea*	MeOH	Kavitha et al., 2003
		J. betonica	MeOH	Day et al., 1999
		J. procumbens	EtOH	Chen et al., 1996
Justicidin E (**27**)	Inhibition of leukotriene biosynthesis by human leukocytes	*J. procumbens*	MeOH	Fukamiya & Lee, 1986; Thérien et al., 1993
Neojusticin A (**28**)	Antiplatelet aggregation	*J. procumbens*	EtOH and MeOH	Fukamiya & Lee, 1986; Chen et al., 1996; Wu et al., 2007
			MeOH	Fukamiya & Lee, 1986; Asano et al., 1996
Justicidin B (**29**)	Anti-inflammatory, antiplatelet aggregation, cytotoxycity, antiviral, fungicidal, antiprotozoal against T. cruzi, antimalarial, and antirheumatic	*J. purpurea*	MeOH	Baba et al., 1996; Gertsch et al., 2003; Kavitha et al., 2003; Rao et al., 2006; Wu et al., 2007; Kaur et al., 2009
		J. procumbens	EtOH	Chen et al., 1996
			MeOH	Asano et al., 1996
Diphyllin (**30**)	Cytotoxycity and antiviral	*J. extensa*	EtOH	Wang & Ripka, 1983
		J. procumbens	MeOH	Fukamiya & Lee, 1986; Chen et al., 1996; Asano et al., 1996
		J. ciliata	MeOH	Day et al., 1999

Justicidin A (**31**)	Cytotoxycity, antiviral, 'fish-killing' properties, and induced apoptosis in human hepatoma cells	*J. extensa*	EtOH	Wang & Ripka, 1983
		J. betonica	EtOH	Munakata et al., 1965; Day et al., 1999
		J. procumbens	MeOH	Fukamiya & Lee, 1986; Asano et al., 1996; Chen et al., 1996; Su et al., 2006
		J. rhodoptera	EtOH	Williams et al., 2003
Cleistanthin B (**32**)	Antitumor	*J. purpurea*	MeOH	Pradheepkumar et al., 2000; Kavitha et al., 2003
Neesiinoside A (**33**)		*J. neesii*	MeOH	Subbaraju et al., 2001
4´´-*O*-Acetylpatentiflorin B (**34**)		*J. patentiflora*	EtOAc	Susplugas et al., 2005
Patentiflorin A (**35**)	Cytotoxicity against human carcinoma cells	*J. patentiflora*	EtOAc	Susplugas et al., 2005
Patentiflorin B (**36**)	Cytotoxicity against human carcinoma cells	*J. patentiflora*	EtOAc	Susplugas et al., 2005
Tuberculatin (**37**)	Antitumor	*J.ciliata*	MeOH	Day et al., 1999; Lu et al., 2008
		J. betonica	MeOH	
Chinensinaphthol methyl ether (**38**)	Antiplatelet aggregation	*J. ciliata*	CH_2Cl_2	Day et al., 1999
Justalakonin (**39**)		*J. purpurea*	MeOH	Kavitha et al., 2003
4´-Dimethyl chinensinaphthol methyl ether (**40**)	Antiplatelet aggregation	*J. ciliata*	CH_2Cl_2	Day et al., 1999
		J. procumbens	EtOH	Chen et al., 1996
Chinensinaphthol (**41**)		*J. betonica*	MeOH	Day et al., 1999
		J. procumbens	EtOH	Chen et al., 1996
Elenoside (**42**)	Sedative, muscle relaxant, cytotoxic, antiviral, insecticidal, cardiotonic, analgesic, inhibition of lipid peroxidation, anti-inflammatory, and stimulant	*J. hyssopifolia*	EtOAc	Alonso et al., 1997; Navarro et al., 2001a; Navarro et al., 2001b
Neojusticin B (**43**)	Antiplatelet aggregation	*J. ciliata*	CH_2Cl_2/ Me_2CO	Day et al., 1999
		J. procumbens	EtOH	Fukamiya & Lee, 1986; Asano et al., 1996; Chen et al., 1996
Justicidinoside A (**44**)	Antiviral	*J. procumbens*	MeOH	Asano et al., 1996
Justicidinoside C (**45**)	Antiviral	*J. procumbens*	MeOH	Asano et al., 1996
Justicidinoside B (**46**)	Antiviral	*J. procumbens*	MeOH	Asano et al., 1996
Justicidin P (**47**)		*J. extensa*	EtOH	Wang & Ripka, 1983
Justicinol (**48**)	Mild effect on the CNS	*J. patentiflora*	EtOAc	Susplugas et al., 2005
Ciliatoside A (**49**)	Anti-inflammatory	*J. ciliata*	MeOH	Day et al., 2000; Wu et al., 2007
Procumbenoside A (**50**)	Antitumor	*J. procumbens*	MeOH	Day et al., 2002; Lu et al., 2008
Cilinaphthalide A (**51**)	Antitumor	*J. betonica*		
		J. ciliata	CH_2Cl_2	Day et al., 1999
Cilinaphthalide B (**52**)	Antiplatelet aggregation induced by adrenaline	*J. betonica*	MeOH	
		J. ciliata	CH_2Cl_2	Day et al., 1999
		J. procumbens	MeOH	Wenga et al., 2004
Diphylin apioside (**53**)	Cytotoxycity and antiviral	*J. procumbens*	MeOH	Asano et al., 1996
Diphyllin apioside-5-acetate (**54**)	Cytotoxycity and antiviral	*J. procumbens*	MeOH	Asano et al., 1996
Juspurpurin (**55**)		*J. purpurea*	MeOH	Kavitha et al., 2003
Carinatone (**56**)		*J. patentiflora*	EtOAc	Susplugas eta al., 2005
Justiflorinol (**57**)		*J. patentiflora*	EtOAc	Susplugas et al., 2005

(+)-Isolariciresinol (**58**)	Anti-inflammatory	*J. flava*	EtOH	Küpeli et al., 2003;
Sesamin (**59**)	Angiogenic	*J. purpurea*	MeOH	Kavitha et al., 2003; Chung et al., 2010
Justiciresinol (**60**)	Cytotoxicity	*J. glauca*	EtOAc	Subbaraju et al., 1991
Xanthoxylol (**61**)	Antitumor effect on mouse, skin, and pulmonary carcinogenesis	*J. purpurea*	MeOH	Konoshima & Atta-Ur-Rahman, 2000; Kavitha et al., 2003
Podophyllotoxin (**62**)	Cancer chemotherapy	*J. flava*	EtOH	Canel et al., 2000; Meckes et al., 2004;
Heliobuphthalmin (**63**)	Antineoplasic	*J. ciliata*	CH_2Cl_2	Day et al., 1999; Duarte et al., 2010

antiplatelet aggregations activities, which warrant further exploration. The chemical and pharmacological data shown in the present work should inspire additional study of the species of *Justicia* for their use in therapeutics.

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References

Abdel-Ghani NT, Shoukry AF, El Nashar RM 2001. Flow injection potentiometric determination of pipazethate hydrochloride. *Analyst 126*: 79-85.

Adams M, Gmunder F, Hamburger M 2007. Plants traditionally used in age related brain disorders - a survey of ethnobotanical literature. *J Ethnopharmacol 113*: 363-381.

Adjanohoun EJ, Ahyi MRA, Aké AL, Alia AM, Amai CA, Gbile ZO, Johnson CLA, Kakooko ZO, Lutakome HK, Morakinyo O, Mubiru NK, Ogwal-Okeng JW, Sofowora EA 1993. *Traditional medicine and pharmacopoeia - contribution to ethnobotanical and floristic studies in Uganda.* Scientific, Technical and Research Commission of the Organization of the African Unity (OAU/STRC).

Agbovie T, Ofusohene-Djan W, Crentsil OR, Dennis F, Odamtten GT, Amponsah K 2002. *Conservation and sustainable use of medicinal plants in Ghana ethnobotanical survey.* http://www.unep-wcmc.org/species/plants/ghana, access in March 2011.

Agra MF, Freitas PF, Barbosa-Filho JM 2007. Synopsis of the plants known as medicinal and poisonous in Northeast of Brazil. *Rev Bras Farmacogn 17*: 114-140.

Ahanchede A, Gbehounou G, Kossou KD, Yayi E, Akpo E 2004. Contribution à l'étude de la caractérisation du pouvoir allélopathique de *Justicia anselliana* (Nees) T. Anders: approche de bioessais utilisant des extraits obtenus à partir du matériel végétal sèche. *Ann Sci Agron Bénin 6*: 1-2.

Ahmad FB, Holdsworth DK 2003. Medicinal plants of Sabah, East Malaysia - Part I. *Pharm Biol 41*: 340-346.

Ajibesin KK, Ekpo BA, Bala DN, Essien EE, Adesanya SA 2008. Ethnobotanical survey of Akwa Ibom State of Nigeria. *J Ethnopharmacol 115*: 387-408.

Al-Juaid SS, Abdel-Mojib MA 2004. A novel podophyllotoxin lignan from *Justicia heterocarpa. Chem Pharmaceult Bull 52*: 507-509.

Alonso SJ, Navarro E, Trujillo J, Jorge E, Pérez C 1997. Profile of activity and cytotoxic screening of elenoside. *Method Find Exp Clin Pharmacol 19*: 186-187.

Alonso-Castro AJ, Villarreal ML, Salazar-Olivo LA, Gomez-Sanchez M, Dominguez F, Garcia-Carranca A 2011. Mexican medicinal plants used for cancer treatment: pharmacological, phytochemical and ethnobotanical studies. *J Ethnopharmacol 133*: 945-972.

Amborabé BE, Fleurat-Lessard P, Chollet JF, Roblin G 2002. Antifungal effects of salicylic acid and other benzoic acid derivatives towards *Eutypa lata*: structure-activity relationship. *Plant Physiol Biochem 40*: 1051-1060.

Amin AH, Mehta DR 1959. Bronchodilator alkaloid from *Adhatoda vasica. Nature 184*: 1317-1318.

Andrade-Cetto A, Heinrich M 2005. Mexican plants with hypoglycaemic effect used in the treatment of diabetes. *J Ethnopharmacol 99*: 325-348.

Angonese MT, Moreira DL, Kaplan MAC 1992. Perfil químico da familia acanthaceae. *Bol Mus Biol Mello Leitão 1*: 3-6.

Arokiyaraj S, Perinbam K, Agastian P, Balaraju K 2007. Immunosuppressive effect of medicinal plants of Kolli hills on mitogen-stimulated proliferation of the human peripheral blood mononuclear cells *in vitro. Indian J Pharmacol 39*: 180-183.

Asano J, Chiba K, Tada M, Yoshii T 1996. Antiviral activity of lignans and their glycosides from *Justicia procumbens. Phytochemistry 42*: 713-717.

Aswal BS, Bhakuni DS, Goel AK, Kar K, Mehrotra BN,

Mukherjee KC 1984. Screening of Indian plants for biological activity: Part X. *Indian J Exp Biol 22*: 312-332.

Awad R, Ahmed F, Bourbonnais-Spear N, Mullally M, Ta CA, Tang A, Merali Z, Maquin P, Caal F, Cal V, Poveda L, Vindas PS, Trudeau VL, Arnason JT 2009. Ethnopharmacology of Q'eqchi' Maya antiepileptic and anxiolytic plants: effects on the GABAergic system. *J Ethnopharmacol 125*: 257-264.

Baba A, Kawamura N, Makino H, Ohta Y, Taketomi S, Sohda T 1996. Studies on disease-modifying antirheumatic drugs: synthesis of novel quinoline and quinazoline derivatives and their antiinflammatory effect. *J Med Chem 39*: 5176-5182.

Badami S, Aneesh R, Sankar S, Sathishkumar MN, Suresh B, Rajan S 2003. Antifertility activity of Derris brevipes variety coriacea. *J Ethnopharmacol 84*: 99-104.

Bedoya LM, Alvarez A, Bermejo M, Gonzalez N, Beltran M, Sanchez-Palomino S, Cruz SM, Gaitán I, Del Olmo E, Escarcena R, Garcia PA, Cáceres A, Feliciano AS, Alcamí J 2008. Guatemalan plants extracts as virucides against HIV-1 infection. *Phytomedicine 15*: 520-524.

Bhalla HL, Cruz JLD, Kokate CK 1982. Improved method of extraction and analysis of vasicine and vasicinone, the alkaloids of *Adhatoda vasica* Nees. *Indian Drugs 20*: 16-18.

Bhattacharyya D, Pandit S, Jana U, Sen S, Sur TK 2005. Hepatoprotective activity of *Adhatoda vasica* aqueous leaf extract on δ-galactosamine-induced liver damage in rats. *Fitoterapia 76*: 223-225.

Bourdy G, Michel LRC, Roca-Coulthard A 2004. Pharmacopoeia in a shamanistic society: the Izoceño-Guaraní (Bolivian Chaco). *J Ethnopharmacol 91*: 189-208.

Braz DM, Carvalho-Okano RM, Kameyama C 2002. Acanthaceae da Reserva Florestal Mata do Paraíso, Viçosa, Minas Gerais. *Rev Brasil Bot 25*: 495-504.

Cáceres-Cortés JR, Cantú-Garza FA, Mendoza-Mata MT, Chavez-González MA, Ramos-Andujano G, Zambrano-Ramírez IR 2001. Cytotoxic activity of *Justicia spicigera* is inhibited by bcl-2 proto-oncogene and induces apoptosis in a cell cycle dependent fashion. *Phytother Res 8*: 691-697.

Cai J, Zhao XL, Liu AW, Nian H, Zhang SH 2011. Apigenin inhibits hepatoma cell growth through alteration of gene expression patterns. *Phytomedicine 18*: 366-373.

Canel C, Moraes RM, Dayan FE, Ferreira D 2000. Podophyllotoxin. *Phytochemistry 54*: 115-120.

Cano JH, Volpato G 2004. Herbal mixtures in the traditional medicine of Eastern Cuba. *J Ethnopharmacol 90*: 293-316.

Caprio V, Guyen B, Opoku-Boahen Y, Mann J, Gowan AM, Kelland LM, Readd MA, Neidled S 2000. A novel inhibitor of human telomerase derived from 10H-Indolo [3,2-b] quinoline. *Bioorg Med Chem Lett 10*: 2063-2066.

Cazarolli LH, Zanatta L, Jorge AP, De Sousa E, Horst H, Woehl VM, Pizzolatti MG, Szpoganicz B, Silva FR 2006. Follow-up studies on glycosylated flavonoids and their complexes with vanadium: their anti-hyperglycemic potential role in diabetes. *Chem-Biol Interact 163*: 177-191.

Chakravarthy AK, Dastidar PPG, Pakrashi SC 1982. Simple aromatic amines from J*ustica gendarussa*. ^{13}C NMR spectra of the bases and their analogues. *Tetrahedron Lett 38*: 1797-1802.

Chang ST, Wang DSY, Wu CL, Shiah SG, Kuo YH, Chang CJ 2000. Cytotoxicity of extractives from *Taiwania cryptomerioides* heartwood. *Phytochemistry 55*: 227-232.

Chariandy CM, Seaforth CE, Phelps RH, Pollard GV, Khambay BPS 1999. Screening of medicinal plants from Trinidad and Tobago for antimicrobial and insecticidal properties. *J Ethnopharmacol 64*: 265-270.

Chen CC, Lin CF, Huang YL, Ko FN, Teng CM 1995. Bioactive constituents from the flower buds and peduncles of *Lindera megaphylla*. *J Nat Prod 58*: 1423-1425.

Chen CC, Hsin WW, Ko FN, Huang YL, Ou JC, Teng CM 1996. Antiplatelet arylnaphthalide lignans from *Justicia procumbens*. *J Nat Prod 59*: 1149-1150.

Chung BH, Lee JJ, Kim JD, Jeoung D, Lee H, Choe J, Ha KS, Kwon YG, Kim YM 2010. Angiogenic activity of sesamin through the activation of multiple signal pathways. *Biochem Bioph Res Co 391*: 254-260.

Claeson UP, Malmfors T, Wikman G, Bruhn JG 2000. *Adhatoda vasica*: a critical review of ethnopharmacological and toxicological data. *J Ethnopharmacol 72*: 1-20.

Day S, Chiu N, Won S, Lin C 1999. Cytotoxic lignans of *Justicia ciliata*. *J Nat Prod 62*: 1056-1058.

Day SH, Chiu NY, Tsao LT, Wang JP, Lin CN 2000. New lignan glycosides with potent antiinflammatory effect, isolated from *Justicia ciliata*. *J Nat Prod 63*: 1560-1562.

Day SH, Lin YC, Tsai ML, Tsao LT, Ko HH, Chung MI, Lee JC, Wang JP, Won SJ, Lin CN 2002. Potent cytotoxic lignans from *Justicia procumbens* and their effects on nitric oxide and tumor necrosis factor-production in mouse macrophages. *J Nat Prod 65*: 379-381.

De Albuquerque UP, Monteiro JM, Ramos MA, De Amorim ELC 2007. Medicinal and magic plants from a public market in Northeast of Brazil. *J Ethnopharmacol 110*: 76-91.

Deepak M, Dipankar G, Prashanth D, Asha MK, Amit A, Venkataraman BV 2002. Tribulosin and β-sitosterol-D-glucoside, the anthelmintic principles of Tribulus terrestris. *Phytomedicine 9*: 753-756.

Domínguez XA, Achenbach H, González CC, Ferré-D´Amore AR 1990. Estudio quimico del muitle (*Justicia spicigera*). *Rev Latinoamer Quím 21*: 142-143.

Duarte N, Lage H, Abrantes M, Ferreira MJU 2010. Phenolic compounds as selective antineoplasic agents against multidrug-resistant human cancer cells. *Planta Med 76*: 975-980.

Durkee LH 1986. Flora Costaricensis: Acanthaceae. *Fieldiana Botany 18*: 1-87.

El-Kamali HH 2009. Ethnopharmacology of Medicinal Plants used in North Kordofan (Western Sudan). *Ethnobot Leaflets 13*: 203-210.

Euler KL, Alam M 1982. Isolation of kaempferitrin from *Justicia spicigera*. *J Nat Prod 45*: 220-221.

Fang SH, Rao YK, Tzeng YM 2005. Inhibitory effects of flavonol glycosides from *Cinnamomum osmophloeum* on inflammatory mediators in LPS/IFN-gamma-activated murine macrophages. *Bioorg Med Chem 13*: 2381-2388.

Fukamiya N, Lee K 1986. Antitumor agents, 81. Justicidin-A and diphyllin, two cytotoxic principles from *Justicia procumbens*. *J Nat Prod 49*: 348-350.

Gertsch J, Tobler RT, Brun R, Sticher O, Heilmann J 2003. Antifungal, antiprotozoal, cytotoxic and piscicidal properties of Justicidin B and a new arylnaphthalide lignan from *Phyllanthus piscatorum*. *Planta Med 69*: 420-424.

Ghosal S, Banerjee S, Frahm AW 1979. Prostalidins A, B, C and retrochinensin: a new antidepressant: 4-aryl-2,3-naphthalide lignans from *Justicia prostrata*. *Chem Ind 23*: 854-855.

Ghosal S, Srivastava AK, Srivastava RS, Chattopadhyay S, Maitra M 1981. Chemical constituents of *Justicia*. Part 4. Justicisaponin-I, a new triterpenoid saponin from *Justicia simplex*. *Planta Med 42*: 279-283.

Gordaliza M, Castro MA, Del Corral JMM, San Feliciano A 2000. Antitumor properties of podophyllotoxin and related compounds. *Curr Pharm Design 6*: 1811-1839.

Gorzalczany S, Marrassini C, Miño J, Acevedo C, Ferraro G 2011. Antinociceptive activity of ethanolic extract and isolated compounds of *Urtica circularis*. *J Ethnopharmacol 134*: 733-738.

Graham VAW 1990. Delimitation and infra-generic classification of *Justicia* (Acanthaceae). *Kew Bull 43*: 551-624.

Gurib-Fakin A, Sewraj MD, Gueho J, Dulloo E 1996. Medicinal plants of Rodrigues. *Pharm Biol 34*: 2-14.

Hadi S, Bremner JB 2001. Initial studies on alkaloids from Lombok medicinal plants. *Molecules 6*: 117-129.

Hui HY, Chang CJ, McLaughlin JL, Powell GP 1986. Justicidin B, a bioactive trace lignan from the seeds of *Sesbania drummondii*. *J Nat Prod 49*: 1175-1176.

Ibrahim B, M'batchi B, Mounzeo H, Bourobou H 2000. Effect of *Tephrosia vogelii* and *Justicia extensa* on *Tilapia nilotica in vivo*. *J Ethnopharmacol 69*: 99-104.

Ignacimuthu S, Ayyanar M, Sankarasivaraman K 2008. Ethnobotanical study of medicinal plants used by Paliyar tribals in Theni district of Tamil Nadu, India. *Fitoterapia 79*: 562-568.

Ikram MM, Huq ME 1966. Estimation of vasicine from the flowering tops of *Adhatoda vasica*. *Pakistan J Sci Res 18*: 109-110.

Irwin S 1968. Comprehensive observational assessment: a systematic, quantitative procedure for assessing the behavioral and physiologic state of the mouse. *Psychopharmacologia 13*: 222-257.

Ismail LD, Lorenz P, Stermitz FR 1998. Isolation and synthesis of an α-malamic acid derivative from *Justicia ghiesbreghtiana*. *J Nat Prod 61*: 1174-1176.

Jiménez G, Hasegawa M, Rodríguez M, Estrada O, Méndez J, Castillo A, Gonzalez-Mujica F, Motta N, Vásquez J, Romero-Vecchione E 2001. Biological screening of plants of the Venezuelan Amazons. *J Ethnopharmacol 77*: 77-83.

Jindal DP, Chattopadhaya R, Minu M 1998. Development of beta 2-adrenoceptor agonists: (antiasthmatics-1). *Indian Drugs 35*: 606-639.

Joshi AR, Joshi K 2000. Indigenous knowledge and uses of medicinal plants by local communities of the Kali Gandaki Watershed Area, Nepal. *J Ethnopharmacol 73*: 175-183.

Kanchanapoom T, Noiarsa P, Ruchirawat S, Kasai R, Otsuka H 2004. Triterpenoidal glycosides from *Justicia betonica*. *Phytochemistry 65*: 2613-2618.

Kanchanapoom T, Noiarsa P, Kasai R, Otsuka H, Ruchirawat S 2005. Justiciosides E-G, triterpenoidal glycosides with an unusual skeleton from *Justicia betonica*. *Tetrahedron 61*: 2583-2587.

Kaur K, Jain M, Kaur T, Jain R 2009. Antimalarials from nature. *Bioorg Med Chem 17*: 3229-3256.

Kavitha J, Gopalaiah K, Rajasekhar DG, Subbaraju V 2003. Juspurpurin, an unusual secolignan glycoside from *Justicia purpurea*. *J Nat Prod 66*: 1113-1115.

Konoshima T, Atta-Ur-Rahman T 2000. Anti-tumor-promoting activities (cancer chemopreventive activities) of natural products. *Stud Nat Prod Chem 24*: 215-267.

Kpoviessi S, Gbaguidi F, Gbenou J, Accrombessi G, Haddad M, Moudachirou M, Quetin-Leclercq J 2006. Allelopathic effects on cowpea (*Vigna unguiculata* (L.) Walp) plant and cytotoxic activities of sterols and triterpenes isolated from *Justicia anselliana* (NEES) T. Anders. *Electron J Nat Subs 1*: 12-19.

Kpoviéssi DSS, Gbaguidi F, Gbénoua J, Accrombessi G, Moudachiroua M, Rozet E, Hubert P, Quetin-Leclercq J 2008. Validation of a method for the determination of sterols and triterpenes in the aerial part of *Justicia anselliana* (Nees) T. Anders by capillary gas chromatography. *J Pharmaceut Biomed 48*: 1127-1135.

Kumar A, Ram J, Samarth RM, Kumar M 2005. Modulatory influence of *Adhatoda vasica* Nees leaf extract against gamma irradiation in Swiss albino mice.

Phytomedicine 12: 285-293.

Küpeli E, Erdemoglu N, Yesilada E, Sener B 2003. Anti-inflammatory and antinociceptive activity of taxoids and lignans from the heartwood of *Taxus baccata* L. *J Ethnopharmacol 89*: 265-270.

Lamorde M, Tabuti JRS, Obua C, Kukunda-Byobona C, Lanyero H, Byakika-Kibwika P, Bbosa GS, Lubega A, Ogwal-Okeng J, Ryan M, Waako PJ, Merry C 2010. Medicinal plants used by traditional medicine practitioners for the treatment of HIV/AIDS and related conditions in Uganda. *J Ethnopharmacol 130*: 43-53.

Leal LKAM, Ferreira AAG, Bezerra GA, Matos FJA, Viana GSB 2000. Antinociceptive, anti-inflammatory and bronchodilator activities of Brazilian medicinal plants containing coumarin: a comparative study. *J Ethnopharmacol 70*: 151-159.

Leão R, Ferreira MRC, Jardim MAG 2007. Levantamento de plantas de uso terapêutico no município de Santa Bárbara do Pará, Estado do Pará, Brasil. *Rev Bras Farmacogn 88*: 21-25.

Lino CS, Viana, GSB, Matos FJA 1997. Analgesic and antiinflammatory activities of *Justicia pectoralis* Jacq and its main constituents: coumarin and umbelliferone. *Phytother Res 11*: 211-215.

Lizcano LJ, Bakkali F, Ruiz-Larrea MB, Ruiz-Sanz JI 2010. Antioxidant activity and polyphenol content of aqueous extracts from Colombian Amazonian plants with medicinal use. *Food Chem 119*: 1566-1570.

Longuefosse JL, Nossin E 1996. Medical ethnobotany survey in Martiniq. *J Ethnopharmacol 53*: 117-142.

Lorenz P, Stermitz FR, Ismail LD 1999. An amide of l-threo-γ-hydroxyglutamic acid from *Justicia ghiesbreghtiana. Phytochemistry 52*: 63-66.

Lockleara TD, Huanga Y, Frasor J, Doyle BJ, Perez A, Gomez-Laurito J, Mahadya GB 2010. Estrogenic and progestagenic effects of extracts of *Justicia pectoralis* Jacq., an herbal medicine from Costa Rica used for the treatment of menopause and PMS. *Maturitas* 66: 315-322.

Lu YH, Wei BL, Ko HH, Lin CN 2008. DNA strand-scission by phloroglucinols and lignans from heartwood of *Garcinia subelliptica* Merr. and *Justicia* plants. *Phytochemistry 69*: 225-233.

Mabberley DJ 1997. *The plant-book: a portable dictionary of the vascular plants.* Cambridge: Cambridge University Press.

MacRae WD, Towers GHN 1984. *Justicia pectoralis*: a study of the basis for it´s use a hallucinogenic snuff ingredient. *J Etnopharmacol 12*: 93-111.

McKenna DJ, Ruiz JM, Hoye TR, Roth BL, Shoemaker AT 2011. Receptor screening technologies in the evaluation of Amazonian ethnomedicines with potential applications to cognitive deficits. *J Ethnopharmacol 134*: 475-492.

Mehta DR, Naravane JS, Desai RM 1963. Vasicinone. A bronchodilator principle from *Adhatoda vasica* Nees (N. O. Acanthaceae). *J Org Chem 28*: 445-448.

Meckes M, David-Rivera AD, Nava-Aguilar V, Jimenez A 2004. Activity of some Mexican medicinal plant extracts on carrageenan-induced rat paw edema. *Phytomedicine 11*: 446-451.

Moreno E, Valero M, Herrera P 1994. El uso de plantas mágicas y medicinales por las parteras tradicionales cubanas. *Fontqueria 39*: 219-241.

Mruthunjaya K, Hukkeri VI 2007. Antioxidant and free radical scavenging potential of *Justicia gendarussa* Burm leaves *in vitro. Nat Prod Sci 13*: 199-206.

Munakata K, Marumo S, Ohta K, Chen Y 1965. Justicidin A and B, the fish-killing components of *Justicia hayatai* var. decumbes. *Tetrahedron Lett 47*: 4167-4170.

Navarro E, Alonso SJ, Trujillo J, Jorge E, Pérez C 2001a. General behavior, toxicity, and cytotoxic activity of elenoside, a lignan from *Justicia hyssopifolia*. *J Nat Prod 64*: 134-135.

Navarro E, Alonso SJ, Trujillo J, Jorge E, Pérez C 2001b. Pharmacological effects of elenoside, an arylnaphthalene lignan. *Biol Pharm Bull 24*: 254-258.

Navarro E, Alonso SJ, Trujillo J, Jorge E, Pérez C 2004. Central nervous activity of elenoside *Phytomedicine 11*: 498-503.

N'Guessan K, Kouassi KH, Ouattara K 2010. Plants used to treat anaemia, in traditional medicine, by Abbey and Krobou populations, in the South of Côte-d'Ivoire. *J Appl Sci Res 6*: 1291-1297.

Niu CS, Chen W, Wu HT, Cheng KC, Wen YJ, Lin KC, Cheng JT 2010. Decrease of plasma glucose by allantoin, an active principle of yam (Dioscorea spp.), in streptozotocin-Induced Diabetic Rats. *J Agr Food Chem 58*: 12031-12035.

Olaniyi AA 1980. Lignans from *Justicia flava. J Nat Prod 43*: 482-486.

Pradheepkumar CP, Panneerselvam N, Shanmugam G 2000. Cleistanthin A causes DNA strand breaks and induces apoptosis in cultured cells. *Mutat Res 464*: 185-193.

Paval J, Kaitheri SK, Potu BK, Govindan S, Kumar RS, Narayanan SN, Moorkoth S 2009. Anti-arthritic potential of the plant *Justicia gendarussa* Burm F. *Clinics 64*: 357-360.

Peraza-Sánchez S, Poot-Kantún S, Torres-Tapia LW, May-Pat F, Simá-Polanco P, Cedillo-Rivera R 2005. Screening of native plants from Yucatan for anti-*Giardia lamblia* activity. *Pharm Biol 43*: 594-598.

Rachana, Sujata B, Mamta P, Manoj KP, Sonam S 2011. Review and future perspectives of using vasicine, and related compounds. *IGJPS 1*: 85-98.

Rajakumar N, Shivanna MB 2009. Ethno-medicinal application of plants in the eastern region of Shimoga district, Karnataka, India. *J Ethnopharmacol 126*: 64-73.

Rajasekhar D, Subbaraju GV 2000. Jusmicranthin, a new arylnaphthalide lignan from *Justicia neesii. Fitoterapia 71*: 598-599.

Rao YK, Fang SH, Tzeng YM 2006. Anti-inflammatory activities of constituents isolated from *Phyllanthus polyphyllus*. *J Ethnopharmacol 103*: 181-186.

Ratnasooriya WD, Deraniyagala SA, Dehigaspitiya DC 2007. Antinoceptive activity and toxicological study of aqueous leaf extract of *Justicia gendarussa* Burn F. in rats. *Pharmacogn Mag 3*: 145-155.

Rodrigues E, Duarte-Almeida JM, Pires JM 2010. Perfil farmacológico e fitoquímico de plantas indicadas pelos caboclos do Parque Nacional do Jaú (AM) como potenciais analgésicas. Parte I. *Rev Bras Farmacogn 20*: 981-991.

Roja G, Vikrant BH, Sandur SK, Sharma A, Pushpa KK 2011. Accumulation of vasicine and vasicinone in tissue cultures of *Adhatoda vasica* and evaluation of the free radical-scavenging activities of the various crude extracts. *Food Chem 126*: 1033-1038.

Rojas R, Bustamante B, Bauer J, Fernández I, Albán J, Lock O 2003. Antimicrobial activity of selected Peruvian medicinal plants. *J Ethnopharmacol 88*: 199-204.

Ruysschaert S, Van Andel T, Van de Putte K, Van Damme P 2009. Bathe the baby to make it strong and healthy: plant use and child care among Saramaccan Maroons in Suriname. *J Ethnopharmacol 121*: 148-170.

Sanmugapriya E, Shanmugasundaram P, Venkataraman S 2005a. Effect of conventional antihypertensive drugs on hypolipidemic action of garlic in rats. *Indian J Exp Biol 43*: 176-181.

Sanmugapriya E, Shanmugasundaram P, Venkataraman S 2005b. Anti-inflammatory activity of *Justicia prostrata* Gamble in acute and sub-acute models of inflammation. *Inflammopharmacology 13*: 493-500.

Savithramma N, Sulochana C, Rao KN 2007. Ethnobotanical survey of plants used to treat asthma in Andhra Pradesh, India. *J Ethnopharmacol 113*: 54-61.

Sawatzky D, Willoughby D, Colville-Nash P, Rossi A 2006. The involvement of the apoptosis-modulating proteins Erk 1/2, Bcl-xL, and Bax in the resolution of acute inflammation *in vivo*. *Am J Pathol 168*: 33-41.

Schultes RE 1993. Plants in treating senile dementia in the Northwest Amazon. *J Ethnopharmacol 38*: 129-135.

Shevyakov SV, Davydova OI, Pershin DG, Krasavin M, Kravchenko DV, Kiselyov A, Tkachenko SE, Ivachtchenko AV 2006. Natural products as templates for bioactive compound libraries: synthesis of biaryl derivatives of (+/-)-vasicine. *Nat Prod Res, Part A 20*: 735-741.

Sridhar C, Krishnaraju AV, Subbaraju GV 2006. Antiinflammatory constituents of *Teramnus labialis*. *Indian J Pharm Sci 68*: 111-114.

Ssegawa P, Kasenene JM 2007. Medicinal plant diversity and uses in the Sango bay area, Southern Uganda. *J Ethnopharmacol 113*: 521-540.

Stevenson R 1995. Some aspects of the chemistry of lignans. *Stud Nat Prod Chem 17*: 311-356.

Su CL, Huang LLH, Huang LM, Lee LMHJC, Lin CN, Won SJ 2006. Caspase-8 acts as a key upstream executor of mitochondria during justicidin A-induced apoptosis in human hepatoma cells. *FEBS Lett 580*: 3185-3191.

Subbaraju GV, Kumar KK, Raju BL, Pillai KR, Reddy MC 1991. Justiciresinol, a new furanoid lignan from *Justicia glauca*. *J Nat Prod 6*: 1639-1641.

Subbaraju GV, Rajasekhar D, Kavitha J, Jimenez JI 2001. Neesiinosides A and B, two new diphyllin glycosides from *Justicia neesii*. *Indian J Chem 4*: 313-319.

Subbaraju GV, Kavitha JDR, Rajasekhar D, Jimenez JI 2004. Jusbetonin, the first indolo [3,2-b] quinoline alkaloid glycoside, from *Justicia betonica*. *J Nat Prod 67*: 461-462.

Susplugas S, Van Hung N, Bignon J, Thoison O, Kruczynski A, Sévenet T, Guéritte F 2005. Cytotoxic arylnaphthalene lignans from a Vietnamese acanthaceae, *Justicia patentiflora*. *J Nat Prod 68*: 734-738.

Tabuti JRS 2008. Herbal medicines used in the treatment of malaria in Budiope country, Uganda. *J Ethnopharmacol 116*: 33-42.

Teklehaymanot T 2009. Ethnobotanical study of knowledge and medicinal plants use by the people in Dek Island in Ethiopia. *J Ethnopharmacol 124*: 69-78.

Tene V, Malagón O, Finzi PV, Vidari G, Armijos C, Zaragoza T 2007. An ethnobotanical survey of medicinal plants used in Loja and Zamora-Chinchipe, Ecuador. *J Ethnopharmacol 111*: 63-81.

Thérien M, Fitzsimmons BJ, Scheigets J, Macdonald D, Choo LY, Guay J, Falgueyret JP, Riendeau D 1993. Justicidin E: a new leukotriene biosynthesis inhibitor. *Bioorg Med Chem Lett 3*: 2063-2066.

Tseng YP, Kuo YH, Hu CP, Jeng KS, Janmanchi D, Lin CH, Chou CK, Yeh SF 2008. The role of helioxanthin in inhibiting human hepatitis B viral replication and gene expression by interfering with the host transcriptional machinery of viral promoters. *Antivir Res 77*: 206-214.

Umer S, Asres K, Veeresham C. 2010. Hepatoprotective activities of two Ethiopian medicinal. *Plant Pharm Biol 48*: 461-468.

Vasilev NP, Ionkova I 2005. Cytotoxic activity of extracts from Linum cell cultures. *Fitoterapia 76*: 50-53.

Vega-Avila E, Espejo-Serna A, Alarcon-Aguilar F, Velazco-Lesama R 2009. Cytotoxic activity of four Mexican medicinal plants. *P W Pharmacol Soc 52*: 78-82.

Wahi SP, Wahi AK, Kapoor R 1974. Chemical study of the leaf of *Justicia gendarussa* Burm. *JRIM 9*: 65-66.

Wang CLJ, Ripka WC 1983. Total synthesis of justikidin P. A new lignan lactone from *Justicia extensa*. *J Org Chem 48*: 2555-2557.

Wang S, Dusting GJ, Woodman OL, Maya CN 2004. Selective vasodilator and chronotropic actions of

3,4-dihydroxyflavonol in conscious sheep. *Eur J Pharmacol 491*: 43-51.

Wasshausen DC, Wood JRI 2004. Acanthaceae of Bolivia. *Contr U S Natl Herb 49*: 1-152.

Wenga JR, Koa HH, Yeha TL, Linb HC, Lina CN 2004. New arylnaphthalide lignans and antiplatelet constituents. *Arch Pharm Pharm Med Chem 337*: 207-212.

Williams RB, Hoch J, Glass TE, Evans R, Miller JS, Wisse JH, Kingston DGI 2003. A novel cytotoxic guttiferone analogue from *Garcinia macrophylla* from the Suriname Rainforest. *Planta Med 69*: 864-866.

Woodman OL, Meeker WF, Boujaoude M 2005. Vasorelaxant and antioxidant activity of flavonols and flavones: structure - activity relationships. *J Cardiovasc Pharmacol 46*: 302-309.

Woodman OL, Malakul W 2009. 3′,4′-Dihydroxyflavonol prevents diabetes-induced endothelial dysfunction in rat aorta. *Life Sci 85*: 54-59.

Woradulayapinij W, Soonthornchareonnon N, Wiwa C 2005. *In vitro* HIV type 1 reverse transcriptase inhibitory activities of Thai medicinal plants and *Canna indica* L. rhizomes. *J Ethnopharmacol 101*: 84-89.

Wu CM, Wu SC, Chung WJ, Lin HC, Chen KT, Chen YC, Hsu MF, Yang JM, Wang JP, Lin CN 2007. Antiplatelet effect and selective binding to cyclooxygenase (COX) by molecular docking analysis of flavonoids and lignans. *Int J Mol Sci 8*: 830-841.

***Correspondence**

Geone M. Corrêa
Departamento de Química, ICEx, Universidade Federal de Minas Gerais 31270-901 Belo Horizonte- MG, Brazil or
Instituto de Ciências Exatas e Tecnologia, Universidade Federal do Amazonas 69100-000 Itacoatiara- AM, Brazil
geonemaia@ufam.edu.br