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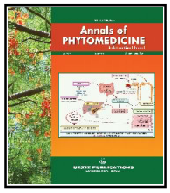

Review Article : Open Access

A review of the diverse pharmacological importance of *Tinospora cordifolia* (Thunb.) Miers

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Abstract

Tinospora cordifolia (Thunb.) Miers, referred to as giloy, has a huge part in the Indian medical system and conventional ayurvedic treatment. Modern research on this plant is growing increasingly because of its well-known therapeutic properties. *T. cordifolia* is used in Ayurvedic medicine to boost immunity, promote vitality, and treat a range of conditions, including fever and specific illnesses. Under the Ayurvedic term "Rasayana," the plant is well recognized for strengthening the immune system and aiding the body's defense against certain germs that could lead to infection. The plant has antibacterial, anticancer, antidiabetic, antioxidant, and immunomodulatory qualities that are widely established. Giloy has increased immunity against the coronavirus. *T. cordifolia* sections, including the root, stem, leaves, and complete plant, have yielded phytoconstituents such as alkaloids, terpenoids, ligands, glycosides, steroids, and carbohydrates. This review article highlights the medicinal potential and phytochemical characteristics of *T. cordifolia*, which gives a new window of opportunity to medicinal chemists to access more phytochemicals as drug candidates for future drug development.

1. Introduction

India has a strong basis for the widespread use of many plants in general healthcare due to its vast biodiversity and deep understanding of traditional Indian medical systems such as Ayurveda, Siddha, and Unani. WHO statistics showed that 81% of people rely on conventional treatments such as herbal medicine. Guduchi is an ayurvedic medication that is mentioned in several medicinal systems, including Charak, Sushrut, and Ashtang Hridaya, as well as in mythological descriptions like Bhavva Prakash and Dhanvanthri Nighantu, under various names, including amara, amritvalli chinnarrhuha, chinnodebha, and vatsadani. *Tinospora cordifolia* (Thunb.) Miers is often known as “Guduchi or Amirtha” and has been used for a long period in Indian medicine. *T. cordifolia* stem yields the Guduchi starch known as sattva. Satva is used as a highly nutritional and digestive treatment for many diseases. It is a member of the Menispermeaceae family, which is native to tropical lowlands and has about 450 species distributed among 70 genera. They are rarely shrubs; instead, they are mostly entanglers or climbers. *T. cordifolia* typically has reniform or hooked seeds, lobed or alternating leaves, and small cymose blooms. The family is one of the most important genera, with about fifteen species. Among the species with important medical applications are: *T. cordifolia, T. malabarica, T. tementora, T. crispa, T. wiginora,* and others. *T. cordifolia* is widely distributed in China, India, Burma, Myanmar, and Sri Lanka. *T. cordifolia* is also known by the popular names heartleafed monsoon and giloy. Common names that are used in multiple places are gurcha, gala, murtavalli, gilo, guduchi, amirta, guduchika, chinnathova, vadradani, and seendil Kodi.

Figure 1: Characteristics of *T. cordifolia:* a.leaf, b.plant, c.flower and d.fruit.

1.1 Distribution

Tinospora cordifolia (Thunb.) Miers can be found in tropical regions such as India, Arunachal Pradesh, Assam, Bihar, Delhi, Gujarat, Goa, Karnataka, Kerala, Maharashtra, Odhisa, Sikkim, Tamil Nadu, Uttar Pradesh, and West Bengal.

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1.2 Vernacular names

English : Indian tinospora, Heart-leaved moon, Tinospora, Gulancha tinospora, Moon creeper

Tamil : Amrutavalli, Seendal, Seendil kodi, Silam, Kunali, Chintilikkoti, Chindil

Malayalam : Chitamrith, Amrtu, Amritavalli, Amrthu, Siddamirth, Amrutavalli, Chitamruthu

Telugu : Amruta, Dussiramu Thippateega, Tippatige

Kannada : Amrutaballi, Agniballi, Amaradaballi

Sanskrit : Vatsahani, Guduchi, Amritha druma, Jivantika

1.3 Chemical constituents

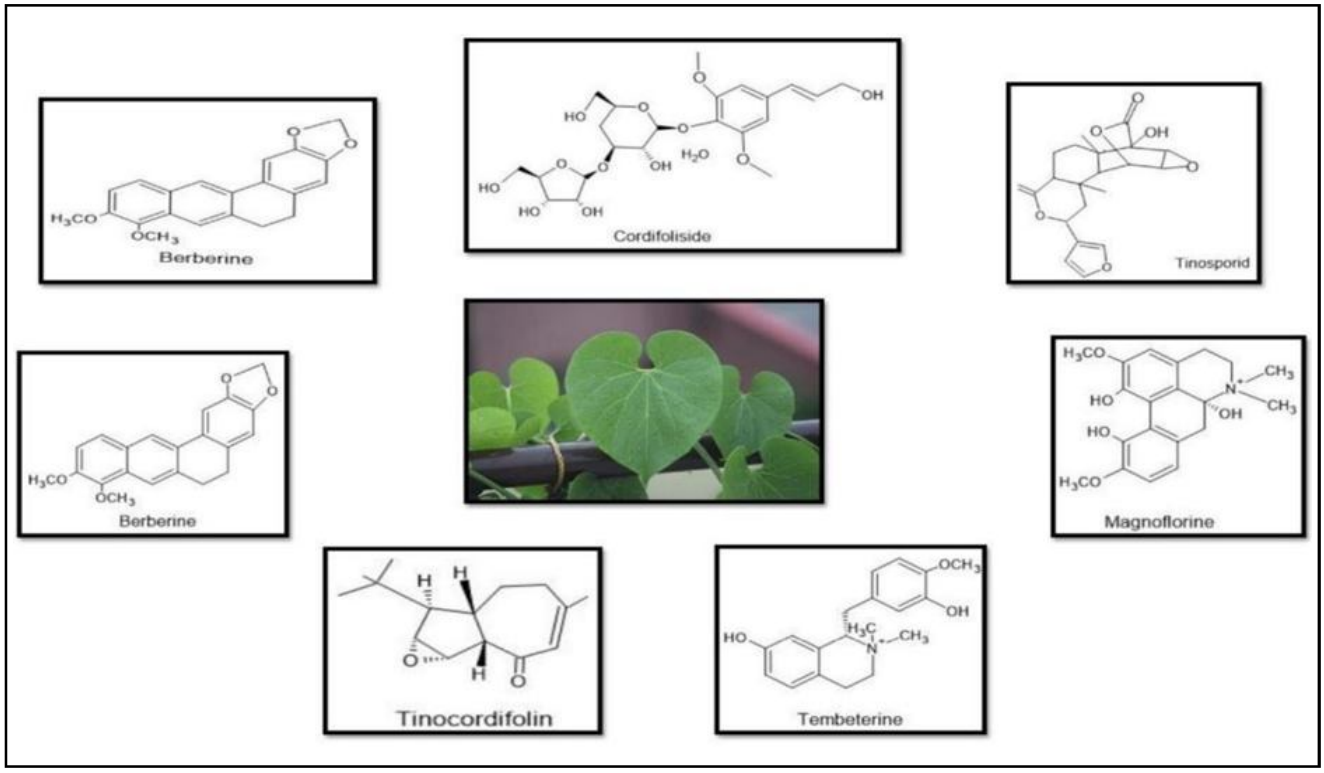

Figure 2: Phytoconstituents of *T. cordifolia.*

The following mentioned chemical constituents are present in *T. cordifolia*: tinosporine, tinosporon, tinosporic acid, tinosporal, tinosporidine, tinosporide, tinocordifolin, columbin, chasmanthin, palmarin, berberine, gilion, gilonisin, 1,2-substituted pyrrolidine, a diterpenoid furanolactone, 18-norclerodanediterpene-O-glucoside, aryltetrahydrofuranolignan, octacosanol, nonacosan-15-one and sitosterol, cardenolide,tinosporin, hepatocosanol, cordifol, cordifoliside, cordiform, magnoflorine, tembetarine, cardifoliosides A & B, phenolic lignan-3-(,4-dihydroxy-3-methoxybenzyl)-4-(4-hydroxy-3methoxybenzyl) tetrahydrofuran and arabinogalactan (Afroz Patan and Vijey Aanandhi, 2023).

2. Pharmacognistical description

Stem: *T. cordifolia* has a relatively succulent, long filiform stem. The branches have thick, squishy, warped bark that is covered in flesh-like aerial roots.

Bark: The bark ranges in colour from creamy white to grey, with big rostle-like lenticels sprinkled in the spaces between it. The bark is deeply left spirally.

Leaf: The membranous leaves have a cordate base. Alternatingly, the leaves are 2-4 inches long, roundish-oval, whole, sharp at the tip, and extremely smooth and thin. They are supported by long, flexnose petioles. The leaves are vividly green when viewed in mass, and they have a harsh flavour and faint odour. Fully grown leaves exhibit a yellow-green colour (Subhamalar *et al.,* 2023).

Flowers: The little blooms have a yellow or greenish colour. Male flowers are typically grouped, whereas female flowers are usually solitary in auxiliary and terminal racemes or racemose panicles.

Fruits: They are small, subglobose drupes with stalks. The drupes are pea-sized, ovoid, shiny, red, and succulent. Summer brings flowers, while winter brings fruits, which are juicy and full of flesh (Amol Gurav Nabi *et al.,* 2017)

2.1 Actions and properties

T. cordifolia stem has a number of different qualities, such as being bitter, sweet, thermogenic, anodyne, anthelmintic, alterant, anti-inflammatory, antispasmodic, antipyretic, antiemetic, digestive, carminative, appetizer, stomachic, constipating, cardiotonic, depurative, haematimic, expectorant, aphrodisiac, rejuvenating, galactic-purifier, and tonic (Santhosha and Dinesh Mohan, 2023). *T. cordifolia*, also known as giloy, is a widely used shrub in folk and Ayurvedic systems of medicine throughout India. It belongs to the family Menispermaceae and has various medicinal properties (Kale *et al.,* 2022).

Roots: The roots of *T. cordifolia* contain alkaloids like berberine, palmitine, temberatine, isocolumbine, magnoflorine, tetrahydrapalmitine, which has shown antiviral, immunomodulatory and anticancer activity.

Stem: The stem of *T. cordifolia* contains diterpenoid lactones, which are known for their anti-inflammatory and immunomodulatory properties.

Leaves: Leaves of *T. cordifolia* are rich in glycosides like syringin, tincordiside, cordifolioside A, steroids like β-stosterol and Ecdysterone, and other phytoactive compounds. These contribute to its antidiabetic potential, among other effects (Reddy *et al.,* 2015)

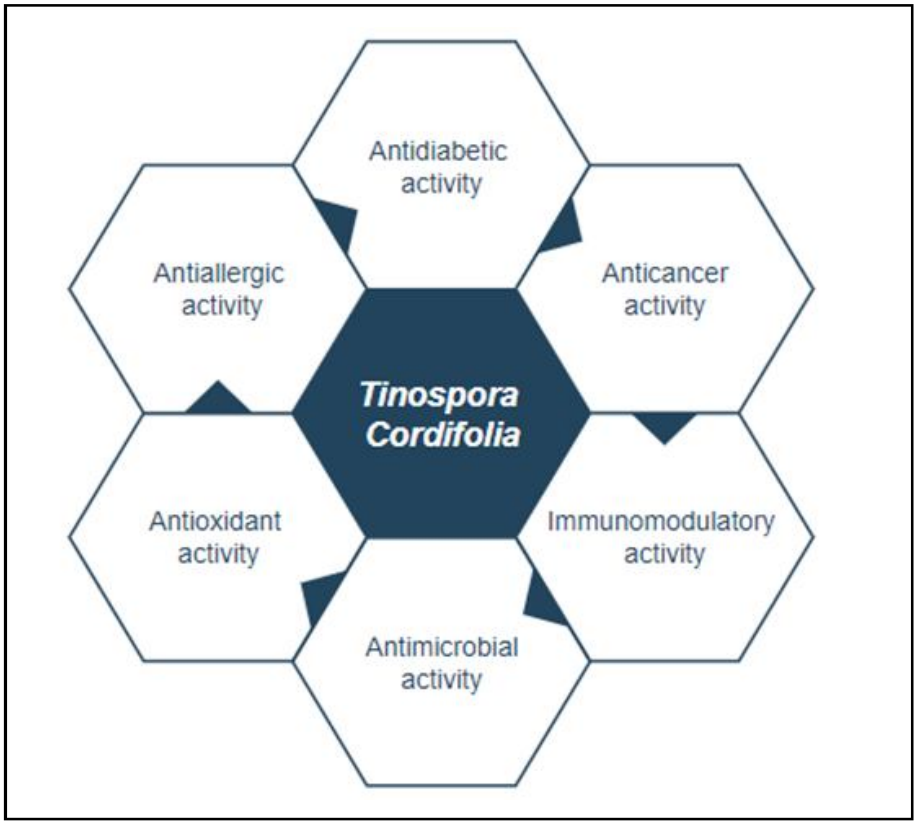

Figure 3: Pharmacological activities of *T. cordifolia*.

Table 1: Activity with mechanism of action for chemical constituents of *T. cordifolia*

S.No.	Class	Chemical constitutents	Activity with mechanism of action	Plant part
1.	Alkaloids	Berberine, palmitine, temberatine, isocolumbine, magnoflorine, tetrahydrapalmitine	Immunomodulatory, antidiabetic activity by mitigating oxidative stress, promoting insulin secretion and also by inhibiting gluconeogenesis and glycogenolysis	Stem and root
2.	Glycosides	Syringin, tincordiside, cordifolioside A	Anticancer activity by inter-leukin-1 (IL-1) anti-gen-presenting capacity and secretion, tumor necrosis factor (TNF) and RNI, as well as decreased tumor growth and prolonged lifetime the tumor-carrying host	Stem
3.	Steroids	like β-stosterol and Ecdysterone	Immunomodulatory by inhibiting the TNF-α, IL-1 β, IL6 and COX2 for inflammatory activity	Shoot
4.	Aliphatic compounds	Octacosanol, Nonacosan-15-one dichloromethane	Anti-inflammatory, antiparkinson's activity by protection against 6-hydroxyl dopamine induced parkinsons disease	Whole plant
5.	Terpenoids	Tinocordifolin	Antiseptic by significant improvement in phagocytosis and intracellular bactericidal activity	Stem

2.2 Uses

T. cordifolia bark possesses anti-inflammatory, antiallergic, antispasmodic, and antileprotic qualities. Powdered roots and stems are mixed with milk to treat cancer. The whole plant of *T.* cardifolia is used to cure syphilis, bronchitis, diarrhea, and scabies in pigs, as well as to extend life, strengthen the body, and increase immunity. When blended with ghee or honey, dried fruit powder is used as a tonic and to treat jaundice and rheumatism. The dry stem crude extract of this plant has polysaccharide properties and polyclonal B-cell mitogen activity. The active components in the stem extract increase the mice's humoral response. A combination of tulasi juice and the giloy plant is used to cure monkey malaria (Ramakrishna Allam *et al.,* 2023).

Table 2: Uses of *T. cordifolia* in folk and tribal medicine

Diseases	Mode of application
Fever	The stem of guduchi (*T. cordifolia*) and the roots of Bharkatiaya (*Solanum surattense*) are ground into a paste to make the tablets.
Jaundice, chronic diarrhea, periodic fever	The entire plant is employed.
Cancer,dysentery, diarrhoea	*T. cordifolia* root and stem bark powder combined with milk for cancer treatment.
Bone fracture	The entire plant is utilized.
General debility	Decoction of stem with 3-4 g of hot and cold water, taken in the morning on an empty stomach as a tonic.
Kasa (cough)	Oral administration of equal amounts of powdered *Terminalia chebula* (Haritiki), *T. cordifolia* (Amrita), and *Trachyspermum ammi* (Ajwain) is done once a day in the early morning, along with salt.
Karna shula (pain in ear)	Juice from two drops of guduchi *(T. sinensis*) or leaves of related plants is applied to the injured ear.
Raktapradara (leukorrhea)	Every morning, five krishnamarich (*Piper nigrum*) seeds and guduchi paste (*T. cordifolia*) are taken orally.
Swasa (asthma)	Oral administration of stem juice along with honey.
Twak - roga (disease of the skin)	Stem decoction is taken orally.

3. Pharmacological properties of *T. cordifolia*

3.1 Antimicrobial activity

Jeyachandran *et al.* (2003) demonstrated that the stem extracts of *T. cordifolia* were screened for bacteria, and the results were expressed as inhibition. *T. cordifolia* ethanolic extraction has been used against Gram-negative bacteria. Antibacterial activity against *Proteus vulgaris* and *Escherichia coli* was shown to be significantly higher, but less activity was observed against *Salmonella typhi, Staphylococcus aureus,* and *Serratia marcescens*. There was also moderate activity against *Enterobacter fecalis.* The stem extraction using chloroform showed no activity against *Staphylococcus aureus* and *S. marcescens,* but it did show moderate activity against *Escherichia coli* and *Proteus vulgaris*. *Salmonella typhi* and *Proteus vulgaris* have less antibacterial activity when using the stem aqueous extract of *T. cordifolia*. This action against both positive and negative microorganisms was investigated using the disc diffusion method. It demonstrated that the increased activity in plant and other ethanolic stem extracts does not prevent the bacteria from growing. The alkaloids present in this plant have shown antibacterial activity against microorganisms.

Priyanka Mishra *et al.* (2014) examined the antibacterial activity against a variety of organisms, including *Escherichia coli, Staphylococcus aureus*, *Proteus vulgaris, Pseudomonas aeruginosa, Bacillus subtilis, Staphylococcus epidermis,* and *Micrococcus leuteus.* The ethanolic extracts effectively inhibit every organism, with the exception of *E. coli.* Limited species, such as *S. aureus,* display inhibition zones when exposed to the hydromethanolic extract. The antibacterial activity was examined due to its excellent therapeutic qualities against harmful organisms. When *T. cordifolia* stem extract was tested for antibacterial activity it was discovered to be effective against pathogenic strains. The plant *T. cordifolia* is abundant in carbohydrates, glycosides, and alkaloids.

Seema Somalwar and Amita Somalwar (2022) evaluated the antibacterial activity of *T. cordifolias* ethanolic stem extract against *Propioni bacterium* acne using both dilution assays. Its main component, berberine, has been linked to numerous studies. The antibacterial properties of *T. cordifolia* stem extract have been demonstrated against the main acne-causing bacterium, *P. acnes. T. cordifolia* stem extracts are used as a novel herbal remedy for treating acne.

Fatima Rose *et al.* (2010) explained that the *T. cordifolia* root methanol extracts, both hot and cold, were subjected to an antibacterial screening process. This shows high antibacterial activity against all tested bacterial strains. Comparing hot and cold methanol extracts to standard medications reveals that it has the highest antibacterial activity against *S. aureus*. When compared to cold methanol extracts, the hot methanol extract of the root of *T. cordifolia* exhibits more activity. Alkaloids, carbohydrates, reducing sugars, glycosides, and other substances were detected in the methanolic extract.

3.2 Antidiabetic activity

Bindurani *et al.* (2019) assess the hypoglycemic activity of the prepared solution in alloxan-induced diabetic rats. Glibenclamide, a standard medication, was administered to diabetic Wistar albino rats

in two separate doses of 100 mg and 200 mg. Alloxan-induced diabetic rats were used to test the hypoglycemic effect of the prepared drug formulation, and the rats were given medication for 21 days to observe its effectiveness (Divya Pingil *et al.,* 2012). Blood glucose levels were statistically examined at the end of the study period by the results. The blood glucose level was significantly lower in the herbal formulation group than in the diabetic rats that were not given any treatment. It validates the significant hypoglycemic effect of the developed herbal medication mixture.

Agha Parvesh Maish and Kumar Gaurav Bajpai (2019) reported employing a calorimetric method to measure the level of non-enzymatic glycosylation of hemoglobin at 520 nm. *T. cordifolia* and callus extracts have antidiabetic effectiveness. A mixture of glucose (2%), phosphate buffer (0.01 M), hemoglobin (0.06%), gentamycin (0.02%), and hemoglobin was assembled. All of the above solutions were combined into one milliliter. Callus extracts and native plant concentrations of 25, 50, and 100 µg/ml were added to the combination. The combination was left to stand at room temperature in the dark for 72 h using a calorimetric technique. The quantity of glycosylation of hemoglobin at 520 nm was measured using a calorimetric technique. Metformin served as the reference medication for the experiment. There was a calculation of the inhibiting percentage.

Abhijith and Ravi Sori (2018) found that the *T. cordifolia* extract has a hypoglycemic effect that is seen in diabetic rats but not in normal rats. *T. cordifolia* extracts, sodium chloride, glibenclamide hydrochloride, and alloxan monohydrate are the substances employed in this action. 24 Albino rats weighing 180-220 g were taken and evaluated for blood glucose levels between 80 and 115 mg/dl. Before the diabetes was induced, the mean blood glucose levels in each of the six groups ranged from 94.2 to 103 mg/dl. In rats with diabetes, the hypoglycemic action is similar to that of glibenclamide. For this reason, a purified *T. cordifolia* plant extract is taken orally to treat hypoglycemia; however, it was also reported that deeper investigations are required in both human and animal trials.

Kinkar Shobha and Patil Kishor Gopal (2015) carried out this study to determine whether the entire plant extract of *T. cordifolia* has effective antidiabetic properties in rats. Albino rats of both sexes were used in this study to assess the antibiotic potential of a whole plant compound extract from *T. cordifolia*. The three groups of rats were separated, therapy group, diabetic control group, and normal control group. Equipment diabetics were induced with Alloxon 180 mg/kg through an intraperitoneal dose, which also confirms that the whole plant extract of *T. cordifolia* significantly lowers the blood glucose levels to a normal level. Because the plant extract behaves like insulin, it also activates insulin secretion, which further lowers blood glucose levels.

Varsha Sonkamble and Laxmikant kamble (2015) carried out this study to find out the potent antidiabetic activity of *T. cordifolia*. The phytochemical profiling of *T. cordifolia* described in this article led to the discovery of a broad range of bioactive phenolics. Several authors documented that some of the identified bioactive phenolics had antidiabetic properties and this was an effort to pinpoint *T. cordifolia* powerful antidiabetic constituents it is based on this research so, it is also possible to predict that *T. cordifolia* potent antidiabetic activity is due to the presence of compounds that inhibit the enzymes α-amylase and α-glucosidase.

3.3 Anticancer activity

Ganesh Chandra and Shaivel (2005) reported that natural products provide important sources that could yield chemotherapeutic medicines. There is a specific place in anticancer chemotherapy for chemotherapeutic drugs such as vincristine, podophyllotoxin, and camptothecin. After conducting acute toxicity testing, guduchi was found to be a nontoxic drug in *in vivo* studies. Moreover, he reported on the antineoplastic action of *T. cordifolia* dichloromethane extract through *in vivo* studies and the results showed that it reduces clonogenic survival in cultural HeLa cells in a dose-dependent manner earlier. The administration of different doses of *T.cordifolia* extract caused dose-dependent retardation in tumor development, which indicates the effectiveness of *T.cordifolia* extract in the tumor cell. The efficacy of *T. cordifolia* extract at different tumor stages was shown to be greater than that of cyclophosphamide indicating its promise as an anticancer medication. The increased antitumorogenic effects of *T. cardifolia* extract are attributed to its composition, which includes alkaloids such as berberine. Although, the precise mechanism of *T. cordifolia* extract is unknown, it may cause DNA damage and inhibit topoisomerase II. Positive outcomes point to the usefulness of *T. cordifolia* extracts in cancer treatment regimens.

Rumana Ahmad *et al.* (2015) reported that the methanolic extract of *T. cordifolia* demonstrates the cytotoxic and dose-dependent inhibitory effects of IC_{50} values for human breast cancer cells (MDA-MB-231) of 59 ± 4.05 µ/ml in 0.25% DMSO and 50 ± 2.05 µg/ml in 0.5% DMSO and explored with morphological analysis, which confirms the *T. cordifolia* cytotoxic impact on cancer cells. Importantly, the extract exhibits minimal cytotoxicity on normal epithelial cells (Vero) at concentrations that are effective against cancer cells. This selective anticancer activity suggests the potential of *T. cordifolia* extract for further exploration as a novel cancer chemotherapeutic agent.

Rashmi *et al.* (2019) examined the impact of bis (2-ethyl hexyl). A naturally occurring substance called 1H-Pyrrole-3,4-dicarboxylate (TCCP) was extracted from *T. cordifolia* leaves and was found to have a substantial effect on triplo negative breast cancer (TNBC) in MDA-MB-231, a triplo negative cell line. It has been demon-strated that Bis (2-ethyl hexyl) 1H-Pyrrole-3,4 dicarboxylate (TCCP) induces ROS generation and modifies apoptotic markers in MDA-MB-231 triple negative breast cancer (TNBC) cells, accounting for 15% of cases of breast cancer globally. By using *in vivo* studies on ehrlich ascites tumor (EAT) mice, the efficacy of Bis (2-ethyl hexyl) 1H-pyrrole-3,4-dicarboxylate (TCCps) in reducing tumor burden and enhancing survival was shown. This study highlights the possible role of bis (2-ethyl hexyl) 1H-Pyrrole-3,4-dicarboxylate (TCCPs) in inducing ROS and apoptosis mediated by the mitochondria.

Parveen Bansal *et al.* (2017) suggested that analyzing traditional herbal remedies for cancer could reveal new approaches to treating the disease, which is still the world's largest cause of cancer-related deaths. The production of G1 phase arrest in KB cells further supports the effectiveness of *T. cordifolia* extract as a therapy, and he reported that significant suppression of KB cell proliferation is shown, along with a dose-dependent decline in the clonogenicity of Ehrlich Ascites tumor cells after treatment with different concentrations of *T. cordifolia.* The findings align with earlier research that highlighted *T. cordifolia's* bioactive components and variety of anticancer effects in both *in vitro* and *in vivo* models. Because *T. cordifolia* extract

arrests the G1 phase of the cell cycle, it suggests that it may be used to treat human carcinomas.

3.4 Antioxidant activity

Ponnaian Stanely *et al.* (2004) investigated by using petroleum ether to soxhlate the dried powdered roots; the roots were defeated, and ethyl alcohol extracts were produced from the isolation process. A key player in the enzymatic antioxidant defense mechanism is superoxide dismutase. Superoxide-induced pathological changes can be prevented by the extracts of *T. cordifolia* roots, which are catalyzed by SOD and have the ability to scavenge free radicals. Phytochemical studies revealed that *T. cordifolia* roots include alkaloids such as choline, tinosporin, isocolumbin, palmitine, tetrahydropalmitine, and magnoflorine. The extract can scavenge free radicals.

Raghu and Seeta Ram Rao (2016) reported that the alkaloid levels in *T. cordifolia* were shown to rise upon foliar application of brassinosteriods. *Brassinospora cardifolia* stem alkaloid concentration was significantly more effectively affected by brassinosteriods. *T. cardifolia* plant sections' alkaloid concentration was positively impacted by brassinosteroids, as this study amply revealed, and he also reported that *T. cordifolia* total phenol content significantly increased when brassinosteroids were applied exogenously. In *T. cordifolia,* these antioxidant levels are higher, as the current study clearly showed. In comparison to other plant parts of *T. cardifolia,* leaf samples showed the highest amounts of flavonoids at 2 mm concentrations of 28 homobrassinolide.

Bhalerao *et al.* (2012) reported that ethanol was found to be a more effective extractive solvent for antioxidant activities. Phenolic components were found at higher concentrations of antioxidant activity. Additionally, the ethanolic stem extract was found to have stronger free radical scavenging activity. The correlation between antioxidant activity and phenolics was also found to be the same. Polyphenols are the compounds found in plants that have antioxidant qualities. The phenolics are in charge of the plants' fluctuating antioxidant activity. The antioxidant effect is demonstrated by either producing lipid free radicals or preventing the hydroperoxides from breaking down into free radicals. It was observed that the most DPPH was caused by the ethanol stem extract which had the highest phenol content according to the estimation of *T. cordifolia* total phenolic content.

3.5 Immunomodulatory activity

Upadhyaya *et al.* (2011) conducted this investigation to support previous reports of *T. cordifolia* which can modify immunological responses and to show that the main source of the action was the glycoprotein-rich aqueous extract of the plant that was isolated from the stem. This extract is primarily intended for use on macrophages, and it promotes the generation of effector molecules such as nitric oxide and cytokine mediators. It also enhances the ability of macrophages to transport antigens and increases the antigen-specific recall response.

Sanjiv Kumar Biradar *et al.* (2021) reported that *T. cordifolia* stem extracts in ethanol and methanol were tested for their immunomodulatory potential at various dose points. The outcome was demonstrated in a concentration-dependent way, which shows immunomodulatory activity. The plant enhanced humoral immunity as well as cell-mediated immunity. According to the study, alcohol-based extracts from the stem of *T. cordifolia* may boost humoral as well as cellular immune responses. The extracts successfully enhance humoral and cell-mediated immunity, in addition to amplifying the nonspecific immune response. Therefore, based on the data acquired by him, it can be said that *T. cordifolia* has medicinal potential and may be useful in immunomodulation.

Ivan Aranha *et al.* (2011) reported that an acidic non-glycoprotein weighing 25 kDa that has immunomodulatory capabilities but lacks hemagglutination activity is present in the guduchi stem. (phagocytosis, activation of macrophages resulting in no release, and mitogenic action). According to this study, the main protein found in the guduchi stem also demonstrates immunomodulatory abilities. Several tiny compounds and polysaccharides have been connected to guduchi's immunomodulatory properties, which have been established through this research.

Nageswari *et al.* (2018) conducted this study to evaluate the immunomodulatory effect of stem and leaf extracts from *T. cordifolia* on immunotoxicity induced by zidovudine. Three distinct extracts of *T. cordifolia* leaves and stem (aqueous, methanol, and n-hexane) were made using the Soxhlet extraction method after the leaves and stem were collected. In all, 24 rats were employed in the research. Rats were split up into four groups, each with six rats. Group I received treatment using purified water. Rats in Group II were given 500 mg/kg of zidovudine; rats in Group III were given 500 mg/kg of *T. cordifolia* stem extract plus 500 mg/kg of zidovudine; and rats in Group IV were given 500 mg/kg of *T. cordifolia* leaf extract + 500 mg/kg of zidovudine. Every week, measurements of the physical, hematological, and immunological parameters were made. Rats were anesthetized and sacrificed after the study. The thymus and spleen were collected and weighed. These findings suggest an enhanced effect of *T. cordifolia* leaf and stem extract on zidovudine-induced immunotoxicity. Through this study, she concluded that *T. cordifolia* has potential immunomodulatory activity, and this work contributes to the scientific understanding needed to explore *T. cordifolia* other pharmacological characteristics and further determine the immunomodulatory activity.

Vishal Thorat *et al.* (2021) reported that globally, the adverse effects of allopathic medications have led to a spike in the demand for phytopharmaceuticals. This offers a strong basis for selecting species for additional phytochemical and pharmacological research. The present review verifies *T. cordifolia* therapeutic value based on pharmacological and clinical studies. Chemical compounds found in the plant suggest that it could be the "lead" for the development of new therapeutic agents in the upcoming years. He also states that more research is therefore required to determine whether *T. cordifolia* has any potential for both disease prevention and treatment. The current analysis guides future investigators looking to study the plant to extract some important therapeutic components.

4. Conclusion

Ayurvedic texts identify guduchi as one of the Rasayana dravyas, or remedies that fortify the body's defenses against disease. Guduchi is an exceptional place to locate a wide variety of chemicals with various

phytochemical compositions and uses. The therapeutic benefits of *T. cordifolia,* as mentioned in Ayurvedic texts, are supported by a variety of modern scientific findings, suggesting that this plant has great promise in modern pharmacotherapeutics. This review highlights the traditional uses of *T. cordifolia* for antibacterial, antidiabetic, anticancer, immunomodulatory, and antioxidant purposes, as well as how modern research has supported these uses. The therapeutic benefits of *T. cordifolia*, as mentioned in ayurvedic texts, are supported by a variety of modern scientific findings, suggesting that this plant has great promise in modern pharmacotherapeutics. Much research has been done on the biological activity and possible uses of these chemicals, but further in-depth study is needed to fully realize and understand the precise molecular mechanism and their therapeutic potential in the treatment of many diseases. A drug development programme should be undertaken to develop modern drugs with the compounds isolated from *T. cordifolia*. This review could result in the development of safe medicinal applications for contemporary medicines and help ongoing research to develop novel medications and clinical purposes.

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Conflict of interest

The authors declare no conflict of interest relevant to this article.

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