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Thunbergia fragrans: An Overview of Phytoconstituents and Pharmacological Applications

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Summary

Thunbergia fragrans Roxb. (Acanthaceae) is used in Siddha medicine, for the management of various ailments. The present review aims to compile and critically analyse the available information on the phytochemical composition, traditional uses, and pharmacological activities of T. fragrans. Traditionally, the plant has been used to treat stomach disorders, wounds, headache, fever, giddiness, and eye diseases. Phytochemical investigations have reported the presence of phenols, flavonoids, tannins, steroids, alkaloids, and fatty acids. Specific compounds such as hexadecanoic acid, neophytadiene, and linoleic acid derivatives have been identified and are considered to contribute to its biological activities. Pharmacological studies have demonstrated that *T. fragrans* exhibits diverse therapeutic properties including antioxidant, antimicrobial, antidiabetic, antidiarrhoeal, anti-inflammatory, and anticancer activities. Toxicological studies suggest that the plant is safe at high doses in animal models; however, long-term toxicity and clinical studies are required to confirm its safety and efficacy in humans. This review consolidates the existing knowledge on T. fragrans, highlights current research gaps, and provides a scientific basis for future pharmacological and clinical investigations of this medicinal plant.

Keywords

Antioxidant, Pharmacological activities, Phytochemistry, Thunbergia fragrans, Traditional medicine.

Introduction

India is one of the world's megadiverse countries and possesses a rich repository of plant biodiversity. It is estimated to have approximately 45,000 plant species, of which nearly 7,500 are used for medicinal or aromatic purposes. Among these, around 15,000 species are flowering plants, representing nearly 6% of the global angiosperm diversity. Plant-derived materials have been used for centuries in traditional healthcare systems and continue to serve as valuable resources for the modern pharmaceutical industry. Numerous therapeutic agents used in contemporary medicine are derived directly or indirectly from plants, emphasizing their significance as sources of bioactive compounds and their continuing relevance in global healthcare. Therefore, systematic scientific investigation of medicinal plants is essential to explore their pharmacological potential and identify novel bioactive molecules [1].

One such underexplored plant is *Thunbergia fragrans* (T. fragrans), a large woody climber belonging to the Acanthaceae family, found in India, Burma, Vietnam, and China, as well as on several islands in the Indian and Pacific Oceans [2,3]. It commonly grows in moist and disturbed habitats, particularly along roadsides, where it is often regarded as a weed [4]. *T. fragrans* is

popularly known as white lady, sweet clock vine, and white thunbergia [5]. In traditional Indian Siddha medicine, the plant is used for the management of several ailments. A paste prepared from tender twigs is applied to the body to reduce fever, leaf juice is used to relieve giddiness, and root juice is used as eye drops. Leaf paste is also applied to wounds and the forehead to alleviate headaches [6].

The present review provides a comprehensive overview of the existing scientific knowledge on the botany, traditional uses, phytochemical constituents, pharmacological activities, and toxicological aspects of T. fragrans. Information was collected from major scientific databases including Scopus, PubMed, and Google Scholar to synthesize the available literature. This review highlights the therapeutic potential of *T. fragrans* while also identifying important research gaps, particularly the need for detailed toxicological evaluation and well-designed clinical investigations. The findings presented here aim to support future research and promote further scientific exploration of this medicinal plant.

Botanical description and taxonomy

T. fragrans is a fast-growing woody climber characterized by slender, twining stems that can reach up to approximately 3 m in length. The leaves are oppositely arranged, ovate to triangular in shape, measuring about 6.5–11 cm in length and 1.8–6 cm in width, with arrow-shaped (sagittate) or occasionally truncate bases and finely toothed to nearly entire margins. The plant bears white, tubular flowers that appear singly or occasionally in small clusters. Flowering occurs throughout the year in many regions, with peak blooming typically observed from June to October, while fruiting mainly occurs between August and December. The fruit is a capsule with a characteristic beak-like tip that dehisces to release globose, pubescent seeds [5].

T. fragrans Figure 1) belongs to the family Acanthaceae, a group of flowering plants characterized by opposite leaves, zygomorphic flowers, and bilocular capsules. The genus Thunbergia was first described by Carl Linnaeus, and later expanded through the work of William Roxburgh, who formally described *T. fragrans* based on specimens collected from India [7].

Figure 1 *Thunbergia fragrans* plant showing characteristic white tubular flowers and opposite leaves. [Source: Author's photograph].

Morphologically, *T. fragrans* is distinguished by its solitary or paired white tubular flowers, opposite ovate leaves with sagittate bases, and beak-shaped fruit capsules that dehisce to release pubescent seeds. These morphological characteristics are typical diagnostic features used to identify species within the genus Thunbergia [5]. The genus includes several species such as T. alata, T. annua, T. battiscombei, T. coccinea, T. cordata, T. erecta, T. elegans, T. fragrans, T. grandiflora, T. gregorii, and T. vogeliana, many of which have been reported to possess diverse biological activities [8].

Over time, several taxonomic synonyms have been associated with *T. fragrans* due to historical reclassification and varying interpretations of morphological characteristics. These include Thunbergia volubilis Pers., Roxburghia rostrata Russell ex Nees, and Meyenia longiflora Benth [7,8].

History and uses

In traditional Indian Siddha medicine, T. fragrans has been used in several simple remedies for the management of common

ailments. A paste prepared from tender twigs is traditionally applied externally to reduce fever. Leaf juice is sometimes instilled into the nose, while leaf paste is applied to relieve dizziness and headache. Fresh root juice has also been used externally as eye drops for certain eye disorders [6]. In addition, a decoction prepared from the leaves is traditionally used to treat stomach-related ailments and fungal infections [2]. The traditional uses of T. fragrans are summarized in Table 1.

Sr. No.	Plant Part Used	Traditional Uses
1	Leaves	Leaf paste applied on wounds and forehead to relieve headache; leaf juice used for giddiness (dizziness).
2	Tender twigs	Paste of tender twigs applied externally to reduce fever.
3	Roots	Root juice used as eye drops for eye disorders in traditional medicine.
4	Whole plant	Used traditionally for the treatment of stomach-related ailments.

Table 1 Traditional uses of Thunbergia fragrans

Active constituents from T. fragrans have traditionally been extracted using simple preparation methods such as decoction and maceration. Ethnomedicinal reports and literature surveys suggest that the plant has been used in traditional medicine for the management of various conditions, including inflammation, fever, cardiovascular disorders, neurological conditions, skin diseases, diarrhoea, diabetes, giddiness, and headache [2,9,10].

Phytochemistry

Various parts of T. fragrans, including leaves, seeds, and tender twigs, contain several phytochemical constituents that may contribute to the biological properties reported for this plant [11]. GC–MS analysis of T. fragrans extracts has identified several fatty acid derivatives, terpenoids, and alcohols, including neophytadiene, hexadecanoic acid derivatives, and linoleic acid esters (Table 2 and Figure 2) [5,11]. Fatty acid methyl ester (FAME) analysis of the plant extract revealed that T. fragrans contains approximately 90.16% unsaturated fatty acids and 9.84% saturated fatty acids, indicating the predominance of unsaturated lipid components [5].

Further studies are required to isolate and characterize the bioactive compounds present in T. fragrans and to elucidate their mechanisms of action. Such investigations may provide insights into the relationship between chemical constituents and their pharmacological properties, supporting the potential development of this plant as a source of therapeutic agents [12,13].

Sr. No.	Phytoconstituents
1.	Propane, 1,1,3-triethoxy [13]
2.	1-Tetradecanol [13]
3.	Neophytadiene [13]
4.	Hexadecanoic acid, methyl ester [13]
5.	n-Hexadecanoic acid [13]
6.	9-Octadecenoic acid, methyl ester [13]
7.	Linoleic acid ethyl ester [13]
8.	Ethyl 9,12,15-octadecatrienoate [13]

Table 2 Major Chemical Constituents of Thunbergia fragrans

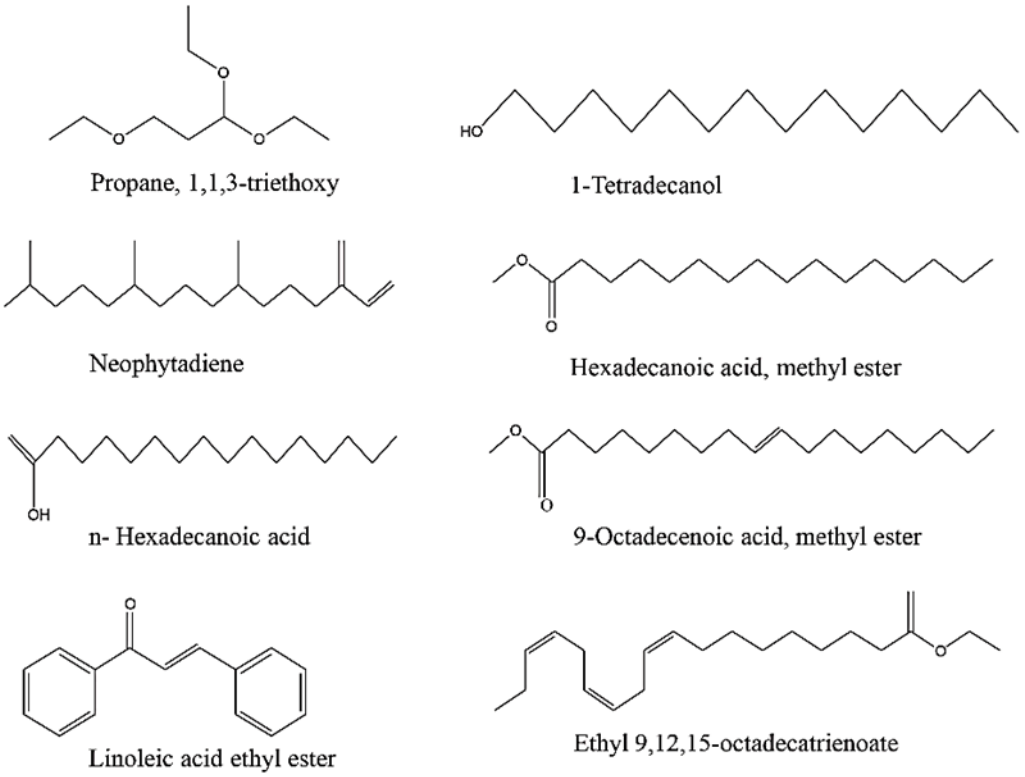

Figure 2 Major Chemical Constituents Present in the *Thunbergia fragrans*

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Pharmacological activities

The pharmacological activities of *T. fragrans* are given in Figure 3.

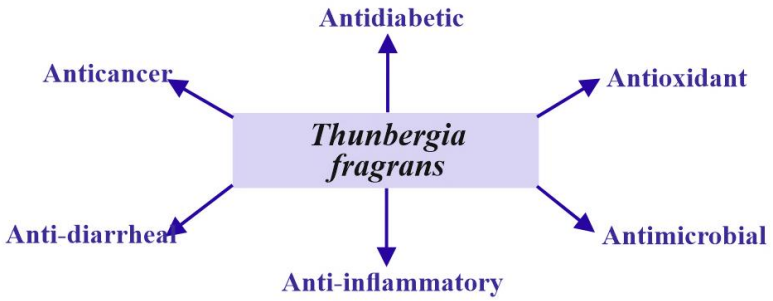

Figure 3 Pharmacological properties of *T. fragrans*

Antidiabetic

Ethanolic and hydroalcoholic extracts of T. fragrans have demonstrated significant antidiabetic activity in experimental animal models. In alloxan-induced diabetic rats, oral administration of the extracts at doses of 150–400

mg/kg body weight resulted in a reduction in blood glucose levels ranging from 21.8% to 35% after two to four weeks of treatment. In addition,

improvements in body weight and white blood cell count were observed, suggesting an overall improvement in diabetic symptoms [14].

The extracts also improved biochemical markers associated with liver and kidney function and enhanced antioxidant enzyme activities such as superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase, and reduced glutathione (GSH), indicating protection against oxidative stress. Furthermore, normalization of hepatic glycogen levels and preservation of the histological structure of the pancreatic islets of Langerhans were reported, suggesting protective effects on pancreatic β-cells [14].

The antidiabetic activity of T. fragrans is likely associated with the presence of bioactive phytochemicals such as flavonoids, chlorogenic acid, and alkaloids, which may enhance insulin secretion and improve peripheral glucose utilization. Importantly, the extracts did not produce significant toxic or adverse hematological effects in experimental animals, indicating a favorable safety profile in these studies [14].

Antioxidant

Extracts of T. fragrans contain several bioactive phytochemicals that contribute to its antioxidant potential. In vitro studies have shown that ethanolic leaf extracts exhibit significant and dose-dependent free-radical scavenging activity against DPPH radicals. Phytochemical screening indicates the presence of flavonoids, phenolic compounds, and other antioxidant constituents that may be responsible for this activity. Fourier transform infrared (FTIR) analysis has further revealed functional groups corresponding to alkenes, alcohols, aromatic compounds, aliphatic amines, and alkanes, suggesting the presence of diverse bioactive molecules within the extract. These phytochemicals may contribute to the neutralization of reactive oxygen species and help protect biological systems from oxidative stress associated with various pathological conditions. Overall, the antioxidant activity of T. fragrans supports its potential as a natural source of therapeutic agents [11].

Antimicrobial

Leaf extracts of Thunbergia fragrans have demonstrated notable antimicrobial activity against several pathogenic microorganisms. Both alcoholic (ethanolic and methanolic) and aqueous extracts have shown inhibitory effects against bacterial strains such as Staphylococcus aureus and Escherichia coli. The observed antimicrobial activity is attributed to the presence of bioactive phytochemicals capable of disrupting microbial cell membranes and interfering with essential metabolic processes. In certain studies, the inhibition exhibited by the plant extracts was comparable to that of standard antimicrobial agents such as streptomycin [6]. These findings support the traditional medicinal use of T. fragrans and highlight its potential as a source of natural antimicrobial compounds [4].

Anti-inflammatory

Phytochemical analysis of T. fragrans extracts collectively contributes to its significant anti-inflammatory activity. Traditional Indian Siddha medicine utilizes the T. fragrans for treating open wounds, and occasionally, leaf paste is applied on the forehead to reduce headaches, indicating its utility in inflammation-related conditions. Scientific studies show that these phytoconstituents can help suppress the inflammatory pathways. These effects are due to their antioxidant properties and modulation of pro-inflammatory mediators. However, despite promising preliminary evidence, further in-depth studies, including in vivo and clinical investigations, are necessary to confirm and clarify the exact anti-inflammatory mechanisms and therapeutic efficacy of T. fragrans extracts [12].

Antidiarrheal

The acetonic and ethanolic leaf extracts of T. fragrans have demonstrated significant antidiarrhoeal activity in Swiss albino mice at an

oral dose of 500 mg/kg body weight. The activity was evaluated using the charcoal meal test and the castor oil-induced diarrhoea model. Both extracts significantly reduced gastrointestinal motility, as evidenced by the decreased distance travelled by the charcoal meal through the intestine. The inhibition percentages were 55.51% for the acetonic extract and 59.34% for the ethanolic extract, compared with 48.92% for the standard drug loperamide. In the castor oil-induced diarrhoea model, both extracts provided complete protection (100%) against diarrhoea, comparable to loperamide. The observed antidiarrhoeal activity may be attributed to the presence of tannins, which are known to exert an astringent effect on the intestinal mucosa and reduce intestinal motility and secretion. These findings support the traditional use of T. fragrans in the management of diarrhoeal disorders. However, further studies are required to isolate the active constituents and clarify their mechanisms of action [2].

Anticancer

Studies have reported that the ethanolic extract of T. fragrans leaves exhibits cytotoxic activity against cancer cell lines such as A549 (lung carcinoma) and SiHa (cervical cancer). Cytotoxicity assays have demonstrated moderate antiproliferative activity with EC_{50} values of approximately 81.31 µg/mL for A549 cells and 91.51 µg/mL for SiHa cells. The extract contains various bioactive phytoconstituents, including phenolic compounds and flavonoids, which may contribute to the observed cytotoxic effects. These compounds are believed to interfere with cellular signaling pathways involved in cancer cell proliferation and survival, thereby inhibiting tumour growth. Additionally, treatment with the extract has been associated with morphological changes in cancer cells, suggesting potential apoptotic or growth-inhibitory effects. Although these findings indicate promising anticancer potential, further investigations, including detailed mechanistic studies and in vivo evaluations, are necessary to validate the therapeutic potential of T. fragrans extracts in cancer treatment [15].

Toxicity studies

Toxicological investigations on T. fragrans are limited but suggest relatively low acute toxicity. Acute oral toxicity studies conducted in Swiss albino mice have shown that ethanolic and acetone leaf extracts are well tolerated at doses up to 2000 mg/kg body weight, with no observed mortality or significant behavioural changes. These findings indicate that the LD_{50} value is greater than 2000 mg/kg body weight, suggesting a relatively wide safety margin for acute exposure. Although these results indicate a favourable safety profile, comprehensive toxicological data are still lacking. Further investigations, including sub-chronic and chronic toxicity, mutagenicity, genotoxicity, teratogenicity, and pharmacokinetic studies, should be conducted according to standardized OECD guidelines to establish the long-term safety of the plant. Traditional use of T. fragrans for the treatment of wounds, fever, and gastrointestinal disorders has not reported significant adverse effects; however, such empirical evidence cannot substitute for systematic scientific evaluation. Therefore, detailed toxicological assessments, including repeated-dose toxicity and reproductive toxicity studies, are required to better define the long-term safety profile, potential risks, dosage parameters, and therapeutic window of T. fragrans preparations [2].

Future perspectives

Future research on T. fragrans should focus on identifying and characterizing its bioactive constituents through bioassay-guided fractionation and structural elucidation. Standardization of plant extracts and evaluation of their dose–response relationships are also necessary to ensure reproducibility and therapeutic reliability.

Further investigations should explore the molecular mechanisms underlying the reported pharmacological activities, including studies on

relevant cell signaling pathways, enzyme inhibition, and gene expression. Comprehensive toxicological evaluations, including chronic toxicity, reproductive toxicity, and pharmacokinetic studies, are required to establish long-term safety.

In addition, well-designed preclinical and clinical studies are needed to confirm the therapeutic efficacy of T. fragrans preparations in humans. The application of modern research approaches such as metabolomics, proteomics, and advanced drug-delivery systems may further support the development of standardized and evidence-based herbal formulations derived from this plant. Such investigations could strengthen the scientific validation and potential therapeutic utilization of T. fragrans.

Conclusion

T. fragrans is a medicinal plant that has attracted scientific interest due to the presence of diverse phytochemical constituents and its long-standing use in traditional medicine. Available studies indicate that the plant possesses several biological properties, including antioxidant, antimicrobial, anti-inflammatory, antidiarrhoeal, and antidiabetic activities. However, most of the current evidence is based on preliminary experimental studies. Further research is required to isolate and characterize the active constituents, clarify their mechanisms of action, and evaluate long-term safety through comprehensive toxicological studies. In addition, well-designed clinical investigations are necessary to confirm the therapeutic potential of T. fragrans. Such systematic studies will be essential to support the development of scientifically validated and standardized herbal preparations derived from this plant.

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