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The botanical essence of *Bougainvillea Glabra*: An integrative review

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Abstract
Bougainvillea glabra is a traditionally important medicinal plant widely used for the treatment of respiratory, gastrointestinal and metabolic disorders. This integrative review summarizes its botanical characteristics, traditional applications, phytochemical profile, pharmacological activities and toxicity. Phytochemical studies have identified diverse bioactive constituents, including flavonoids, phenolic compounds, alkaloids, saponins, glycosides, steroids and betalains, which are responsible for its therapeutic properties. Experimental investigations demonstrate significant antioxidant, hepatoprotective, antimicrobial, antiparasitic, antihyperlipidemic, antidiabetic and anticancer activities across different plant parts, particularly the leaves, flowers and underexplored bracts. Toxicological evaluations generally indicate a favourable safety profile at therapeutic doses, although comprehensive long-term and clinical studies remain limited. Overall, *Bougainvillea glabra* represents a promising source of safe, cost-effective, plant-based therapeutic agents and further systematic research is essential for its clinical translation.

Keywords: *Bougainvillea glabra*, traditional medicine, phytochemistry, pharmacological activities, antioxidant activity, toxicity

Introduction

Traditional medicine has been used by the majority of the world population for thousands of years. The World Health Organization (WHO) reported that an estimated 80% of the population in developing countries depend on traditionally used medicinal plants for their primary health care [1].

Each plant contains several important bioactive constituents that can be utilized in the medical field and may contribute to the development of various therapeutic agents. Since ancient times, humans have relied on plants and herbs to preserve and flavour food, alleviate pain, treat headaches and prevent diseases, including epidemics. Knowledge of the medicinal properties of plants has been transmitted across generations within and among human communities. The biological activities of medicinal plants are largely attributed to active compounds produced during secondary metabolism, which are responsible for their widespread use in the treatment of various ailments, including infectious diseases [2].

Plant Description

Table 1: Botanical classification and plant description of *Bougainvillea glabra*

Parameter	Description
Scientific name	*Bougainvillea glabra*
Family	Nyctaginaceae
Common name	Glory of the Garden / Paper flower
Plant type	Thorny woody climber
Native region	South America
Plant height	3–9 m
Bracts	Coloured, papery, showy
Leaves	Ovate to lanceolate

The genus Bougainvillea, belonging to the family Nyctaginaceae, comprises approximately 14 species. Bougainvillea glabra is characterized by a smooth and hairless surface texture [3].

Bougainvillea, popularly known as the "Glory of the Garden," is a thorny, woody ornamental plant native to South America and is widely cultivated in tropical and warm regions, including Southern California, Florida and the Caribbean. The plant is well known for its showy and vibrant inflorescences, which occur in a wide range of colours such as pink, purple, red, orange, yellow and white [4].

Fig 1: Plant of *Bougainvillea glabra*

The leaves of *Bougainvillea glabra* are attached to the stem by petioles measuring 3–10 mm in length. The leaf blades are ovate to ovate-lanceolate in shape, with pointed or shortly pointed apices, typically ranging from 5 to 13 cm in length and 3 to 6 cm in width. The abaxial surface is sparsely covered with fine hairs, while the adaxial surface is smooth. The plant generally grows to a height of 3-3.5 m, although it may occasionally reach up to 9 m. The small white flowers, approximately 0.4 cm in diameter, are borne

in clusters and are surrounded by brightly coloured, papery bracts, giving rise to the common name "paper flower." The vivid pink structures often mistaken for petals are, in fact, modified bracts [5].

Traditional Uses and Phytochemical Profile

Table 1: Traditional uses of *Bougainvillea glabra* [5]

Plant part	Traditional use	Ethnomedicinal claim
Leaves	Respiratory disorders	Cough, asthma, bronchitis
Leaves	Gastrointestinal disorders	Diarrhoea, stomach ache
Flowers	Anti- inflammatory	Pain and swelling
Bracts	Antioxidant	General health
Whole plant	Antidiabetic	Blood sugar control

Phytochemical constituents reported in *Bougainvillea glabra*

Alkaloids, glycosides (in trace levels), flavonoids, tannins, steroids, proteins and saponins were found in several extracts of *Bougainvillea glabra* leaves, according to preliminary phytochemical screening. The plant is exceptionally rich in phenolic chemicals, notably in its leaves and flowers, contributing to its medicinal potential [9].

Reason for review

Despite the long-standing use of medicinal plants in traditional healthcare systems, many species with considerable therapeutic potential remain scientifically underexplored. *Bougainvillea glabra*, although widely cultivated for its ornamental value, has been traditionally employed in the treatment of various ailments, particularly respiratory and gastrointestinal disorders. However, comprehensive scientific evaluation of its pharmacological properties and bioactive constituents remains limited.

Most existing studies on *Bougainvillea glabra* have focused primarily on its phytochemical composition, while systematic reviews integrating ethnomedicinal uses, phytochemistry and experimentally validated pharmacological activities are scarce. Furthermore, certain plant parts, especially the bracts, have received minimal scientific attention despite evidence indicating the presence of valuable secondary metabolites.

In view of the growing global interest in plant-based therapeutics and the urgent need for safer, cost-effective alternatives to synthetic drugs, a consolidated review of *Bougainvillea glabra* is warranted. This review aims to compile and critically analyse available literature on its traditional uses, phytochemical profile and pharmacological activities, identify existing knowledge gaps and highlight future research directions. Such an evaluation may contribute to the development of novel therapeutic agents derived from this plant.

Objectives

- To summarize the phytochemical constituents and pharmacological activities of *Bougainvillea glabra*.
- To highlight the therapeutic potential of different plant parts, including underexplored bracts.
- To identify research gaps and future directions for clinical and pharmacological studies.

Pharmacological activities

Hepatoprotective activity

Substances such as paracetamol, ethanol and certain chemotherapeutic agents are well known to induce hepatotoxicity through oxidative stress and cellular damage. In the reported study, ethanolic extracts of *Bougainvillea glabra* were prepared using Soxhlet extraction and were found to contain several bioactive phytochemicals, including alkaloids, glycosides and saponins. Biochemical parameters and histopathological examinations demonstrated a significant improvement in liver function markers and marked protection of hepatic tissue following treatment with the extract. These findings suggest that B. glabra possesses notable hepatoprotective potential, supporting its traditional use in liver-related disorders [7].

Antioxidant activity

The ethanolic extract of *Bougainvillea glabra* bracts (EEBGB) exhibited pronounced antioxidant activity, as evidenced by significant scavenging effects in DPPH and superoxide radical assays, despite its relatively low betalain content. Cytotoxicity evaluation revealed that EEBGB was non-toxic to WRL-68 human liver cells and monkey kidney cells, indicating a favorable safety profile. These findings suggest that non-betalain phytoconstituents present in *B. glabra* bracts contribute substantially to free-radical scavenging activity, thereby offering protection against oxidative damage. Such antioxidant properties may play a role in delaying premature aging and reducing the risk of chronic degenerative diseases [8].

Antiparasitic activity

Various extracts of *Bougainvillea glabra* leaves were prepared using solvents of increasing polarity, including petroleum ether, ethyl acetate, methanol and water. These extracts, at concentrations of 25 and 50 mg/mL, were evaluated for anthelmintic activity by assessing their ability to induce paralysis and mortality in experimental worms. Albendazole was used as the standard reference drug, while normal saline served as the control. All extracts exhibited dose-dependent anthelmintic effects, with higher concentrations producing more pronounced activity. The findings suggest that *B. glabra* leaf extracts possess promising anthelmintic potential and may serve as a natural source for the development of antiparasitic agents [9].

Antimicrobial activity

The antimicrobial activity of the extract was evaluated using the disc diffusion method against Candida albicans (yeast), Salmonella typhi (Gram-negative) and Staphylococcus aureus (Gram-positive). Chloramphenicol and fluconazole were employed as standard reference drugs. The extract demonstrated notable inhibitory activity against all tested microorganisms. In addition, significant anticancer activity was observed against a human cancer cell line, with an IC_{50} value of 47.11 µg/mL as determined by the MTT assay. These results highlight the broad-spectrum antimicrobial and promising cytotoxic potential of *Bougainvillea glabra* extracts [10].

Analgesic activity

Methanolic extract of *Bougainvillea glabra* leaves (MEBG) exhibited significant analgesic activity in the tail immersion test in mice, producing 79.88% inhibition at a dose of 300 mg/kg, which was comparable to the standard drug pentazocine (81.21%). This suggests that the extract possesses potent central analgesic properties, likely attributable to its flavonoid and steroid constituents [11].

Antihyperlipidemic activity

Different fractions of *Bougainvillea glabra* extracts, including ethanolic, aqueous, chloroform and ethyl acetate fractions, were evaluated for their antihyperlipidemic activity. The results demonstrated that treatment with these fractions significantly reduced serum cholesterol and triglyceride levels in experimental models, indicating the potential of *B. glabra* in the management of hyperlipidaemia [12].

Neuroprotective effect

The neuroprotective effect of *Bougainvillea glabra* leaf extract has been investigated in a paraquat (PQ)-induced neurotoxicity model using Drosophila melanogaster. Exposure of 1-4-day old male flies to 3.5 mM PQ for four days resulted in impaired locomotor performance in the negative geotaxis assay and increased mortality compared to controls. PQ toxicity was associated with elevated acetylcholinesterase (AChE) activity, increased reactive oxygen species (ROS) generation, enhanced lipid peroxidation and significant depletion of dopamine levels. Co-administration of *B. glabra* leaf extract (120 µg/mL) markedly attenuated these effects by improving locomotor activity, reducing AChE activity and oxidative stress markers, preventing dopamine depletion and lowering mortality. These findings indicate that *B. glabra* exhibits notable neuroprotective properties, possibly through antioxidant mechanisms and may be beneficial in neurodegenerative conditions such as Parkinson's disease characterized by oxidative stress and dopaminergic neuronal damage [13].

Antidiabetic activity

Bougainvillea glabra shows significant antidiabetic activity in alloxan-induced diabetic rats. Oral administration of the plant extract effectively reduced elevated blood glucose levels. The higher dose produced results comparable to the standard drug glibenclamide. The extract also helped improve metabolic imbalance associated with diabetes. These findings support its traditional use in diabetes management [14].

Toxicity

Although natural products are often perceived as inherently safe, this assumption is not always valid, making toxicological evaluation essential for ensuring the safe development of plant-based drugs. Several studies have assessed the toxicity profile of *Bougainvillea glabra*. *In vitro* cytotoxicity studies using ethanolic bract extracts on WRL-68 human fetal liver cells and Vero kidney cells reported IC_{50} values that were within non-toxic limits, indicating cellular safety. Acute toxicity and teratogenicity assessments of aqueous bract extracts of different colour variants using zebrafish embryos revealed mild embryotoxic effects at higher concentrations, including yolk sac oedema and hypopigmentation; however, no major developmental abnormalities were observed and the extracts were considered non-toxic overall [15].

Additionally, methanolic and dichloromethane flower extracts demonstrated cytotoxic activity against several cancer cell lines, with methanolic extracts showing greater efficacy, possibly due to the presence of polar phenolic compounds known to induce apoptosis. *In vivo* studies further support the safety of *B. glabra*, as acute and sub chronic toxicity evaluations of methanolic extracts in Wistar rats showed no mortality or significant alterations in haematological, biochemical, or histopathological parameters, even at high doses [16].

Overall, existing evidence suggests that *B. glabra* exhibits a favourable safety profile, potentially attributable to its major phytoconstituents such as betalains, which are associated with minimal toxicity. Nevertheless, further *in vitro* and *in vivo* investigations, along with ecotoxicological studies involving aquatic organisms, are required to comprehensively establish its toxicological safety and environmental impact.

Future perspectives

Although *Bougainvillea glabra* has demonstrated promising pharmacological activities in several experimental studies, further research is required to fully explore its therapeutic potential. Future investigations should focus on the isolation and structural characterization of bioactive compounds using advanced analytical techniques, along with detailed mechanistic studies to elucidate their molecular targets. Standardization of extracts and identification of reliable marker compounds are essential to ensure reproducibility and quality control. Comprehensive toxicological evaluations, including long-term safety and dose-response studies, are necessary prior to clinical application. Moreover, well-designed preclinical and clinical trials are needed to validate its efficacy in humans. The development of novel herbal formulations and advanced drug-delivery systems may further enhance the bioavailability and therapeutic effectiveness of *B. glabra*. With systematic scientific validation, this plant holds considerable promise as a source of safe and effective phytotherapeutic agents.

Conclusion

Bougainvillea glabra is a traditionally valued medicinal plant with growing scientific evidence supporting its diverse pharmacological activities, including antioxidant, hepatoprotective, antimicrobial, antiparasitic, antihyperlipidemic, and anticancer effects. These activities are attributed to its rich phytochemical profile, particularly flavonoids, phenolic compounds and betalains, present in various plant parts, including the underexplored bracts. Available toxicological studies suggest a favorable safety profile. However, gaps remain regarding mechanistic understanding, standardization and clinical validation. Further systematic research may facilitate the development of *Bougainvillea glabra* as a safe, effective and affordable plant-based therapeutic agent.

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