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Pyrostegia venusta (Ker Gawl.) Miers: A Botanical, Pharmacological and Phytochemical Review

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Abstract

Objective: *Pyrostegia venusta* (Ker Gawl.) Miers (*Bignoniaceae)* has been commonly used in the traditional Brazilian medicine as a general tonic, treating skin infections (leukoderma, vitiligo), as well as a treatment for diarrhoea, cough and common respiratory diseases related to infections, such as bronchitis, flu and cold. This study highlights the botany, traditional uses, phytochemistry and pharmacology of *Pyrostegia venusta*. Information was obtained from Google Scholar, Scirus, PubMed and Science Direct.

Key Phytochemical studies on *Pyrostegia venusta* have shown the presence of triterpenes, sterols, flavonoids, fatty acids, *n*-alkanes, nitrogenous compounds as allantoin and carbohydrates. Crude extracts of *Pyrostegia venusta* possess a wide range of pharmacological activities, such as antioxidant, anti-inflammatory, analgesic, antinociceptive, wound healing, antimicrobial, and useful in the treatment of disorders that induced sickness behavior, such as flu and cold. Also used to reduce menopausal symptoms, and for enhancement of melanogenesis.

Conclusions: *Pyrostegia venusta* is a natural source of antioxidants. and has been widely used in the traditional Brazilian medicine. *Pyrostegia venusta* 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: *Pyrostegia venusta*; *Bignoniaceae*; Traditional uses; Phytochemistry; Pharmacology

Introduction

Family *Bignoniaceae* is a dicot family, which contains 100-125 genera and 700-800 species [1]. Chemical constituents recognized in the family are naphthoquinones of the lapachol type, iridoid glucosides, alkaloids, flavones, triterpenes, polyphenols, tannins and seed oils [2].

Pyrostegia C. Presl (*Bignoniaceae*) is a genus of four species. All four species are native to South America [3]. *Pyrostegia venusta* (Ker Gawl.) Miers, a popular ornamental, is cultivated throughout the tropics, and is native to the Brazilian Cerrado, and popularly known as "cipó-de-são-joão." [3,4].

In the traditional Brazilian medicine, the aerial parts of *Pyrostegia venusta* are used as infusion or decoction and administered orally as a general tonic, as well as a treatment for diarrhoea, vitiligo, cough, and common diseases of the respiratory system related to infections, such as bronchitis, flu and cold [4,5].

The literature records the isolation of oleanolic acid from both the aerial parts and flowers of *Pyrostegia venusta* [6]. Oleanolic acid proved to be biologically very important. It has cytotoxic, antitumer, antioxidant, anti-inflamatory, anti-HIV, acetyl cholinesterase, alpha-glucosidase, antimicrobial, hepatoprotective, anti-inflammatory, antipruritic, spasmolytic activity, anti-angiogenic, antiallergic, antiviral and immunomodulatory activities [7]. Also, the compounds acacetin-7-*O*-β-glucopyranoside and β-sitosterol isolated from flowers, roots and aerial parts of *Pyrostegia venusta* [6,8,9], showed anti-inflammatory activity [10,11]. These results highlight the possible promising activities of *Pyrostegia venusta*.

Botanical Characterizations

Pyrostegia species are lianas; the most reliable way to identify *Pyrostegia venusta* is by the disposition of the leaves, the type of inflorescence, the level of the staminode insertion, and the characteristics of the fruits, which according to Pool [3].

Leaves

2-foliolate, often with an apically trifid terminal tendril (the ends rarely branched again, bifid or trifid), or leaves 3-foliolate; petioles densely pubescent, pilose in the adaxial canal or glabrous; leaflets ovate (rarely lanceolate), slightly subinequilateral, chartaceous (rarely membranous), 3 to 5 pairs of lateral veins prominent below, densely short-pilose to glabrous, pellucidlepidote, often especially conspicuous abaxially, with large glands in the axils of lower lateral veins, base rounded or truncate (rarely cordate), apex briefly acuminate-mucronulate, or acuminate-mucronulate (obtuse-mucronulate or acuminate).

Inflorescence

A terminal or axillary panicle, generally dense or subcorymbose, with calyces often overlapping in dried specimens; unbranched or 1 or 2 (rarely 3) times branched; peduncle, rachis, and bracteoles nearly glabrous to densely puberulent or pilose; the trichomes initially perpendicular to the surface; calyx excluding denticules at apex, with sparse lepidote scales; glabrous to densely short-pilose to puberulent, apex ciliate; corolla narrow tubular-infundibular, orange or reddish orange (rarely yellow); tube internally sericeous at and below insertion of stamens and staminode, externally glabrous; lobes oblong, puberulent apically and marginally; stamens inserted 1.3-3.5 cm from base of corolla tube, stigma lobes broadly ovate, ovate, orbicular, or broadly oblong.

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Staminode

Inserted (rarely 0.8)1.2-1.6 cm above insertion of higher stamens.

Fruit

Capsule glabrous; drying with olive cast, midvein apparent, but not conspicuous; base acute; apex aristate.

Flowers of *Pyrostegia venusta* are typical of those pollinated by humming birds: odorless and the corolla usually bright red orange, of fairly thick texture, with a narrow tube and wider mouth, and more or less glabrous internally [12].

Distribution

Pyrostegia venusta is cultivated throughout the tropics and subtropics as a popular ornamental, and possibly naturalizing in some areas [3]. It was included (as *Pyrostegia ignea*) on a list of the most beautiful flowering climbers in the world, and was ranked as the most popular of all in the tropics [13]. In table 1 [3,14-16], the common names for *Pyrostegia venusta* are reported. In table 2 [3], the names and distribution of the four species are presented.

Ethnobotanical studies

Pyrostegia venusta is a native Brazilian plant, which has been used in traditional folk medicine as a remedy for treating white patches and infections on the skin (leukoderma, vitiligo) [17,18].

Native Brazilians use the aerial parts of *Pyrostegia venusta* for the treatment of cough and common diseases of the respiratory system related to infections, such as bronchitis, flu and cold. They administer its decoction orally as a general tonic, and also as an infusion to treat diarrhoea, vitiligo and jaundice [4,5,9,19]. Tonics made from the stems of this plant are useful for the treatment of diarrhoea, whereas flower preparations have been shown to atttenuate vomiting [4,5].

Country	Common names
Brazil	Cipo´ de Sa˜o Joa˜o[a], Cipo´ Caititu[b], Cipo´ Tinga´[b], Dedo de Moc¸a[b]
Argentina	Pico de Tuca´n[b], Flor de San Juan[b]
Peru	Lluvia de Oro[b]
Guatemala	Chiltote[c], Chorro de Oro[c], Chorro[c]
El Salvador	San Carlos[c]
Costa Rica	Triquitraque[c]
U.S.A.	Flame Flower[d], Flaming-Trumpet[d], Golden-Shower[d]

The names marked with [a]correspond to the source Bignonia´ceas [14]. The names marked with [b]correspond to the source A Review of The Genus *Pyrostegia* (*Bignoniaceae)* [3].The names marked with [c]correspond to the source *Bignoniaceae,* in Flora of Guatemala [15]. The names marked with [d] correspond to the source *Pyrostegia,* a Concise Dictionary of Plants Cultivated in the United States and Canada [16].

Table 1: Common names for *Pyrostegia venusta.*

Biological studies

A summary of some of the relevant literature is given in table 3, and discussed in the following section.

Antioxidant activity

The antioxidant potential of the flowers and roots of *Pyrostegia venusta* were evaluated using 1,1-Diphenyl-2-picrylhydrazyl (DPPH), 2, 2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS), and ferric reducing antioxidant power (FRAP) assays. The reducing ability of both extracts was in the range (in µm Fe(II)/g) of 112.49-3046.98, compared with butylated hydroxytoluene (BHT; 63.56 ± 2.62), catechin (972.02 ± 0.72 µm) and quercetin 3208.27 ± 31.29. A significant inhibitory effect of extracts of flowers (IC_{50}=0.018 ± 0.69 mg/ml) and roots (IC_{50}=0.026 ± 0.94 mg/ml) on ABTS free radicals was detected. The antioxidant activity of the extracts of flowers (95%) and roots (94%) on DPPH radicals was comparable with that of ascorbic acid (98.9%) and BHT (97.6%) [5].

Treatment of sickness behavior

A study was conducted to evaluate the effects of a hydroethanolic extract of flowers of *Pyrostegia venusta* on sickness behaviors induced by lipopolysaccharide in mice. *Pyrostegia venusta* extract attenuated the depressive-like and exploratory behaviors induced by lipopolysaccharide. These results supported the previous claims of the usefulness of these plants in traditional therapies, and suggest that these plants may be useful in the treatment of disorders that induced sickness behavior, such as flu and cold [4].

Estrogenic activity

In recent years, the tea from the plant, *Pyrostegia venusta,* has been used to reduce the symptoms of menopause. However, the active ingredients in this extract are found in rather low concentration. Plant tissue culture represents an alternative for the generation of plant extracts with higher concentration of metabolites [20].

Genotoxic activity

The genotoxic effect of extracts of *Pyrostegia venusta* was evaluated in mice, using the micronucleus (MN) and chromosome aberration tests (CA). The experimental groups received different concentrations (50, 100, and 200 mg/kg body weight) orally. Frequency of micronucleated polychromatic erythrocytes (MNPCE) of experimental controls was significantly lower, when compared with negative control group receiving water, and was statistically lower than that of positive control group receiving Ciclophosphamide*. *Pyrostegia venusta* did not show genotoxicity activity [21].

Anti-inflammatory, antinociceptive and wound healing activities

Pyrostegia venusta hydroethanolic extract (PvHE) was used to

Species	Br	Am	Ma	Gu	Su	P	V	B	Co	Pa/Ma	Ar	Par
Pyrostegia cinerea Bureau ex K. Schum.	x	x	x									
*Pyrostegia dichotoma*Miers ex K. Schum	x	x		x	x	x	x	x	x			
Pyrostegia millingtonioide Sandwith, Kew Bull.sd	x									x		
Pyrostegia venusta (Ker Gawl.) Miers	x										x	x

Abbreviations: Br: Brazil; Am: State of Amazonas; Ma: campinas (white sand areas) near Manaus; Gu: Guyana; Su: Suriname; P: Peru; V: Venezuela; B: Bolivia; Co: Colombia; P/M: in the states of Para´ and Maranha˜o; Ar: Argentina; Par: Paraguay

Table 2: Distribution of *Pyrostegiavenusta* among other species [3].

Extract	Model	Main pharmacological activities	Controls	References
Flowers and roots extract	*In vitro*	(–)DPPH (–)ABTS (–)FRAP Antioxidant	Ascorbic acid BHT	[5]
Hydroethanolic flowers extract	Mice	(–)Depressive-like behaviors (–)Exploratory behaviors (–)Sickness behavior, as flu and cold		[4]
Tea	*In vivo*	(–)Menopausal symptoms		[20]
Different extracts	Mice	(–)MNPCE (n)Genotoxic activity	Negative control receiving water Positive control receiving Ciclophosphamide®	[21]
Hydroethanolic extract	Swiss male mice	Anti-inflammatory Analgesic (–)Paw edema (–)Leukocyte recruitment Antinociceptive		[22]
Methanol extracts of flowers	Wistar rats	Wound healing (+)Cytokines production (+)Wound contraction (+)Tensile strength (+)Hydroxyproline content (+)Hexosamine expression (+)TNF-α level (+)IL-6 level		[18]
Methanol extract	Agar-well diffusion method	Antibacterial		[23]
Flower extract	In vitro	Antibacterial Antifungal		[18]
Hydroalcoholic leaves and flowers extracts	Murine B16F10 melanoma cells	(+)Melanin content in concentration dependent manner No cell death in MTT assay		[17]
Hydroalcoholic leaves and flowers extracts	*In vitro*	(n)Mushroom tyrosinase activity		[17]

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

DPPH: 1,1-Diphenyl-2-picrylhydrazyl; ABTS: 2, 2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid; FRAP: Ferric reducing antioxidant power; BHT: Butylated hydroxyl toluene; MNPCE: Micronucleated polychromatic erythrocytes; TNF-α: Tumour necrosis factor-alpha; IL-6: Interleukin-6; MTT: 3-(4,5-dimethythiazol-2-yl)-2,5-diphenyl tetrazolium bromide

Table 3: Pharmacological activity of different extracts of *Pyrostegia venusta*.

evaluate the anti-inflammatory and analgesic effects in carrageenan-induced paw edema, peritonitis induced by lipopolysaccharide. PvHE at doses of 30-300 mg/kg orally demonstrated an anti-inflammatory effect. PvHE reduced paw edema induced by carrageenan and inhibited leukocyte recruitment into the peritoneal cavity. The extracts also showed antinociceptive activity in acetic acid-induced writhing and formalin-induced paw-licking tests in Swiss male mice tests [22].

Methanol extracts of *Pyrostegia venusta* flowers were studied for wound healing efficiency, along with its effect on pro-inflammatory and anti-inflammatory cytokines, which was assessed using excision and incision model of wound repair in Wistar rats. Healing was assessed by the rate of wound contraction, tensile strength, breaking strength, hydroxyproline and hexosamine content. The results indicated that *Pyrostegia venusta* extract has potent wound healing capacity, as evident from the wound contraction and increased tensile strength. Hydroxyproline and hexosamine expression were also correlative with the healing pattern observed [18]. *In vivo* antioxidant activity was performed to understand the mechanism of wound healing potency. It was found that during early wound healing phase, TNF-α and IL-6 level, were found to be up regulated by *Pyrostegia venusta* treatment [18].

Antimicrobial activity

Pyrostegia venusta methanol extract was evaluated for its antibacterial activity, using agar-well diffusion method against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Shigella sonnei*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Bacillus cereus*. According to the results of the agar diffusion assay, *Pyrostegia venusta* extract showed antibacterial activity against all bacteria tested [23].

Antimicrobial activity of the flower extract against twelve microorganisms was assessed. *Pyrostegia venusta* extract exhibited moderate antimicrobial activity against the organisms: *Bacillus subtilis*, *Staphylococcus epidermidis*, *Staphylococcus pyogenes*, *Staphylococcus aureus*, *Escherichia coli*, *Micrococcus luteus*, *Enterobacter* aerogenes, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Candida albicans*, *Aspergillus niger* and *Candida tropicana* [18].

Melanogenic activity

Recently, the melanogenic activity of hydroalcoholic extracts from the leaves and flowers of *Pyrostegia venusta* on murine B16F10 melanoma cells was investigated; both extracts, leaves (0.1; 0.3; 1 and 3 µg/mL) and flowers (0.03 and 0.1 µg/mL) increased the melanin content in a concentration dependent manner, after 4 days of incubation on melanoma cells. Also, cell viability was tested by using the MTT (3-(4,5-dimethythiazol-2-yl)-2,5-diphenyl tetrazolium bromide) assay in murine B16F10 cells, and showed that in the same tested concentrations of both extracts, no cell death was detected. Both extracts were also evaluated for the mushroom tyrosinase activity *in vitro*. Actually, either extract was not able to cause any change in the tyrosinase activity [17].

Chemistry

Phytochemical screening revealed the presence of terpenoids, alkaloids, tannins, steroids, and saponins [5]. Compounds identified upon in-depth phytochemical study of *Pyrostegia venusta* constituents

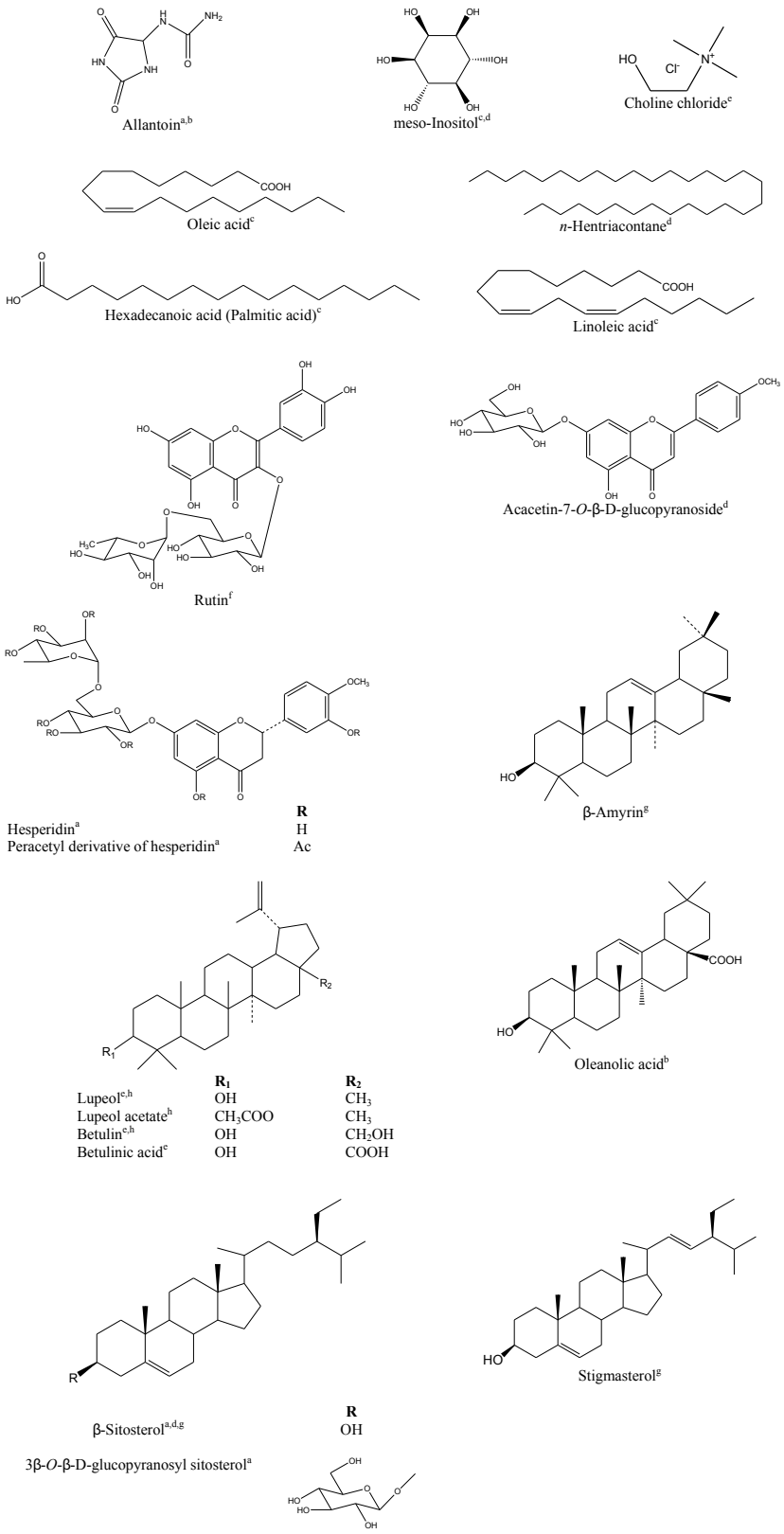

Figure 1: Representatives from different classes of compounds isolated from *Pyrostegia venusta*.

Isolated from [a]the root [9], [b]leaves and flowers [17], [c,d]flowers [5,8], [e]stem bark [24], [f]leaves [25], [g]both aerial parts and flowers [6], [h]aerial parts [6].

were classified as triterpenes, sterols, carbohydrates as meso-inositol, fatty acids, nitrogenous compounds as allantoin, flavonoids, *n*-alkanes as *n*-hentriacontane, and choline chloride. In figure 1, a full description of the phytochemistry, the part of the plant investigated, and the molecular structures are presented.

Gas chromatography-mass spectroscopy (GC-MS) studies were also undertaken to assess the phytochemical composition of the flower methanol extracts. GC-MS study on HP-5 MS column revealed the presence of myoinositol, hexadecanoic acid, linoleic acid, oleic acid, stigmasteryl tosylate, diazoprogesterone, arabipyranose, propanoic acid, pentamethyldisilanyl ester, acetophenone, *trans*-3-hexenedioic acid, and 9-octadecenoic acid (*Z*)-methyl ester in the flower extracts [5].

HPLC analysis of *Pyrostegia venusta* extracts found 0.09% and 1.08% of allantoin on leaves and flowers extracts, respectively [17].

All the anti-inflammatory actions obtained are also suggested to due the presence of acacetin-7-*O*-β-glucopyranoside and β-sitosterol [10,11,22].

Four known compounds, lupeol, betulin, betulinic acid and choline chloride were reported from the stem bark of *Pyrostegia venusta* [24]. Also, rutin was isolated from the leaves [25].

In comparison to the yellow flowers, the more common orange ones are characterized by a wider floral tube, a higher total nectar production, a higher sucrose content, a higher amino acid content, and a higher concentration of carotenoids in the petals [26]. The total sugar content of nectar collected in January from *Pyrostegia venusta* flowers was 22%, as determined by the phenol-H_2SO_4 method. Descending paper chromatography indicated that the nectar consisted of sucrose, glucose and fructose, in an approximate molar ratio of 1.5:1.0:1.0. No oligosaccharides were detected in fresh nectar, whereas stored nectar contained small amounts of oligosaccharides, having retardation factor (R_f) values lower than that of sucrose [27].

Orange and yellow petal colors in *Pyrostegia venusta* were due to carotenoids, and not to 3-deoxyanthocyanins [28].

Conclusion

Pyrostegia venusta is one of the most popular and beautiful flowering climbers in the world. It has been used in Brazil as a traditional medicine throughout history. It is considered a natural source of antioxidants, containing significant amounts of phytochemicals with antioxidative properties, that could serve as inhibitors or scavengers of free radicals. *Pyrostegia venusta* could be a potential source for plant-based pharmaceutical products, and could form a sound basis for further investigation in the potential discovery of new natural bioactive compounds.

Pyrostegia venusta extracts have been used in the treatment of different skin diseases, it may be useful in the tropical management of wound healing. The mechanism could be attributed to increased wound contraction, tensile strength, hydroxyproline, hexosamine and cytokine content, along with antioxidative and antimicrobial activities. These healing properties could be associated with activities of isolated compounds reported in *Pyrostegia venusta,* such as oleanolic acid, which has shown wound healing properties in tests performed *in vivo*. *Pyrostegia venusta* can be also used in the treatment of hypopigmentation diseases such as vitiligo, through stimulation of melanogenesis. *Pyrostegia venusta* may provide us with pharmaceutical preparations for the treatment of common diseases of the respiratory system related to infections, such as bronchitis, flu and cold. Since active ingredients may be found in low concentration, nowadays, plant tissue culture can bring the solution; this can help us explore more pharmacological activities of *Pyrostegia venusta,* as reduction of menopausal symptoms.

Clearly, *Pyrostegia venusta* has significant pharmacological potential and promising activities, especially in the field of tropical diseases, skin problems and respiratory diseases. Therefore, *Pyrostegia venusta* described in this review may serve as a vital natural bioactive medicinal source, and promote a high degree of interest in further studies.

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