

INSIGHTS INTO PHYTOCHEMICAL PROFILE AND THERAPEUTICS IMPORTANT OF TINOSPORA CARDIFOLIA (GUDUCHI)

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ABSTRACT

Tinospora cordifolia (Guduchi) is a widely revered medicinal climbing shrub used across traditional healing systems in India and Southeast Asia. Its therapeutic importance stems from a rich reservoir of bioactive constituents, including alkaloids, glycosides, terpenoids, steroids, and polysaccharides. This review provides an integrated overview of the plant's taxonomy, morphology, and global distribution, followed by a detailed examination of its diverse phytochemical profile. Major alkaloids such as berberine, palmatine, and magnoflorine; glycosides including tinosporaside and cordifoliosides; and diterpenoid lactones like tinosporon and cordifolin are highlighted for their structural diversity and pharmacological relevance. The therapeutic activities of *T. cordifolia* are multifaceted, with strong evidence supporting its immunomodulatory, antidiabetic, antioxidant, anti-inflammatory, antimicrobial, cardioprotective, and nephroprotective properties. These pharmacological effects are largely attributed to the plant's ability to modulate immune cell function, enhance antioxidant defenses, regulate glucose metabolism, and attenuate pro-inflammatory pathways. Particular emphasis is placed on its immunomodulatory mechanisms, including activation of macrophages, stimulation of cytokine release, enhancement of phagocytic activity, and regulation of Th1/Th2 responses. By synthesizing current findings from phytochemistry, pharmacology, and mechanistic studies, this review underscores *T. cordifolia* as a promising natural source for therapeutic interventions. The consolidated evidence further supports its potential in developing novel plant-based immunomodulators and adjunct therapies for metabolic, infectious, and inflammatory disorders.

KEYWORDS: *Tinospora cordifolia*, Guduchi, Phytochemistry, Immunomodulatory activity, Antioxidant activity, Antidiabetic activity.

INTRODUCTION

Tinospora cordifolia (Family: Menispermaceae) is one of the most widely used plant from the Ayurvedic system of medicine. *Tinospora cordifolia* is commonly known as Amrita, Guduchi (Sanskrit), Giloe (Hindi) and its huge application in the treatment of various diseases. According to recent studies, the discovery of numerous active components from the plant and their biological function in the management of disease control has led to active interest across the world.^[1-3] Guduchi is a plant also known as *Tinospora cordifolia*, having heart shaped leave In our classical Ayurvedic texts, it is indicated to be beneficial in treating various types of diseases like skin disorders, different types of fever, jaundice & gout. Guduchi also claimed to have various properties as an anti-oxidant, antihyperglycemic, antihyperlipidemic, hepatoprotective, cardiovascular protective, neuroprotective, osteoprotective, radioprotective, anti-anxiety, adaptogenic agent, analgesic, anti-inflammatory, antipyretic, athrombolytic agent, anti-diarrheal, anti-ulcer, antimicrobial and anti-cancer agent. Present paper is an attempt to assemble the information based on several experimental and clinical reports on immunomodulating role of *Tinospora cordifolia*.^[4]

Classical Ayurvedic literature (Charaka, Sushruta) recommend Guduchi for fever, jaundice, stomach issues, and as a general tonic often. Guduchi has been often consumed in traditional polyherbal formulas all around the Indian subcontinent, ethnobotanical records reveal. Public health officials and scientists regarded it as a potential immune-supportive herb during the COVID-19 pandemic, therefore generating several topical reviews and mechanical studies.^[5]

Tinospora cordifolia (Willd.) Miers ex Hook. f. & Thomas. (Menispermaceae) is one of the most widely used plants in various traditional medicinal systems including "Ayurveda". The plant is used for the treatment of jaundice, rheumatism, urinary disorder, skin diseases, diabetes and anemia. The phytoconstituents present in the plant belongs to different class of compounds such as alkaloids, diterpenoids lactones, glycosides, steroids, phenol, aliphatic compounds and polysaccharides.^[6]

Botanical Description

Taxonomy and Nomenclature

Tinospora cordifolia (Willd.) Miers ex Hook. f. & Thomson is a well-known medicinal climber belonging to the family Menispermaceae. It is commonly referred to as Guduchi, Giloy, Amrita, or Heart-leaved moonseed in traditional Indian medicine. The genus *Tinospora* comprises around 34 species distributed mainly in tropical and subtropical regions of Asia, Africa, and Australia.^[7]

Morphology of the stem, leaves, flowers

Stem

The plant is a vigorous, extensively spreading, deciduous climbing shrub. Its stem is slender, branching, and characterized by a green to grey-green surface covered with warty protuberances and longitudinal fissures. Mature stems exhibit aerial roots that emerge at the nodes, aiding in climbing over tall trees. The internal pith is soft, spongy, and watery, which is often used in traditional preparations.^[8]

Leaves

Leaves are simple, alternate, and broadly cordate, measuring 10–20 cm in length. They possess long, slender petioles, which sometimes twist to allow better exposure to sunlight. The lamina is glabrous, thin, and displays 7–9 palmately arranged veins. The leaf surface is bright green on the upper side and pale beneath.^[9]

Flowers

The plant is dioecious, meaning male and female flowers occur on separate plants. Flowers are small, greenish-yellow, and arranged in axillary racemes or clusters. Male flowers possess six sepals in two whorls and six stamens, whereas female flowers contain a trilocular ovary with three carpels.^[10]

Geographical distribution.

Tinospora cordifolia thrives in tropical and subtropical climates and is widely distributed across India, Sri Lanka, Myanmar, Bangladesh, and parts of China. It commonly grows over hedges, trees, and rocky terrain in dry to moist deciduous forests.^[7]

Phytochemical profile

The chemical makeup of guduchi is complex significant groups noted in phytochemical investigations and assessments include:

Table 1: Phytochemistry of *T. cordifolia* plant.

S.No.	Phytochemical Class	Phytoconstituent	References
1.	Alkaloids	Berberine, Tembeterine, Choline, Aporphine alkaloids, Jatrorrhizine, Magnoflorine, Tetrahydropalmatine, Tinosporin, Palmetine, Isocolumbin.	10-15
2.	Terpenoids	Tinosporide Furano lactone diterpene, Furanolactone clerodane diterpene, phenylpropene disaccharides cordifolioside A, B and C, cordifolioside D and E, Tinocordioside, cordioside, palmatosides C and F, furanoid diterpene, Tinosporaside, ecdysterone makisterone and several glucosides isolated as poly acetate	16-20
3.	Glycosides	Norclerodane glucoside, furanoid diterpene glucoside, cordiofoliosideA, cordiofoliosideB, palmatosides C, palmatosidesP1, cordiofolioside C cordiofoliosideD, cordiofolioside E	21-24
4.	Sesquiterpene	Tinocordifolin	25-26
5.	Steroids	β -sitosterol, δ -sitosterol, 20 β hydroxyecdysone, Eddystone, Makisterone A, Giloinsterol	27-29

Pharmacological activities

A significant body of preclinical and clinical studies show several pharmacological effects of Guduchi. The most often mentioned are:

Immunomodulatory Activity

Well-known as a Rasayana plant, *T. cordifolia* has been used for millennia in Ayurveda for too many years as a revitalizing herb and other therapeutic treatments.^[30] Numerous extracts in *T. cordifolia* exhibit immunomodulatory and anti-tumor effects. Animals with cyclophosphamide tumors have been shown to be removed synergistically.^[31-32] Acting as an immunomodulator, helping to eradicate dangerous organisms, and strengthening the patient's immune system to reduce the influence of inflammation, most of the antibacterial effects of *T. cordifolia* are aimed against the bacteria causing urinary tract infections. *T. cordifolia* increases the immune capacity of the animal by activating macrophages and other immune cells like interleukins and TNF.^[33-34]

Anti-Hyperlipidemic Property

Guduchi sawras lowers hyperlipidaemia by lowering oxidative stress and activating dopamine receptors, which leads to increased cAMP and protein kinase A levels.^[35] Long alcohol consumption causes guduchi sawras to help to prevent

hyperlipidaemia by reducing oxidative stress and activating dopamine receptors, therefore boosting cAMP and protein kinase A levels. In alloxan-induced diabetic rats, oral consumption of guduchi roots significantly decreased blood sugar, urinary glucose, and lipid concentrations in serum and brain tissue.^[36] The aqueous extract showed antihyperglycemic effect on several experimental models. One rodent model shows to lower blood glucose, improve glucose tolerance, and help to prevent body mass loss.^[37] The alloxan treatment caused the liver to decrease glutathione levels and elevate lipid peroxide, superoxide dismutase, and catalase. Rising glutathione levels and decreased the liver peroxidase enzyme were brought about by the guduchi therapy.^[38]

Anti-HIV activity

Research on the effectiveness of *T. cordifolia* in lowering antiretroviral therapy resistance in treating HIV-positive patients has been conducted.^[39] *T. cordifolia*'s anti-HIV activity raises CD4 T-cell count and lowers eosinophil count in HIV-positive individuals, therefore pointing its possible use in disease treatment. Phagocytic and intracellular bactericidal capacities were much improved by the *T. cordifolia* extract. *T. cordifolia*'s effects include the activation of peritoneal macrophages and the promotion of intracellular killing and phagocytosis. *T. cordifolia* promotes a notable increase in the activation of macrophages, polymorph nuclear leukocytes, and B-lymphocytes.^[40-42]

Cardiovascular Protective Property

This effect is caused by the alkaloid berberine, which improves vascular health by reducing endothelial inflammation in this plant.^[43] Furthermore, found to change lipid metabolism, this plant prevents cholesterol and glucuronides when alcohol consumption resulted in disturbed lipid metabolism.^[44] Furthermore, by manipulating the levels of several serum marker enzymes including kinase and lactate dehydrogenase, and by maintaining the concentrations of hexose, hexosamine, fucose, and sialic acid glycoproteins and antioxidants including superoxide dismutase, catalase, glutathione, glutathione peroxidase, and glutathione-S-transferase.^[45] Furthermore, this herb corrects atrial and ventricular fibrillation to normal,^[46] hence curing calcium chloride-induced arrhythmia. Thanks to its antioxidant capabilities, it has the potential to protect the heart from infarction brought on by ischemia-reperfusion damage where oxidative stress is the major damage causer.^[47-48]

Analgesic, Anti-Inflammatory, and Antipyretic Activity

This plant has a long history of use for fever, inflammation, and pain treatment, its experimentally demonstrated efficacy.^[49-51] The pain-relieving action has been found to be caused by both central and peripherally driven processes.^[52] Its anti-inflammatory effect has also been observed in autoimmune arthritis, caused by a fall in pro-inflammatory cytokines including IL-1, TNF-, IL-17, and IL-17.^[53] To lower temperature, Pushpangadan et al. developed and filed a synergistic antipyretic combination for patent.^[54]

Nephroprotective Property

Guduchi helps to relieve nephrotic syndrome because of its anti-inflammatory, antioxidant, and immunomodulatory effects.^[55] Sodium nitrite, used as a meat preservative, is bad for the kidneys because of the oxidative stress it generates. Under such conditions, guduchi extract reduces blood levels of urea and creatinine.^[56] Both the tablet form, DRDC/AY/8080, and the syrup form, DRDC/AY8081, contain *T. cordifolia* extract and might aid in kidney stone prevention.^[57] Nephrotic syndrome is a common chronic kidney condition in youngsters. The podocyte function is changed as a result of T lymphocyte dysfunction and a change in vascular permeability, therefore causing nephritic syndrome. An invention for which Acharya et al. have patents granted.^[58,59] A standard extract of *T. cordifolia* has been

used to treat renal diseases like nephrotic syndrome and chronic recurring urinary tract infections, Gram-negative bacteria like Klebsiella and E. coli cause it.^[60,61]

Mechanism of Action in Immunomodulation

Tinospora cordifolia (TC), commonly known as Giloy, is a medicinal plant widely recognized for its immunomodulatory properties. Its mechanism of action involves both stimulation and regulation of the immune system, mediated by its bioactive constituents such as alkaloids, glycosides, steroids, and polysaccharides.^[62] TC enhances innate immunity by activating macrophages and increasing phagocytic activity. Studies show that its aqueous and alcoholic extracts stimulate the production of pro-inflammatory cytokines like interleukin-1 (IL-1), IL-6, and tumor necrosis factor-alpha (TNF- α), which are essential for initiating immune responses.^[63,64] It also promotes the proliferation of T lymphocytes and enhances the humoral immune response by stimulating B cells and antibody production.^[65,66] Polysaccharides isolated from TC have demonstrated significant immunostimulatory effects, including increased nitric oxide production and enhanced antigen presentation by dendritic cells.^[67,68] Additionally, TC exhibits antioxidant properties that protect immune cells from oxidative stress, thereby maintaining their functional integrity.^[69,70] Importantly, TC also shows immunoregulatory effects, making it beneficial in autoimmune and inflammatory conditions. It downregulates excessive cytokine production and modulates Th1/Th2 balance, contributing to immune homeostasis.^[71,72] In vivo studies in mice have confirmed increased leukocyte counts, enhanced delayed-type hypersensitivity responses, and improved resistance to infections following TC administration.^[72,73]

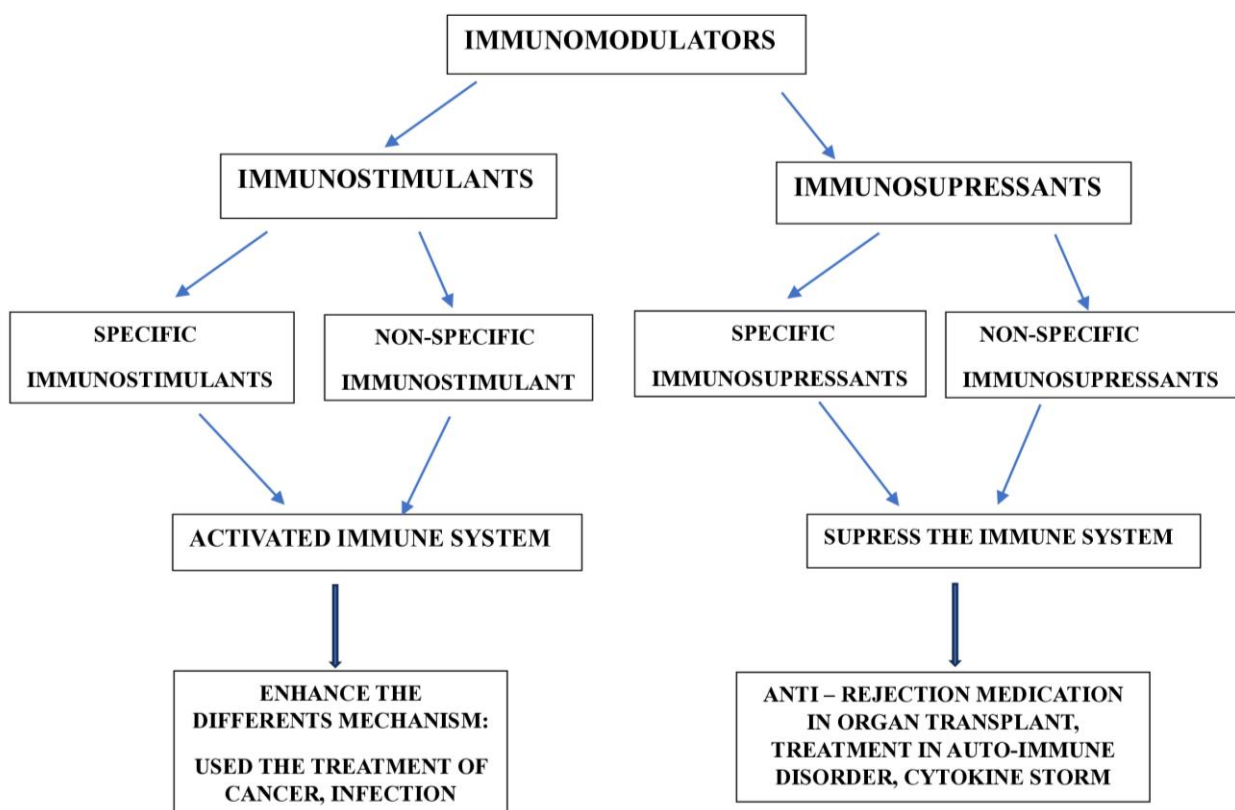


Figure 2: Physiological action of immunomodulators.

Physiological action of immunomodulators**Therapeutic application**

Tinospora cordifolia is used in therapeutics as a single herb (in various dosage forms) as well as is an essential ingredient of several polyherbal Ayurvedic formulations.^[74] Several Ayurvedic dosage forms of *Tinospora cordifolia* are being used in traditional Ayurvedic practice as a rejuvenative, health promotive, as well as curative medicine.^[75,76] *Tinospora cordifolia* is one of the components of several traditional formulations with potent rejuvenating, immunomodulatory, cytoprotective, and antioxidant properties.^[77-82] Several published reports suggest potential bioactivities of *Tinospora cordifolia* in immune-enhancement and immune protection.^[83-88] *Tinospora cordifolia* has long been recognized in Ayurvedic medicine for its broad therapeutic potential, supported by a growing body of contemporary pharmacological evidence. Its immunomodulatory activity is one of its most significant attributes, where Guduchi extracts have demonstrated the ability to enhance macrophage function, stimulate cytokine production, and improve overall immune responsiveness.^[89-92]

(i) Immunomodulatory Activity

Guduchi is widely recognized as a natural immunomodulator. It enhances both innate and adaptive immunity by:”[93]

- Activating macrophages
- Increasing phagocytic activity
- Modulating cytokines (IL-1, IL-6, TNF- α)

(ii) Antioxidant Activity

Its polyphenols and diterpenoids exhibit potent antioxidant effects, helping neutralize free radicals and protect cells against oxidative stress-related disorders, including premature aging, arthritis, and neurodegeneration.^[94]

(iii) Antidiabetic and Anti-Hyperglycemic Effects

Guduchi helps regulate blood glucose levels by:

- Enhancing insulin secretion
- Improving glucose tolerance

(iv) Anti-Inflammatory and Analgesic Activity

Guduchi reduces inflammation by inhibiting pro-inflammatory mediators such as TNF- α , IL-1 β , and COX-2. It is useful in arthritis, gout, and chronic inflammatory conditions. It also provides mild to moderate pain-relieving effects.

(v) Antipyretic (Fever-Reducing) Activity

Traditionally used for fevers (Jvara), Guduchi has been shown to reduce body temperature through central antipyretic mechanisms and modulation of inflammatory cytokines. It is commonly used in dengue, malaria, and viral fevers [95]. These effects make the plant particularly valuable in managing immune-compromised states and as an adjunct in infectious diseases. *Tinospora cordifolia* demonstrates a remarkable range of therapeutic applications spanning immunomodulation, antidiabetic action, antioxidant defense, anti-inflammatory activity, cardioprotection, nephroprotection, antimicrobial action, and radioprotection. The breadth of evidence from biochemical, preclinical, and clinical studies collectively supports its role as a versatile medicinal herb with significant potential for modern therapeutics.^[96-99]

Future prospects

Despite extensive traditional use and growing scientific evidence, *Tinospora cordifolia* still presents substantial opportunities for advanced research and translational development. Future studies should prioritize comprehensive phytochemical profiling using high-resolution analytical platforms such as LC–MS/MS, metabolomics, and NMR-based fingerprinting to identify minor, synergistic, or previously uncharacterized constituents. Standardization of extracts and bioactive markers remains a major gap; establishing validated chemotypic profiles and pharmacopoeial standards will significantly enhance its reproducibility, efficacy, and regulatory acceptance.^[100-104]

Mechanistic investigations are particularly needed to delineate receptor-level interactions, immune signaling pathways, and molecular targets associated with its immunomodulatory, antidiabetic, and anti-inflammatory effects. Emerging fields such as network pharmacology, systems biology, and in silico docking can support such mechanistic insights.^[105]

Clinically, well-designed randomized controlled trials evaluating dosage, safety, long-term use, and herb–drug interactions are essential for transitioning Guduchi from traditional therapy to evidence-based clinical application. Its bioactive polysaccharides and diterpenoid lactones also show potential for development as semi-synthetic derivatives, immunotherapeutic adjuvants, and nanocarrier-based formulations, including pulmonary or nasal delivery systems.^[106]

CONCLUSION

Tinospora cordifolia (Guduchi) stands out as one of the most versatile and scientifically supported medicinal plants in traditional and modern therapeutics. Its rich phytochemical composition comprising alkaloids, glycosides, terpenoids, steroids, and polysaccharides contributes to a broad spectrum of pharmacological activities. Extensive preclinical and clinical findings demonstrate its potent immunomodulatory, antioxidant, antidiabetic, anti-inflammatory, cardioprotective, nephroprotective, and antimicrobial effects. Among these, its immunomodulatory potential is especially significant, supported by evidence of macrophage activation, cytokine regulation, enhanced phagocytic activity, and modulation of both innate and adaptive immune responses.

The plant's traditional applications described in classical Ayurvedic texts align closely with contemporary scientific observations, validating its role as a rejuvenative and therapeutic agent. Despite this progress, variations in phytochemical content, lack of standardized extracts, limited mechanistic clarity, and insufficient clinical trials remain key challenges. Addressing these gaps through advanced analytical techniques, well-designed human studies, and development of standardized formulations will strengthen its scientific credibility and clinical applicability.

Overall, the consolidated evidence positions *Tinospora cordifolia* as a promising natural candidate for developing novel immunomodulators and adjunct therapies for metabolic, infectious, and inflammatory disorders. With continued research and translational advancements, Guduchi has the potential to evolve from a revered traditional remedy into a globally recognized therapeutic resource.

Human and animal rights

No animals or humans were used in this study.

Availability of data and material

The data will be available from the corresponding author, upon request.

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Conflict of interests

The authors declare that they have no conflicts of interest.

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