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Pyrostegia venusta: An Interdisciplinary Review of its inflammatory Properties, Ethnobotanical and Pharmacological Significance

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Abstract

Background: *Pyrostegia venusta*, an evergreen climber belonging to Bignoniaceae, native to South America, naturalised in tropical parts, including India, has been found to possess good ethnomedicinal properties. Traditionally used in treating respiratory infections, wounds, skin problems, inflammation, and as a tonic, the plant's above-ground parts, such as flowers, leaves, stems, and roots, are used in infusion or decoction forms. **Aim:** The present review is an interdisciplinary approach that consolidates evidence from ethnobotanical, phytochemical, and pharmacological standpoints, explaining the anti-inflammatory mechanism, therapeutic potential, and prospects of *P. venusta* with respect to natural product-based drug development targeting inflammation-related disorders. **Methods:** A total literature survey integrated traditional uses from ethnopharmacological records with modern studies employing *in vivo* models (e.g., carrageenan-induced paw oedema, leukocyte migration inhibition), *in vitro* assays (e.g., DPPH radical scavenging, enzyme inhibition), phytochemical analyses [GC-MS, HPLC for flavonoids/sterols], and histological evaluations for wound healing. Data from Brazilian folk medicine, animal toxicity tests, and molecular pathway analysis, such as COX-2, NOS, and cytokines, were synthesised in the absence of primary experimentation. **Results:** The hydroethanolic/methanolic extracts were very effective against inflammation through COX-2/NOS inhibition, reduction of TNF-α/IL-6, and antioxidant activity, superior to controls in oedema models. The acceleration of wound healing with enhanced collagen-hydroxyproline content, tensile strength, and modulated cytokines, antinociceptive activity comparable to standards in pain models, along with ancillary antimicrobial action against *S. aureus/E. coli*, hepatoprotection, immunomodulation, and low acute toxicity-LD_{50} (>2000 mg/kg)-all support their use. Phytoconstituents such as oleanolic acid and flavonoids correlated well with multi-target modulation of the oxidative/inflammatory cascades. **Conclusion:** *Pyrostegia venusta* promises to be one of the most workable phytotherapies for inflammation, lesions, and pain, which the traditional and scientific data support with a very low level of toxicity. Future research should emphasise clinical trials, enhancement of bioavailability, and molecular docking for drug leads, thus advocating for sustainable integration into evidence-based medicine.

Major Findings: *Pyrostegia venusta* extracts demonstrate potent anti-inflammatory effects by inhibiting COX-2, NOS, TNF-α, and IL-6, while reducing oxidative stress via flavonoids like quercetin and oleanolic acid.

Keywords: Anti-inflammatory Activity, Antioxidant Potential, Ethnomedicinal Use, Phytochemical Constituents, Pharmacological Significance, *Pyrostegia venusta*

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Abbreviations: COX- Cyclooxygenase; COX-2 - Cyclooxygenase-2; NOS - Nitric Oxide Synthase; TNF-α -Tumour Necrosis Factor-alpha; IL-6 - Interleukin-6; NSAIDs - Nonsteroidal Anti-Inflammatory Drugs; LOX - Lipoxygenase; GC-MS - Gas Chromatography-Mass Spectrometry; HPLC - High-Performance Liquid Chromatography; LD_{50} - Lethal Dose 50; ADMET - Absorption, Distribution, Metabolism, Excretion, Toxicity.

1. Introduction

Pyrostegia venusta, or flame vine or orange trumpet vine, is a perennial climber of South American origin, presently cultivated and naturalised throughout tropical and subtropical areas, including India. *P. venusta* is a member of the family *Bignoniaceae*. This plant has attracted significant interest in recent times, not just due to its beauty but also due to its varied pharmacological and therapeutic applications. Used traditionally in traditional medicine to treat respiratory infections, wounds, skin diseases, and inflammatory diseases, as shown in Table 1, *P. venusta* is a valuable source of bioactive secondary metabolites of pharmaceutical importance. Growing evidence from scientific research confirms its anti-inflammatory, antioxidant, antimicrobial, and wound-healing activities, identifying it as a novel candidate for natural product drug discovery and development. Elucidation of its pharmacological significance from an interdisciplinary perspective—merged phytochemistry, pharmacology, molecular biology, and ethnomedicine—is thus critical to unlocking its full therapeutic potential[1,2]. Inflammation is an intricate physiological defence response that, when dysregulated, makes contributions to the pathogenesis of chronic conditions like rheumatoid arthritis, cardiovascular disease, diabetes mellitus, and neurodegenerative disorders.

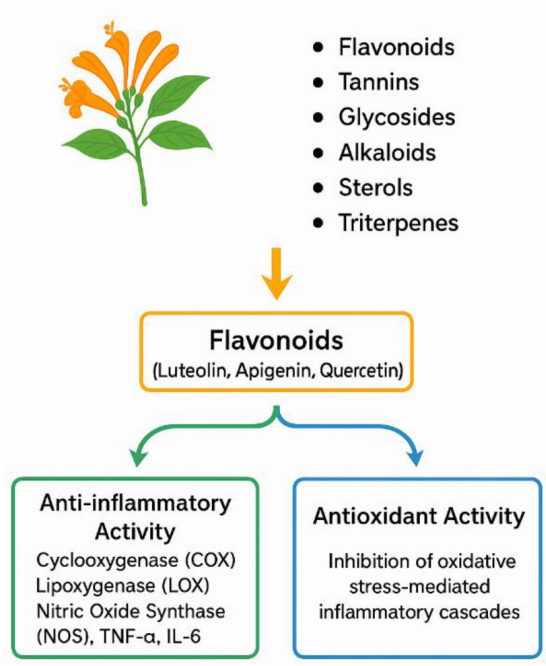


Figure 1. Schematic representation of *Pyrostegia venusta*, its pharmacological constituents and their therapeutic implications.

The use of herbal and plant anti-inflammatory agents has become increasingly popular worldwide since synthetic drugs such as corticosteroids and nonsteroidal anti-inflammatory drugs (NSAIDs) tend to have severe side effects when taken long-term. In this regard, *P. venusta* is a credible natural source of bioactive compounds that has the potential to modulate inflammatory pathways well and safely. The crop is reported to yield a variety of phytoconstituents such as flavonoids, tannins, glycosides, alkaloids, sterols, and triterpenes[3-7]. Of these, flavonoids like luteolin, apigenin, and quercetin have been reported to manifest strong inhibitory activities against pro-inflammatory mediators such as cyclooxygenase (COX), lipoxygenase (LOX), nitric oxide synthase (NOS), and cytokines like TNF-α and IL-6. Phytochemical and pharmacological studies of *P. venusta* have also shown that its extracts, especially ethanol and methanol extracts, possess remarkable anti-inflammatory and antioxidant activities in numerous *in vivo* and *in vitro* models. The antioxidative property of the plant aids synergistically to its anti-inflammatory activity by inhibiting oxidative stress-mediated inflammatory cascades, as shown in Figure 1. Moreover, its documented antimicrobial and wound-healing activities complement its application in traditional medicine for infection and skin inflammation healing. The cross-disciplinary investigation of *P. venusta* not only enhances ethnopharmacological information but also paves the way for natural product-derived drug development and biomedical investigation. Recent breakthroughs in pharmacognosy and bioinformatics have made it possible to screen the potential lead molecules in *P. venusta* as possible templates for creating new anti-inflammatory agents[8-11]. Combining

the classical pharmacological assays with advanced computational methodologies, including molecular docking and ADMET prediction, will lead to a better understanding of its mechanism of action at the cellular and molecular levels. Secondly, the conservation and sustainability of this medicinally important species are important, considering the escalating demand for natural therapeutic resources. In general, an interdisciplinary assessment of *P. venusta* emphasises its importance in pharmacology as shown in Figure 2 and provides a scientific rationale for its traditional application with a basis for future investigation aimed at introducing safe, potent, and plant-based anti-inflammatory therapeutics for clinical use[12,13].

Table 1. Key features of *Pyrostegia venusta*

Sr. No.	Aspect	Description	Scientific Relevance	References
1	Botanical Identity	*Pyrostegia venusta* (Ker Gawl.) Miers, family Bignoniaceae; commonly known as flame vine or orange trumpet vine	Widely distributed in tropical regions and serves as an ornamental and medicinal plant	12,13
2	Traditional Use	Used in folk medicine for respiratory infections, skin disorders, wound healing, and inflammation	Basis for exploration of therapeutic and pharmacological potentials	14
3	Phytochemical Constituents	Contains flavonoids (quercetin, luteolin, apigenin), tannins, glycosides, alkaloids, sterols, and triterpenes	Responsible for bioactivities such as antioxidant and anti-inflammatory effects	15,16
4	Anti-inflammatory Mechanism	Inhibits mediators, including COX, LOX, NOS, TNF-α, and IL-6 through modulation of oxidative and cytokine pathways	Demonstrates potential as a natural alternative to NSAIDs and corticosteroids	17,18
5	Antioxidant Properties	Neutralises free radicals and reduces oxidative stress, contributing to inflammation progression	Supports anti-inflammatory and wound-healing activities	19,20
6	Therapeutic Applications	Shows antimicrobial, antioxidant, anti-inflammatory, and wound-healing potentials	Provides broad pharmacological significance for drug development	20

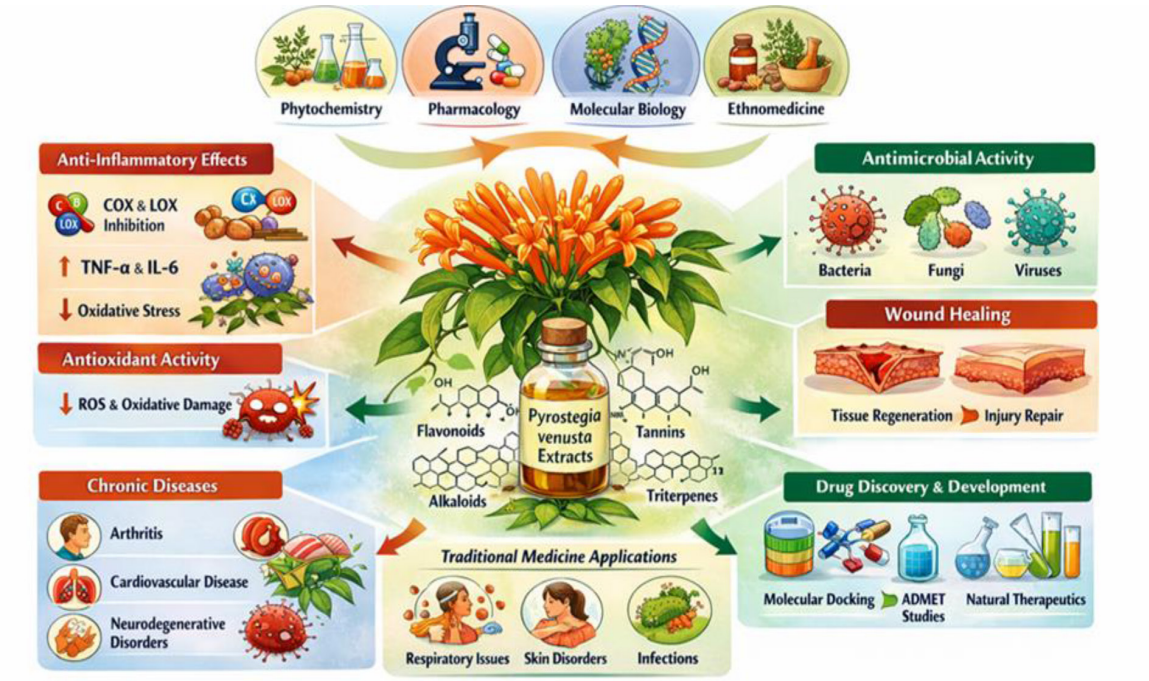


Figure 2. Overview of the pharmacological potential of *Pyrostegia venusta*, highlighting its phytochemical basis and interdisciplinary relevance across phytochemistry, pharmacology, molecular biology, and ethnomedicine.

2. Botanical Description of *Pyrostegia venusta*

Pyrostegia venusta is an evergreen or semi-deciduous vigorous climber of the family Bignoniaceae. It grows up to 5–6 meters tall by twining around rugged surfaces like walls or trees with its forked tendrils. The pinnate leaves are typically two to three ovate to lanceolate leaflets that are 4 to 8 cm long, with a trifid or bifid tendril in place of the terminal leaflet. The leaf surfaces vary from densely short-pilose to glabrous, with conspicuous lateral veins and large glandular structures in the vein axils[21] as shown in Table 2.

The *P. venusta* flowers are especially beautiful, in dense clusters of reddish-orange to orange tubular corollas that are 5 to 9 cm long. They are hummingbird pollination-adapted, meaning they are odourless but brightly colored, thick-textured corolla with a narrow tubular base and a broader mouth. Stamens and staminodes are found within the corolla tube, and the staminode is roughly 1.2 to 1.6 cm above certain stamens. The flowering season typically occurs fromwinter to spring, providing ornamental value during cold months. The fruit is smooth and elongated, measuring roughly 3 cm long, with an olive cast when dried. It has an acute base and an aristate (pointed) apex. The plant grows optimally in sunny but sheltered positions, but is not tolerant to cold winds and frost, hence being found in USDA hardiness zones 9 through 11. *P. venusta* is also tolerant to different types of soils, such as clay, acidic, alkaline, and sandy soils and has soil salinity resistance[22].

This botanical characterisation highlights the plant's versatility and significance as an ornamental climber and medicinal plant, with extensive applications in traditional systems for its anti-inflammatory and other pharmacological activities. The unique morphological features, including the tubular, brightly colored flowers, pinnate leaves with tendrils, and woody climbing habit, provide the basis for its identification and additional interdisciplinary research on its bioactive components and therapeutic values.

3. Phytochemical Constituents of *Pyrostegia venusta*

The phytochemicals of *P. venusta* are well researched and are a key component of its remarkable anti-inflammatory and pharmacological activities. The plant contains a rich cocktail of different bioactive molecules such as triterpenes, flavonoids, sterols, alkaloids, tannins, and saponins[30,31].

3.1 Flavonoids

Flavonoids such as acacetin-7-O-β-glucopyranoside, quercetin, luteolin, and apigenin have exhibited high anti-inflammatory activity (Figure 3) through the inhibition of major inflammatory enzymes like cyclooxygenase (COX) and nitric oxide synthase (NOS) and the reduction of pro-inflammatory cytokines like TNF-α and IL-6. These flavonoids also exhibit antioxidant activity that is useful in reducing oxidative stress, an important cause of inflammation and cancer immunotherapy[32].

Table 2. Botanical description of *Pyrostegia venusta*

Sr. No.	Botanical Aspect	Description	Dimension/Characteristic	References
1	Habit	Evergreen or semi-deciduous woody climber	Grows up to 5–6 meters in height	23,24
2	Leaves	Pinnate with 2–3 leaflets, ovate to lanceolate	Leaflets 4–8 cm long, with large glands in the axils of veins	24
3	Flowers	Bright orange tubular corolla, clustered inflorescence	Corolla size 5–9 cm, adapted for hummingbird pollination	25,26
4	Inflorescence	Terminal or axillary panicles, dense or subcorymbose clusters	Peduncle and rachis range from glabrous to densely hairy	27
5	Fruit	Smooth, elongated capsule	About 3 cm long, olive cast when dry, base acute, apex aristate	28
6	Habitat and Cultivation	Prefers sunny, sheltered locations, frost sensitive	USDA zones 9–11, tolerant to soil salinity	29

3.2 Sterols

The sterols, like β-sitosterol, found in *P. venusta* also help impart anti-inflammatory and wound-healing activity to it. Tannins and phenolic compounds further complement the activity by imparting antioxidant, antimicrobial, and anti-inflammatory properties. The nitrogenous compounds, like allantoin, help in tissue repair and skin regeneration as shown in Figure 4.

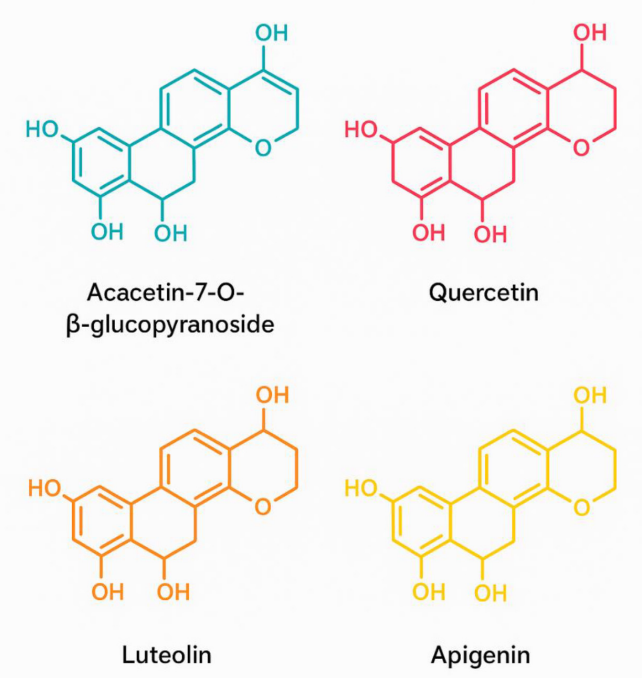


Figure 3. The figure illustrates the chemical structures of four key flavonoids — acacetin-7-O-β-glucopyranoside, quercetin, luteolin, and apigenin derived from *P. venusta*, known for their potent anti-inflammatory and antioxidant properties.

3.3 Triterpenes

Among the most important groups found, with significant compounds like oleanolic acid, which show anti-inflammatory, antioxidant, antimicrobial, and hepatoprotective activity[33].

3.4 Tannins and Phenolics

Strong antioxidants, they inhibit microbial growth and inflammation through scavenging of free radicals.

3.5 Carbohydrates and Nitrogenous Compounds

Of particular interest are meso-inositol (carbohydrate) and allantoin (nitrogenous compound). Allantoin promotes tissue repair and dermal regeneration, associated with the plant's traditional application in wound healing.

3.6 Fatty Acids and Other Metabolites

GC-MS analysis has been able to detect fatty acids like hexadecanoic acid (palmitic acid), linoleic acid, oleic acid, and other bioactive metabolites like myo-inositol, acetophenone, propanoic acid, and sterol derivatives,

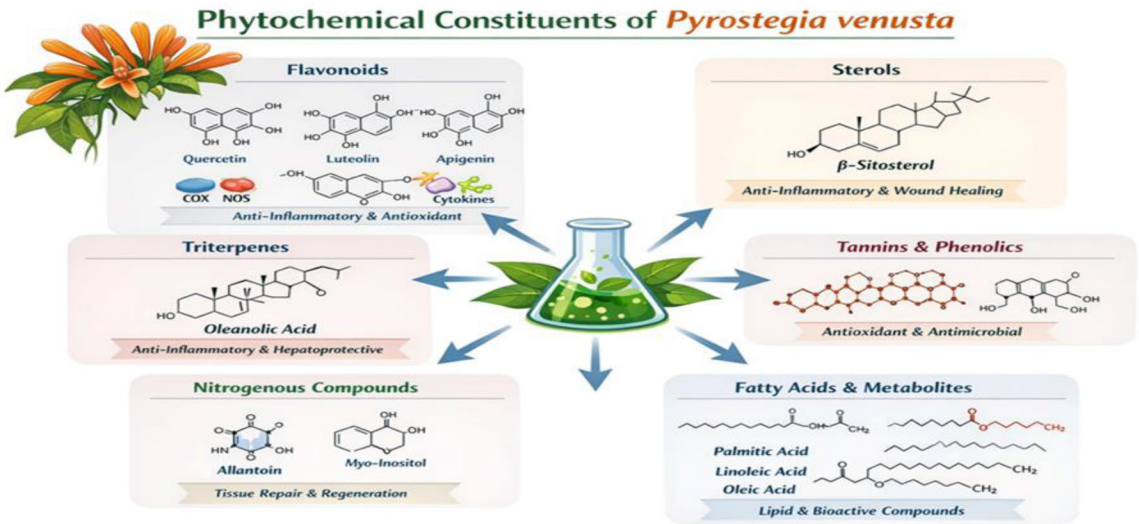


Figure 4. Schematic representation of the major phytochemical constituents of *Pyrostegia venusta*, including flavonoids, sterols, triterpenes, tannins, phenolics, nitrogenous compounds, and fatty acids with their key bioactive molecules.

all contributing towards the overall pharmacological activity[34].

4. Traditional Uses of *P. venusta*

Pyrostegia venusta boasts a rich tradition of indigenous use, especially in Brazilian traditional medicine, where different parts of the plant are used because of their medicinal properties, as shown in Table 3. The aerial parts, which consist of flowers, leaves, stems, and roots, are traditionally prepared as infusions and decoctions and administered orally as a general tonic for the enhancement of overall health and energy. The overall tonic application indicates the perceived broad-spectrum utility of the plant in strengthening the body's own defence and health. The plant has been used prominently in treating respiratory diseases like coughs, colds, bronchitis, flu, and other respiratory infections. Its expectorant and anti-inflammatory nature assists in relieving congestion, checking inflammation, and improving respiratory health. To this end, *P. venusta* functions as a natural treatment for universal respiratory diseases common in tropical and subtropical areas[35].

Aside from respiratory applications, *P. venusta* is traditionally used to treat gastrointestinal disorders, such as diarrhoea and digestive ailments. Its calming nature for the digestive system and antibacterial activity make it useful against diarrhoea and associated infections. Additionally, the plant also finds use in the treatment of skin conditions like leukoderma, vitiligo, ulcers, sores, and dermatitis, where its anti-inflammatory and antimicrobial activities play a role in increased wound healing as well as skin regeneration. The flowers are also utilised culturally for their hyperpigmenting activity, to improve melanogenesis, especially in diseases like vitiligo. This application documents its possible use in traditional dermatology. Besides, it has been utilised to alleviate symptoms of menopause and is deemed helpful in immune modulation, as some research has proven that it can stimulate the immune system and modulate inflammatory cytokines. Overall, the complex traditional applications of *P. venusta* — general tonic, respiratory therapy, digestive agent, skin healing agent, and immunomodulator — are an indication of its *Ayurvedic* and ethnopharmacological importance, laying the foundation for the modern pharmacological study of its constituents and therapeutic activities[36].

5. Pharmacological Activities of *Pyrostegia venusta*

All of these processes are substantiated by known bioactive phytochemicals like oleanolic acid, flavonoids (e.g., acacetin derivatives), sterols (e.g., β-sitosterol), and fatty acids (e.g., palmitic, linoleic acids), characterised by chemical analyses such as GC-MS as shown in Table 4. All of these prove the interdisciplinary significance of the plant to pharmacology and natural medicine[40] (Figure 5).

5.1 Antioxidant Activity

Pyrostegia venusta is rich in flavonoids and coumarins that have very high antioxidant activity. It tends to

Table 3. Traditional uses of *Pyrostegia venusta*

Sr.No.	Traditional Use	Region/Community	References
1	Treatment of respiratory ailments such as cough, bronchitis, and flu	Brazil (Amazonian folk medicine)	35-36
2	Use as a general tonic to boost immunity and vitality	South America (Indigenous communities)	36
3	Remedy for digestive disorders, including diarrhoea and stomach ache	Brazil, Paraguay	37
4	Treatment of skin disorders like leukoderma and vitiligo, promoting pigmentation	Brazil (Traditional medicine)	37
5	Application in wound healing for sores, ulcers, and dermatitis	Various tropical regions, including India and South America	38
6	Use as an anti-inflammatory for joint pain and swelling	Brazil, tropical South America	39
7	Alleviation of menopausal symptoms	Folk use in South America	39
8	Immune system modulation and antimicrobial use	Amazonian and rural tropical communities	39

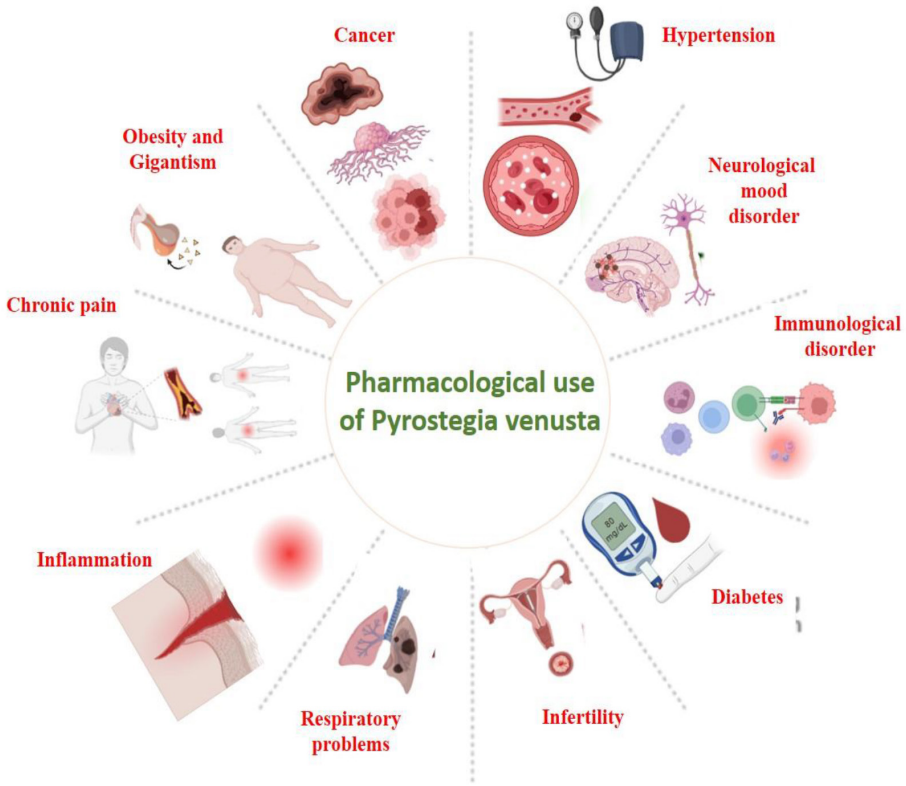


Figure 5. Comprehensive illustration depicting the diverse pharmacological and therapeutic applications of *P. venusta* in the management of various diseases. The figure highlights its broad-spectrum biological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, and wound-healing properties, demonstrating the plant's multifaceted role in traditional and modern medicinal systems.

neutralise free radicals and lowers oxidative stress, a major cause of chronic inflammation and tissue damage.

5.2 Anti-inflammatory Activity

Phytoconstituents such as methyl linoleate, methyl oleate, and stigmasterol derivatives of *P. venusta* possess strong anti-inflammatory activity through inhibition of enzymes such as cyclooxygenase. This validates its traditional use in mitigating inflammation.

5.3 Wound Healing

Experiments illustrate that *P. venusta* flower extracts speed up wound contraction, enhance tensile strength, and boost hydroxyproline levels, which is an indicator of collagen formation. The extract also regulates early inflammatory cytokines, favouring quicker tissue repair.

5.4 Antimicrobial Activity

The plant has moderate antimicrobial activities, which support its traditional wound healing and anti-infective activities.

5.5 Analgesic and Antinociceptive Activities

Pyrostegia venusta extracts demonstrated analgesic activity by influencing nociceptive pathways, which may be of value in the management of pain that is inflammation-related.

5.6 Hepatoprotective Action

Some phytochemicals, such as methyl linoleate and oleanolic acid, have hepatoprotective activity, reducing liver cell damage and aiding metabolic wellness.

5.7 Immunomodulatory Effect

The herb immunomodulates by affecting the production of cytokines, boosting the immune defence system without causing excessive inflammation.

5.8 Other Activities

Other activities include antitumor, cytotoxic, vasorelaxant, antihypertensive, estrogenic, and hyperpigmentation/melanogenic activities, expanding the therapeutic value of *P. venusta*.

Table 4. Pharmacological activities of *Pyrostegia venusta*

Sr. No.	Pharmacological Activity	Description	References
1	Antioxidant	*Pyrostegia venusta* contains phenolic compounds like flavonoids and coumarins, which neutralise free radicals, mitigating oxidative stress and preventing cellular damage.	38
2	Anti-inflammatory	Extracts inhibit key inflammatory enzymes (e.g., cyclooxygenase) and cytokines (TNF-α, IL-6), reducing inflammation and supporting traditional uses in respiratory and skin inflammation.	39
3	Wound Healing	Enhances wound contraction, collagen synthesis, and tensile strength, accelerating repair processes by modulating inflammatory and healing mediators.	39
4	Antimicrobial	Shows moderate activity against bacteria and fungi such as *Staphylococcus aureus, Escherichia coli*, and *Candida albicans*, supporting its use in infection control and wound care.	40
5	Analgesic and Antinociceptive	Provides pain relief by modulating nociceptive pathways, beneficial in inflammatory and injury-related pain conditions.	41
6	Hepatoprotective	Certain compounds protect liver cells from toxins and oxidative damage, potentially supporting liver health and metabolism.	42
7	Immunomodulatory	Modulates immune responses by regulating cytokine production, enhancing host defence without causing excessive inflammation.	43
8	Additional Activities	Includes antitumor, cytotoxic, vasorelaxant, antihypertensive, estrogenic, antitussive, hyperpigmentation, and anthelmintic effects, broadening the therapeutic scope.	9

6. Conclusion

Pyrostegia venusta proves to be of very high medicinal value with varied pharmacological activities, especially its significant anti-inflammatory activity. Scientific evidence has confirmed its age-old uses by exhibiting strong anti-inflammatory, analgesic, antioxidant, antimicrobial, and wound healing actions. The presence of bioactive phytochemicals such as oleanolic acid, flavonoids (acacetin derivatives), sterols (β-sitosterol), and fatty acids is responsible for these therapeutic properties. Experimental models have indicated that *P. venusta* extracts suppress inflammatory reactions by inhibiting enzymes like cyclooxygenase and attenuating pro-inflammatory cytokines, while additionally promoting tissue repair and protecting against oxidative stress. Additionally, its safety record in animals points towards relative non-toxicity, lending credibility to its development into natural therapeutics. Apart from anti-inflammatory activity, the plant is also promising in immunomodulation, hepatoprotection, analgesia, and antimicrobial activity, and thus is a holistic prospect for interdisciplinary investigation encompassing ethnobotany, pharmacology, and phytochemistry. The convergence of classical knowledge with contemporary scientific findings brings to the fore *P. venusta* as a viable prospect for the generation of new plant-derived anti-inflammatory compounds that might treat inflammatory conditions with fewer side effects than traditional medicines. Future studies aimed at molecular mechanisms, clinical effectiveness, bioavailability, and formulation optimisation will further establish it in phytomedicine and natural therapeutic applications. Overall, this critical review supports the pharmacological relevance of *P. venusta* and provides a foundation for systematic investigation in drug discovery and therapeutic applications.

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