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TINOSPORA CORDIFOLIA: A REVIEW ON SINGLE HERB WITH MULTIPLE PHARMACOLOGICAL EFFECTS

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ABSTRACT: Given their well-known lack of side effects in comparison to pharmaceuticals, natural materials with medical potential are rising in prominence in clinical research. Since the dawn of civilization, humans have relied on plants as a vital resource for healing. Medicines, health aids, pharmaceuticals, dietary supplements, cosmetics and other similar items derived from plants are becoming more popular. In this article, the chemical components and pharmacological effects of *Tinospora cordifolia* are described. "Guduchi," a popular name for the plant *T. cordifolia*, has a long history of use in traditional Ayurvedic medicine. *T. cordifolia*, most often known as guduchi, is a prominent medicinal plant found across the tropics. The therapeutic benefits of this method are well recognized internationally. The advantages it has for your diet are less well-known. Native Indians and other Indians have long included guduchi [*T. cordifolia* (Willd.) Hook. F. Thoms] in their diets. It is also recommended for use in Ayurvedic diets. Interest in the plant has surged recently due to the identification of active components from the plant and their biological significance in disease management. Exploiting the biochemical and signaling pathways impacted by the chemicals extracted from Tinospora to allow novel and effective formulation in disease eradication is still within the purview of the review's future work. This synthesis has applications in both basic and clinical research.

INTRODUCTION: Since analgesics, antibiotics, and other allopathic drugs were not accessible everywhere at the turn of the twentieth century, phytomedicine was one of the preeminent medical paradigms of the time. The allopathic medical system's popularity grew throughout time. The rapid therapeutic effect of allopathic drugs has contributed to a gradual reduction in phytomedicines' once-high reputation.

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Despite this, a sizeable population continues to utilize phytomedicines, despite the fact that they have less negative consequences. According to the World Health Organization, the vast majority of the world's population (80%) uses traditional medicines that primarily make use of plant extracts or their active ingredients.

India's wealth of plant life and historic medical practices (including Ayurveda, Siddha, Unani, Amchi, and regional healing modalities) give a solid foundation for the use of many plants in general healthcare and the treatment of common disorders [1]. *Tinospora cordifolia* (Wild) in its native Bangladesh, Myanmar, Sri Lanka and China, it was found a spreading and climbing shrub with a

lot of twisted branches known as Hook (Guduchi/Amrita; English: Indian Tinospora, Hindi: Giloya/ Gulancha). Inflammation, rheumatism, anemia, urinary dysfunction, skin illnesses, jaundice, diabetes, allergic condition, *etc*. are just a few of the many ailments that *T. cordifolia* may treat, making it a popular component of the Ayurvedic medical system. *T. cordifolia* root is used to treat both nausea and vomiting as well as intestinal blockage. A small number of studies have shown that *T. cordifolia* may reduce persistent fever, improve appetite and energy levels and soothe painful sensations. Traditional Chinese Medicine practitioners utilize Guduchi to treat leprosy, helminthiasis, rheumatoid arthritis, and to increase the body's resistance against infection. Colitis, hyperacidity, gastrointestinal discomfort, vomiting, and worm infestation are all possible side effects of this plant. All of these therapeutic effects could be attributable to a specific chemical component of this plant. The stem, the root, and the whole plant contain a wide variety of chemical substances. These include glycosides, sesquiterpenoids, aliphatic compounds, polysaccharides, steroids, aliphatic compounds, phenolics, and a mixture of fatty acid residues [2]. In this article, the chemical components and pharmacological effects of *Tinospora cordifolia* are described.

Vernacular Names: In Latin it is known as *T. cordifolia*; English known as Gulancha or Indian Tinospora; Sanskrit Madhuparni; Amrita, Guduchi, *etc*.; Hindi Giloya or Guduchi; In Marathi, it is well known as Gulvel, giroli as well as Amberveli; Assamese Amarlata; Bengali Gulancha, Giloe; Gujrati Galo, Gulo; Tamil Amridavalli; Telugu Tippatige, Guduchi [3].

Taxonomical Classification: Guduchi comes under the Kingdome Plantae (Plant) Division is Magnoliophyta (Flowering), Class Magnoliopsida (Dicotyledons), the order is Ranunculales, and it belongs to Menispermaceae family (The moonseed family), Tribe Tinosporeace, Genus Tinospora and species is cordifolia [4].

Distribution: Guduchi prefers to grow India's tropical a well as subtropical regions, especially areas of Maharashtra, Tamil Nadu, Madhya Pradesh, Uttar Pradesh, and Kerala. It is also native to the area of Sri Lanka, China, Myanmar, Philippines, South Africa, Thailand, Bangladesh, and parts of the south-east Asian continent such as Indonesia and Malaysia [5].

Substitutes and Adulterants: Other species of Tinospora including *T. sinensis* (Lour.) Merrill (syn. *T. malaberica* Miers ex Hook. f. and *T. crispa* (Linn.) Miers ex Hook. f. & Thoms.), are used in place of or together with *T. cordifolia*. Although *T. sinensis* and *T. cordifolia* share many microscopic characteristics, there are a few traits that allow for differentiation between the two species. In the cortical regions of *T. cordifolia*, the sclerenchymatous sheath disintegrates into sporadic irregular patches, but in the cortical regions of *T. sinensis*, it is fragmented into portions that cap the vascular bundle and persists even after additional secondary development.

While *T. cordifolia* lacks crystals, *T. sinensis* has a sizable calcium oxalate crystal inside the lumen of every cork cell. In comparison to *T. sinensis*, *T. cordifolia* has more mucilaginous cells. But there are more vascular strands in *T. sinensis* than in *T. cordifolia*, each strip of vascular strand in *T. cordifolia* has well-developed xylem while this is not the case in *T. sinensis*. When compared to T. sinensis, *T. cordifolia*'s pith is large and made up of cells with thin walls. *T. cordifolia* has more starch than *T. sinensis* does [6].

Growth Requirement: Guduchi is found in many different climates and soil types; however, it does best in medium black or red soil, or light to medium sandy loam soil, and enjoys a warm temperature. Having sufficient water on hand is crucial. The months of July and August are often used for cultivating (during the wet season) [7].

Macroscopic Description:

Aerial Root: The aerial root is a thin, horizontal stem that may extend all the way to the soil. Young aerial roots, which are long and filiform, develop from fully developed branches or stem cuttings. The aerial roots that have matured are fat and look very much like the juvenile aerial stem, but for the presence of nodal swelling. Dried aerial roots are 3–6 centimeters in diameter, have a short fracture, a harsh flavor, and no discernible odor [8].

Stem: The guduchi plant has a long, succulent, slender, juicy stem that grows upward and has aerial roots that grow out of it and into the earth. The stem twists in a helical pattern, and the bark is various shades of milky white and grey [9].

Leaves: Leaves of the guduchi are simple, alternating, stipulate, long-petioled (2.5–7.0 cm), heart-shaped (partially twisted), 7-9-nerved, and deeply cordate (cuneate) at the base and halfway around. The lamina is membranous and is 8-15 cm in width and 10-20 cm in length. Adult leaves are yellowish-green to yellow in color, bitter, and have an ambiguous odor, whereas juvenile leaves are a vibrant green. Tiny, unisexual racemes appear when the plant is leafless, becoming a greenish yellow color. Male flowers bloom in clusters, whereas female blossoms often grow alone. There are two sets of three sepals, for a total of six. Compared to the sepals, the outer ones are more delicate, independent, and membraneous. From March through June, the summer months, the flowers blossom [10].

Fruit: The fruits are gathered in clusters of 1, 3, and are fleshy drupelets with a solitary seed. The fruit has an oblong shape and an orange to crimson color with a velvety smooth feel. Fruits develop even during the colder months [11].

Seed: It has been observed that the seeds of this species often take on a curled or hooked shape. Therefore, the name "Moonseed" was given to this clan. The embryo takes on the same bean shape as the white, curved seed [12].

Microscopic Description:

Root: Aerial roots are composed of tetrahedra similar to the Penta-arch, the basic structure of plants. The cortex is divided between the outer thick-walled zone, which symbolizes the velamen, and the inner parenchymatous zone, which includes mucilage cells and tannin-containing cells. The parenchyma of the areal root is rich in starch [13].

Stem: Transverse sections of Guduchi stems reveal the plant's cork, cortex, and vascular bundle. Cork is made up of two distinct types of cells, the outer layer being made up of thick-walled, compressed brownish cells and the inner layer being made up of thin-walled, colorless, tangentially orientated cells. Lenticels induce cracks in the cork tissue. The cortex is thick and has many layers: the outer layer is made up of irregularly organized, tangentially elongated chlorenchyamatous cells, while the inner layer is made up of polygonal cells laden with abundant starch granules. Ovoid and uncomplicated, starch grains have just a scattering of secretory cells across their cortices. A large number of crystal fibers, each carrying a single prism, are linked to lignified pericyclic threads. Vessel elements, tracheids, parenchyma, and fibers make up the xylem, whereas the phloem parenchyma includes calcium oxalate crystals. The cambium consists of one to two layers. The pith is predominantly made up of big thin-walled cells holding starch grains, and the pith of the vessel components is cylindrical in form and has a bordered pith. The medullary rays are 15–20 cells wide [14].

Leaf: A Guduchi leaf's midrib cross-section shows a little convex on the upper side, a huge hump on the lower side, and a single, well-developed collateral vascular bundle in the middle. In a dorsiventral cross-section of the lamina, the mesophyll is shown to be partitioned into palisade and spongy tissue. Approximately half of the mesophyll's diameter is occupied by a palisade layer of thin-walled columnar cells that have undergone differentiation. There is a wide variety of palisade ratios, from 4 to 12. Upon close inspection, it is clear that epidermal cells are angular and occur at a density of between 1000 and 1500 mm2, while cellular trichomes range in size from 115 to 145 m in length and 32 to 42 m in breadth. The length, width, and thickness of anomalocytic stomata are as follows: 200–600 mm-2, 36–54 m, and 18–36 m, respectively. Veins are complex, with many main veins branching out. The veins on the dorsal side are numerous and easily visible. There are as many as three vein islets for every sixteen vein terminations. When seen in cross-section, the petiole has a rather round appearance. There is just one layer of epidermis, one layer of endodermis, a large zone of cortex, three to four layers of fibrous pericycle, eight to ten vascular bundles arranged in a ring, and a wide central parenchymatous pith [15].

Qualitative Analysis:

Physicochemical Analysis: In accordance with the Indian Pharmacopoeia, researchers had conducted a

physicochemical examination of Guduchi stem and presented their findings. The stem was tested for foreign matter, total ash, acid insoluble ash, water soluble ash, loss on drying, and extractive values. Guduchi's leaf, stem, and aerial root were subjected to physicochemical examination. The ash and extractive levels, as well as the physicochemical properties of powdered air-dried leaf, stem, and aerial root, were recorded [16].

TLC Analysis: In a study, explorers used a simple reflux approach to generate methanolic extracts of the leaf, stem and aerial root. At UV 254 nm and 366 nm, the biomarkers berberine and tinosporaside were detected in all three fractions of the mobile phase extract. TLC was carried out on the Soxhlet extracted Guduchi stem extracts using hexane, chloroform, ethyl acetate, and methanol. Spots were detected both with visible light and with derivatizing agents such the Natural Product (NP) reagent, which is active at 366 nm. The results show that Rf values in the ranges of 0.14 to 0.51, 0.19 to 0.78, 0.06-0.81, and 0.05-0.87 are produced by the hexane, chloroform, and ethyl acetate extracts, respectively, whereas methanol produces Rf values in the range of 8 to 1. Four distinct powdered extracts (fresh aqueous extract, freeze-drying powder, aqueous freeze-drying powder, and dried powder) of Guduchi stem were analyzed using TLC. Bands were seen at UV 366 nm using anisaldehyde as the spray reagent and two different solvent solutions as the mobile phase. There are several bands with comparable Rf values in the first three samples in both solvent systems, and there is one band with a distinct Rf value in the final sample. Every single Rf value was recorded, and tinosporaside, a significant component, was discovered to have an Rf of 0.58 in this study [17].

HPTLC Analysis: The measurement of tinosporaside in Guduchi was made easier and more reliable through a HPTLC method. Pre-coated silica gel 60F 254 plates were used to separate tinosporaside using TLC, and the plates were scanned using a densitometric scanner in UV reflectance photomode at 220 nm. The solvent solution consisted of toluene, acetone, and water at a ratio of 5:15:1. The Rf of tinosporaside was calculated to be 0.58 using the suggested HPTLC technique, and its concentration in the test sample was determined to be 0.40% w/w.

Methanolic stem extract of Guduchi was prepared using the Soxhlet extraction technique, and the detection of berberine in this extract was the focus of research. Using a solvent solution of butanol: ethyl acetate: acetic acid: water (3: 5: 1: 1), compounds were separated by TLC on pre-coated silica gel 60F 254 plates, which were then scanned using a densitometric scanner in UV reflectance photo mode at 366 nm.

The methanolic stem extract of Guduchi contained 0.23% (w/w) berberine, with an Rf of 0.23. The Soxhlet methanolic extract of Guduchi stem was analyzed by fingerprinting it using a CAMAG HPTLC system with a Linomat-V spotting and scanner 3 and the solvent system Toluene: ethyl acetate: formic acid (5:4:1). Chromatograms obtained at 254 nm and 366 nm were analyzed. Seven fingerprint spots at 254 nm and ten at 366 nm were identified for Guduchi. To assess berberine concentration in the test sample, HPTLC examination of methanolic extract of Guduchi was done using MAE, soxhlation, and maceration as extraction techniques. The mobile phase for this experiment was an 8:1:1 mixture of methanol, acetic acid, and water. The density scans were taken using a CAMAG TLC scanner 3 set to absorbance mode and 366nm. Maximum absorption of berberine measured at 348 nm. Researchers showed that MAE was much more effective than other techniques for obtaining berberine. For their study, scientists used a CAMAG HPTLC system to analyze four different powdered extracts of Guduchi stem extracted in various solvent systems, including chloroform: methanol: ethyl acetate (9.5: 0.5: 0.1 v/v/v). At 254 nm and again after derivatization with anisaldehyde, the Rf value of several compounds was recorded [18].

Total Phenolic Content: The total phenolic content of Guduchi stem extracts made using hexane, chloroform, ethyl acetate, and methanol was analyzed. Tannic acid used as a reference in a modified Folin-Ciocalteu test to determine the results. The UV- VIS spectrophotometer read 765 nm as the absorption reading. The results demonstrate that the phenolic content of Guduchi is highest in the ethyl acetate extract (9.8 µg/g), and lowest in the hexane extract (4.8 µg/g) [19].

Total Flavonoid Content: Absorbance at 415 nm was used to determine the total flavonoid concentration in hexane, chloroform, ethyl acetate, and methanol extracts of Guduchi stem, using quercetin as a reference. Based on the results of the present study, the flavonoid concentration of Guduchi stem extract prepared using methanol is much higher than that obtained using hexane (11.08 µg/g vs. 3.62 µg/g) [20].

Preliminary Phytochemical Analysis: The leaves and stem of Guduchi were used in a preliminary qualitative phytochemical investigation conducted **Fig. 1**.

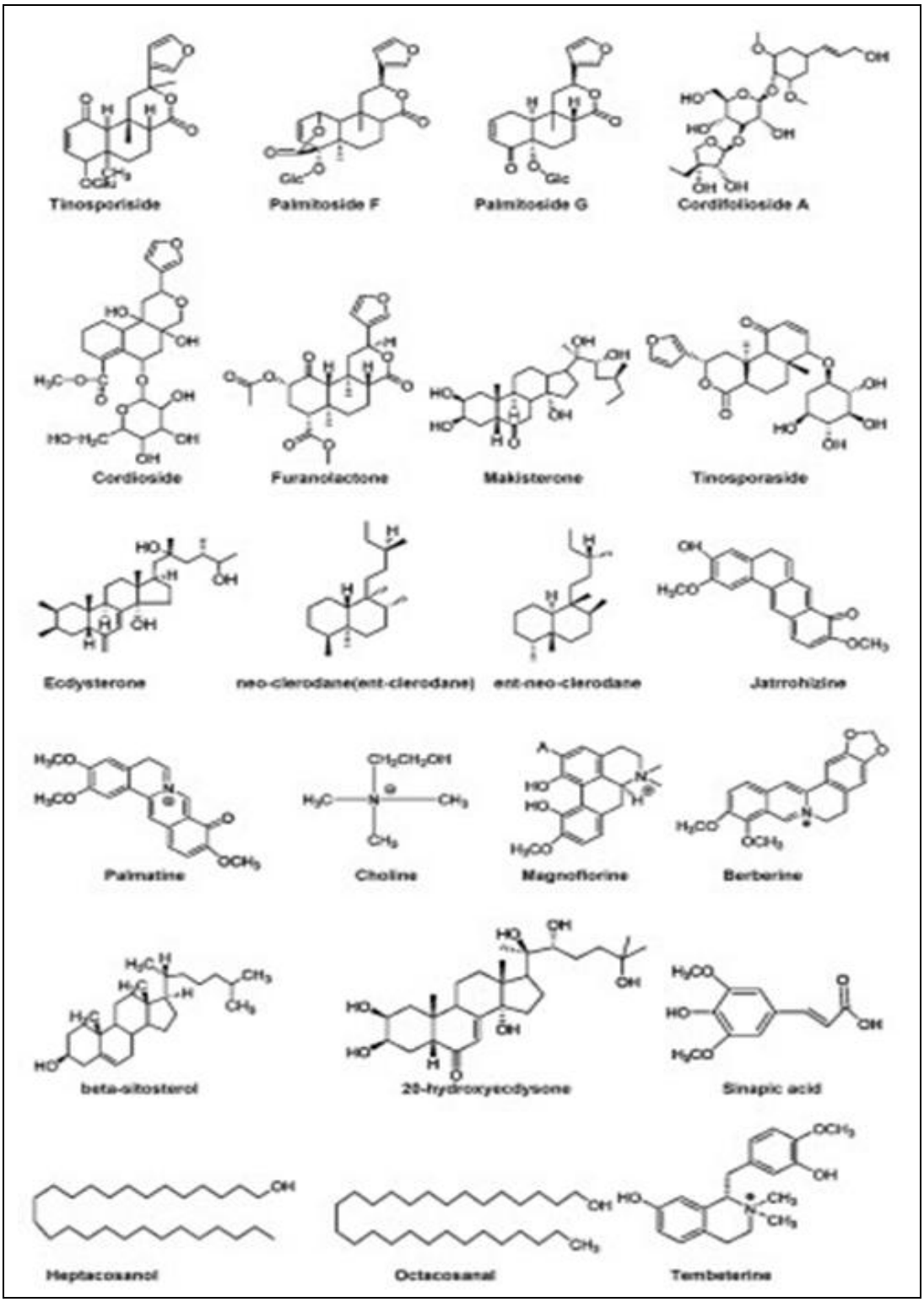

FIG. 1: MAJOR PHYTOCONSTITUENTS PRESENT IN *T. CORDIFOLIA*

The maceration method yielded the extract, and the five solvents used were water, ethanol, methanol, chloroform, and petroleum ether. Alkaloids, cardiac glycosides, tannins, phenols, polysaccharides and flavonoids were all found in the leaves and stem extract of Guduchi in this phytochemical analysis. Due to the increased solubility of the active molecule of Guduchi compared to other solvents, the study determined that most phytochemical components were discovered in methanolic extract. As a first step, researchers analyzed the phytochemistry of Guduchi. Solvents including hexane, chloroform, ethyl acetate, and methanol were used in a Soxhlet assembly to extract the stem extract in succession. Carbohydrates, glycosides, flavonoids, phenols, tannins, and amino acids were all found. The phytochemical content of methanolic stem extract is higher than that of extracts made using other solvents. Preliminary phytochemical screening was conducted on four powdered samples of Guduchi stem. These samples included a fresh aqueous extract, freeze-drying powder, aqueous freeze-drying powder, and dried powder. Many different types of phytochemicals were found to be present, including alkaloids, glycosides, flavonoids, phenolic compounds, fixed oil, tannin, polysaccharides and steroids. More phytochemicals of type AS can be found in the fresh aqueous extract than in any of the other samples. The leaves and stem were extracted using chloroform, methanol, and ethanol, and then screened for potential phytochemicals. Flavonoids, amino acids, diterpenes, protein, saponins, and carbs were all identified as being present in Guduchi. The phytochemical content of methanolic stem extract is highest compared to that of other extracts of leaves and stems **Table 1** [21].

TABLE 1: CONCERNED BIOLOGICAL ACTIVITIES OF ESSENTIAL CHEMICAL CONSTITUENTS AND DIFFERENT PLANT PARTS OF *T. CORDIFOLIA*

Dynamic component	Constituents	Biological properties
Alkaloids	Tinosporine, Magnoflorine, Berberine, Choline, Jatrorrhizine, 1,2-Substituted pyrrolidine alkaloids; *viz.* jatrorrhizine, palmatine, beberine, tembeterine, choline	Stem and plant root: Anti-proliferative potential, Antioxidant property
Lignans	3 (a, 4-dihydroxy-3-methoxybenzyl)-4-(4-hydroxy-3-methoxybenzyl)	Plant root: Anti-neoplastic property, Antioxidant property
Steroids	Giloinsterol, ß-Sitosterol, 20a-Hydroxy ecdysone	Arial part of stem: Anti-stress action
Terpenoids	Tinosporide, Furanolactone diterpene, Furanolactone clerodane diterpene, furanoid diterpene, Tinosporaside, ecdysterone makisterone and several glucosides isolated as poly acetate, phenylpropene disaccharides cordifolioside A, B and C, cordifoliside D and E, Tinocordioside, cordioside, palmatosides C and F, Sesquiterpene glucoside tinocordifolioside, Sesquiterpene tinocordifolin	Stem: Infectious disease related to lower and upper respiratory tract, disease related to skin, properties to counter glucose deviation
Others	Giloin, Tinosporan acetate, Tinosporal acetate, Tinosporidine, Heptacosanol, Octacosanol, Sinapic acid, Tinosponone, Phytoecdysones	The entire part of plant: Rheumatoid joint pain, elevated cholesterol content, gout, diabetes, neuropharmacological and analgesic effects, cancer, anti-fever and radioprotective properties

Nutritive Value: *T. cordifolia* is a desirable plant because of the abundance of beneficial elements it contains. There are a variety of micronutrients and macronutrients present. Explorers report that the nutritional profile of *T. cordifolia* stem normally consists of a high quantity of protein (4.5-11.2%), an appropriate quantity of carbs (20.78%), a low quantity of fat (6.68%), and a reasonable quantity of fiber (39.26%). One hundred grams of it has 156.44 calories **Table 2** [22].

TABLE 2: NUTRITIVE COMPOSITION OF *T. CORDIFOLIA*

Nutrients	Amount
Proximate analysis	
Ash content (%)	6.86
Carbohydrates (%)	20.78
Energy (KCal/ 100 g)	156.44
Fats (%)	6.68
Fiber (%)	39.26

Moisture content (%)	23.11
Proteins (%)	4.5-11.2
Minerals	
Calcium (%)	0.131
Chromium (%)	0.006
Copper (mg/100 g)	0.81
Iodine (mg/100 g)	72.4
Iron (%)	0.28
Magnesium (mg/100 g)	67.57
Potassium (%)	0.845
Sodium (mg/100 g)	39.32
Zinc (mg/100 g)	3.3
Vitamins	
β-carotene (%)	0.11
Ascorbic acid (µg/g)	0.24
Niacin (mg/100 g)	0.7
Tocopherol (mg/100 g)	0.7
Others	
Lipids (%)	5.9
Lycopene (mg/100 g)	58.1
Saturated Fatty Acids (%)	37
Total Soluble Solids (°Brix)	10.4
Unsaturated Fatty Acids (%)	57

Health Benefits: According to Ayurvedic and ethnobotanical studies, *T. cordifolia* has several pharmacological uses. The pharmaceutical, preclinical, and clinical industries often use *T. cordifolia* extracts such as aqueous, alcohol, methanol, chloroform, ethanol and acetone. Cancer, hypertension, cardiovascular disease, and other illnesses are all well treated using *T. cordifolia* stem. This wonder plant has healing benefits like as cancer prevention, liver protection, heart health, pain relief, and more **Table 3** [23].

TABLE 3: HEALTH BENEFITS OF *T. CORDIFOLIA*

Health benefits	Plant part / extract	Key findings
Analgesic	Whole plant / Ethanol extract	Analgesic action is caused by the presence of phytochemical elements such as alkaloids, glycosides, flavonoid, steroids, and terpenoids in the aqueous extract of the aerial section. *T. cordifolia* is a healthier alternative to NSAIDs, which cause gastrointestinal discomfort, while guduchi has gastroprotective properties
Anti-allergic	Aqueous	Sneezing, nasal discharge, nasal blockage, and nasal pruritus were all significantly relieved by *T. cordifolia*
Anti- bacterial	Stem / Aqueous and Ethanolic	Guduchi leaf ethanolic extract has the best antibacterial efficacy against Klebsiella pneumoniae and Pseudomonas aeruginosa. Methanolic extract of *T. cordifolia* has been shown to be antimicrobial. *T. cordifolia* extract also inhibited bacterial growth and increased neutrophil phagocytic and intracellular bacterial capabilities in mice
Antihyperglycemic	Stem / Aqueous	The stem of this plant has been reported to work as an anti-diabetic medication through inducing oxidative stress, boosting insulin production by reducing gluconeogenesis and glycogenolysis. The presence of Alkaloids (Magnoflorine, Palmetime, Jatrorrhizine), tannins, cardiac glycosides, flavonoids, saponins, and steroids is thought to be responsible for anti-diabetic benefits
Antiinflammatory	Stem / Aqueous	Carrageenan and histamine- induced rat edoema can be treated with an aqueous extract of guduchi stem. The presence of alkaloids and flavonoids in *T. cordifolia* methanolic extract inhibited COX and LOX enzymes, resulting in anti-inflammatory action
Antioxidant	Whole plant / ethanol	The presence of phytochemicals such as polyphenols and tannins contribute to this property. *T. cordifolia* aqueous extract possesses radioprotective properties, allowing mice to survive a sub- lethal dosage of gamma radiation. Leaf and stem extract also offer considerable protection against plasmid DNA

		damage and protein oxidation caused by free radicals
Cardioprotective	Whole plant / Alcohol	To induce arrhythmia in rats, calcium chloride was infused intravenously. *T. cordifolia* contains an alkaloid (berberine) that has cardiovascular protective properties. Berberine improves health by lowering endothelium infection.
Chemoprotective	Stem / Aqueous alcohol	*T. cordifolia* ethanolic extract can reduce the number of drug- resistant cancer cells. Epoxy clerodane diterpene is a component of *T. cordifolia* that protects against chemically induced human breast cancer and hepatocellular carcinoma. The phenolic concentration of ethanolic bark extracts is higher, resulting in the highest amount of free radical scavenging (71.49%). *T. cordifolia* could be considered as a potential therapeutic vector for degenerative disorders induced by free radicals, according to the findings
Hepatoprotective	Whole plant / Aqueous	A decrease in eosinophil count, stimulation of B lymphocytes, macrophages, and polymorphonuclear leukocytes, and a decrease in hemoglobin percentage indicate that it plays a role in illness control
Immune booster	Whole plant / Aqueous	11-hydroxymuskatone, N- methyl-2-pyrrolidone, N-formylannonain, cordifolioside A, magnoflorine, tinocordioside, and syrigin are some of the chemicals that have immunomodulatory and cytotoxic properties. These natural substances have been shown to improve macrophage phagocytic function. *T. cordifolia* and its component α-D-glucan induce the synthesis of many immune-stimulatory cytokines by stimulating NK cells, B cells, and T cells

Traditional Uses: People and tribes all over the world have relied on the medicinal properties of *T. cordifolia* for centuries as a treatment for a wide range of illnesses, and its usage predates the development of Ayurvedic medicine. It has various therapeutic advantages in Ayurveda, including energizing, immune-boosting, antirheumatic and cleaning actions. The healing properties of *T. cordifolia* have been put to use in modern medicine for a wide variety of conditions, including but not limited to: the common cold, skin issues, liver disorders, immunological support, gout, arthritis, and most recently, the mitigation of chemotherapy's negative effects. *T. cordifolia* is utilized for a wide variety of medical conditions, including but not limited to: chronic fever, jaundice, dysentery, cough, asthma, leucorrhea, skin illnesses, fractures, eye issues, deadly bug bites, and venomous snake bites. Jaundice, intestinal worms, and vermifuge are only some of the conditions that may be helped by taking an extract from the stems of the plant *T. cordifolia*. When combined with ghee or honey, dried fruit is a powerful remedy for rheumatism and jaundice. The National Ayurveda Dietetics Research Institute (Bangalore), which conducts local health traditional survey excursions in several parts of Karnataka, India, compiled a number of Guduchi's many applications. Guduchi decoction, according to the Davanagere district of Karnataka folk healers, may be used orally to treat hyperacidity, indigestion, and leucorrhoea **Table 4** [24].

TABLE 4: TRADITIONAL USES OF *T. CORDIFOLIA*

Plant part	Traditional Uses
Bark	The bark acted as an antiallergic, antispasmodic and antileprotic
Fruit	Fruits were helpful in treating jaundice and rheumatism; it was also used as a tonic
Leaf	Leaves were used to treat ear pain and burning sensations; they were also effective in the treatment of gout and ulcer
Root	Roots were helpful in treating leprosy, fevers, and dysentery
Stem	Stems were effective in treating skin diseases, jaundice, chronic diarrhea, chronic dysentery, intestinal problems, low fevers; stems were useful to treat diabetes; acted as diuretic and enriches blood; stems are also helpful with vaginal and urethral discharges; they were also believed to stimulate bile secretion
Stem + Root	The combination of stem and root with other drugs worked as an antidote to snake bite and scorpion sting; it was also helpful in treating cancer when taken along with milk

Uses in Folk and Tribal Medicine:

1. Guduchi (*T. cordifolia*) stem paste and Bhatkatiaya root paste are used by the Baiga people of Naugarh and Chakia Block in the Varanasi district of Uttar Pradesh (*Solanum surattense*). For three days, the tablets are used to bring down a temperature.

2. *T. cordifolia* is used as a medicine for the treatment of fever, jaundice, chronic diarrhoea, and dysentery by the indigenous people of Mumbai and the surrounding regions, as well as by fisherman living along the shore.

3. The Khedbrahma people of Northern Gujarat's Khedbrahma area often consume or medicate themselves with the herb. Powdered *T. cordifolia* root and stem bark mixed with milk is used to treat cancer; a decoction of the root is recommended for the treatment of dysentery and diarrhoea; and decoction of old stems is used to treat periodic fever.

4. The inhabitants of Jammu (J & K) and Bigwada (Rajasthan) traditionally treated fever by drinking a decoction made from the stem.

5. Locals in Bhuvneshwar, Orissa take a warm drink made from the root of *T. cordifolia* to bring down a high temperature.

6. The locals of Patiyala have a tradition of treating fever using a mixture of honey and leaf juice or decoction (Punjab).

7. Muslim Rajouri, Jammu (Tawi) tribals, including the Gujjar and Backwals, traditionally utilized the herb to treat bone fractures.

8. The Agaris, Bhils, Dhodias, Dublas, Khakaris, Rimoshis, Thakurs, Vardaris, Vagharis and Varlis of Maharashtra's Dahanu forest division drink a decoction made from the plant's stem mixed with either cold or hot water (roughly 3-4 gm) on an empty stomach first thing in the morning to combat general weakness.

9. Balashosha (childhood malnutrition) in Banka is signified by the practice of dying children's shirts with Guduchi juice (Bihar).

10. Local application of Amrita (*T. cordifolia*) leaf paste or juice and Sarsapa beeja churna (*Brassica campestris* seed powder) is used to treat Daha (Burning sensation).

11. For the treatment of Kasa, you may take a mixture of *Terminalia chebula* (Haritaki), *T. cordifolia* (Amrita) and *Trachyspermum ammi* (Ajwain) powder mixed with a pinch of salt once day in the morning (cough). The inhabitants of Dhurala may also cure Kasa (cough) with a decoction made from these substances, administered orally at a quantity of 50 ml (Haryana).

12. The locals of Patiyala use two drops of the leaf juice of a related species of Guduchi to cure Karna Shula (ear discomfort) (Punjab).

13. Treatment for rakta pradar (leucorrhea) among the ladies of Arjunpura consists of taking a mixture of Guduchi (*T. cordifolia*) paste and five seeds of Krishna marich (Piper nigrum) once daily in the morning (Rajasthan).

14. Locals in Badala, Uttar Pradesh, cure swasa (a kind of asthma) by ingesting stem juice mixed with honey, while locals in Dehrabara Kolaras, Sivpuri District, Madhya Pradesh, treat twak-roga (skin illness) by ingesting a decoction of stems [25].

Market Products Based on *T. cordifolia*: There are a number of *T. cordifolia*-based products on the market, each of which plays an important part in promoting wellness and preventing illness. You may get Giloy in many various forms, including syrup, powder, pills, juice, and many more.

The immune system is strengthened and many disorders are treated with these products. Products containing giloy are sold by well-known companies like Dabur and Patanjali, and they are often used to alleviate symptoms of diarrhea, asthma, bronchitis, eczema, viral fever, and the common cold **Table 5** [26].

TABLE 5: MARKET PRODUCTS OF *T. CORDIFOLIA*

Product names	Brands	Roles
Brave heart capsule	Brave Heart	Regulates heart function, strengthens heart, lowers blood pressure, lipid levels especially cholesterol and LDL cholesterol
Cirrholiv-ds syrup	Paul Medicos	Used as a hepatoprotector and immunomodulator Treats liver related diseases
Giloy capsules	Zandu	Helps in maintaining healthy liver, balances blood sugar level, strengthens digestive system

Giloy ghanvati	Dabur	Helps in building immunity and protects against various infections, improves digestion
Giloy ghan vati	Patanjali	Helps in gastroenteritis, Provides immunity against infectious diseases, chronic fever, cough and cold
Guduchi churna	Baidyanath	Contains antioxidants that fight free radicals, treats dengue, swine flu, malaria, acts as a hypoglycemic agent and helps in treating diabetes, has anti- ageing properties that helps in improving skin health
Guduchi ghrita	Guduchi	Treats gout and skin disorders
Guduchi sattva	DAV Pharmacy	Soothes burning sensation, Effective in liver diseases, Fever, cough, diabetes
Giloy juice	Kapiva	Effective in fever, gout, jaundice, anemia, Works as good detoxifier by flushing out toxins, Improves skin health and controls respiratory problems as well
Immuniveda Chyawanprash	Saffola	Acts as a bioavailability enhancer, improves respiratory health and immunity, provides strength, energy and stamina
Madhumehari	Baidyanath	Reduces blood and urine sugar levels, helps in beating fatigue
Panchanimbadi churna	Prakruti Remedies	Leukoderma, eczema, dermatitis, skin disorders, diabetes, poison, ascites, arthritis

Pharmacognostic Description: *T. cordifolia* is a climbing shrub that has numerous coiled branches and spreads rapidly. The plant has a fleshy, filiform, rising stem with somewhat gray bark. The powdered stem, which is brown or dark brown in color, has a bitter taste and a strong, disagreeable odor. Long and heart-shaped, with rounded, somewhat twisted leaf stalks. The lamina has a deep membranous ovaloid form. Flowers are sterile, and the leaflets are split or branching and a yellowish green. Only one seed develops within each fruit, and the seeds normally mature in the winter, when the temperature is cold and dry, while the flowers bloom in the hot, muggy summer. The bent, slender seeds of this plant are indicative of its high, threadlike base [27].

Chemical Constituents: Phosphorus, calcium, and protein are especially concentrated in *T. cordifolia* leaves, and the plant also contains polysaccharides, steroids, phenolics, aliphatic compounds, alkaloids, and steroids. Numbered spectroscopic examination provides light on the chemical structure. Alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, aliphatic chemicals, and polysaccharides are only some of the constituents identified from *T. cordifolia*. In addition to tinosporone and tinosporic acid, cordifolisides A through E, syringen, berberine, giloin, gilenin, crude giloininand, arabinogalactan polysaccharide, picrotene, bergenin, gilosterol, tinosporidine, sitosterol, cordifol, heptacosano Flavonoids, glycosides, saponins and even phytosterols may be found in this. It is possible that the observed antioxidant activity is due, in whole or in part, to the presence of these active ingredients. Both alkaloids and terpenes may be found in abundance in this family. Protein content in the leaves of this plant is high (11.2%), and they also contain respectable amounts of calcium and phosphorus [28].

Pharmacological Activities:

Antioxidant: In order to understand why individuals with different ailments have used different sections of this remarkable plant since ancient times, Mehra and his research group investigated the antioxidant activity in several parts of the *T. cordifolia* [29].

Antimicrobial: It has been claimed that *T. cordifolia* has antibacterial capabilities in a variety of solvents, and *in-vitro* tests have shown that it is effective against both gram-positive and gram-negative bacteria. *Salmonella paratyphi, Proteus vulgarisus, Salmonella typhi, Klebsiella pneumoniae, Shigella flexneri, Staphylococcus aureus* and *Serratia marcescens* were only some of the harmful bacteria that the plants showed efficacy against. The *T. cordifolia* extracts in acetone, ethyl alcohol, and water were able to stop the growth of several harmful microorganisms in human urine. Additionally, it has been found that silver nanoparticles have antibacterial action against a variety of bacterial species. *Aspergillus fumigatus, Aspergillus flavus,* and *Aspergillus niger* were only few of the fungus that showed significant resistance to the treatment. Positive and negative controls, 0.2% chlorhexidine and dimethylformamide, were employed in conjunction with the ethanolic extract prepared by exposing plates to different doses for 48 hours, and the zone of inhibition was determined.

The results of the analytical testing showed that the highest antibacterial activity could be achieved with a 2% concentration of *T. cordifolia*. Against many types of *Aspergillus*, TCAE (*T. cordifolia* aqueous extract) was studied in vitro for its anti-fungal effectiveness at three distinct dosages (10, 25, and 50 mg/kg). Mice were also used to test the drug's efficacy in the wild [30].

Antidiabetic: Several components, including alkaloids, tannins, flavonoids, and saponins, may contribute to the antidiabetic effect of the *T. cordifolia* stems. Research on the enzyme's inhibitory effects on hypoglycemic and normal mice included testing crude extract of the stem in dichloromethane, ethyl acetate, chloroform, and hexane. *T. cordifolia* aqueous extract increased glucose by 21.3%, insulin by 51.5%, triglycerides by 54.12%, and glucose-insulin index by 59.8% in rats. In-vivo tests of several extracts have shown a link with diabetes patients. *T. cordifolia* leaf ethanolic plant extracts were made in two concentrations (200 mg/kg and 400 mg/kg b.w.). Albino rats induced to develop diabetes by streptozotocin were given the quantities mentioned above orally for ten and thirty days, respectively. Anti-diabetic action of *T. cordifolia* was shown in animal tests, with results similar to those seen with insulin (50-70 percent).

The alkaloids isolated from *T. cordifolia* acted in ways regulated by insulin, suggesting the hormone plays a role in their pharmacological effects. Including *T. cordifolia* in the diets of pregnant rats with diabetes (streptozocin-induced diabetes) showed a protective effect by reducing the oxidative load and so avoiding the occurrence of illness. Brain interstitial cholesterol and blood glucose were reduced in a diabetic rat model, suggesting that *T. cordifolia* may have lipid-lowering and antidiabetic effects. Antihyperglycemic effects of Guduchi root extract were seen in an alloxan-induced diabetes model, as measured by a decrease in the animal's excessive glucose excretion in its urine. The antidiabetic action of *T. cordifolia* was seen in diabetic mouse models whereby a number of natural medicines, including Guduchi, were administered. In addition to reducing the severity of hyperglycemia, extract enhanced the effectiveness of insulin by increasing the hormone's blood concentration.

Despite sustaining oxidative load by reducing reactive species, hyponidd was shown to reduce glucose-mediated hemoglobin count. An evaluation of "Dihar" over the course of 1.5 months in a streptozotocin-induced animal model found that it decreased urea and systemic creatinine levels while increasing enzyme activity [31].

Anti-Anxiety: When compared to the conventional dose of diazepam (2.5 mg/kg), the anti-anxiety effects of a 100 mg/kg ethanolic extract of *T. cordifolia* were shown to be much greater. Clinical research has shown that patients' IQs have increased. Traditionally, *T. cordifolia* has been used as a brain tonic in Ayurvedic medicine, with the expectation that it may enhance cognitive functions like memory and recall [32].

Antihyperlipidemic: Study examined the hypolipidemic effect of an aqueous extract of the root on rats weighing 2.5 and 5.0 g/kg body weight on the sixth week; this resulted in decreased tissue cholesterol, decreased serum, phospholipids, and frees fatty acid. The greatest hypolipidemic effect was seen when the root extract was given at a dosage of 5.0 g/kg of body weight. The ability of *T. cordifolia* root extract to reduce blood or tissue lipid level in diabetic rats has never been studied before [33].

Hepatic Disorder: The effects of *T. cordifolia* water extract (TCE) on hepatic and gastrointestinal toxicity were studied, who discovered elevated levels of gamma-glutamyl transferase, aspartate transaminase, alanine transaminase, triglyceride, cholesterol, HDL and LDL in alcohol samples, though these markers were reduced following TCE mediation [34].

Anti-Proliferative: In order to determine whether or not *T. cordifolia* extract is effective against cancer, scientists employed a response surface methodology. The extract inhibited tumor growth in a DMBA-induced animal model of skin cancer. C57 BI mice were administered a 50% methanolic extract of *T. cordifolia* for 30 days at a concentration of 750 mg/kg body weight, and the results were similar to those shown when the extract was made at 200, 400, and 600 mg/kg dry weight. As the size of the tumor increased, so did the likelihood of dying [35].

Anti-HIV: An extract from *T. cordifolia*'s roots may help HIV-positive individuals feel more at ease in their living situations. *T. cordifolia* stem concentrate may have strong anti-HIV potential due to its ability to reduce eosinophil count, B lymphocyte incitement, macrophage incitement, hemoglobin level, and polymorphonuclear leucocytes [36].

Wound Healing: Based on their analysis, studies concluded that dexamethasone inhibited the wound healing profile of alcoholic extract of *T. cordifolia* and its effect on wound healing. Increased flexibility in the *T. cordifolia* extract, which may be attributable to the maturation of collagen combination, contributed to the plant's wound-healing efficacy. *T. cordifolia* extract did not counteract the negative effects of dexamethasone on wound healing [37].

Immunomodulation: Syringin and cordiol, two isolated chemicals from *T. cordifolia*, were shown to inhibit the in-vitro resistant hemolysis of sheep erythrocytes by guinea pig serum in a research done. Reduced immune system hemolysis may be attributed to the interference of the C3-convertase in the classical complement pathway. *T. cordifolia* combinations are associated with substantial increases in guinea pig serum IgG antibodies. Cordiol, cordioside, and cordiofolioside-A all lengthened the incubation period and triggered macrophase. Different types of dynamic mixtures and their immunomodulatory behavior were reported [38].

Parkinson's Disease: *T. cordifolia* concentrate is quite appealing in the treatment of parkinosis. In a parkinsonian mouse model where 1-methyl-4-phenyl-1, 2, 3, 6-tetra hydropyridine (MPTP) was injected, they observed that watery concentrate had an anti-inflammatory effect. The results suggested that *T. cordifolia* protected dopaminergic neurons by reversing neuroinflammation in MPTP-induced parkinsonism, and the concentrate reversed the behavioral abnormalities seen in objective MPTP-inebriated rats. The plant's varied bioactivities may be attributed to the wide range of compounds it contains. Parts of the *T. cordifolia* plant containing diverse organically dynamic substances were used historically by persons suffering from a wide range of ailments [39].

Anti-Osteoporotic: *T. cordifolia* influences differentiation in proliferation, mineralization of bone-like matrix on osteoblast model frameworks in-vitro, and therefore finds an intended use to treat osteoporosis. *T. cordifolia* ethanol extract stimulates osteoblast formation by increasing cell division and differentiation into osteoblastic ancestry, as well as mineralization of bone-like trabecular matrix.

Protein anabolic and anti-osteoporotic effects in vertebrates have been attributed to plant-isolated ecdysteroids. Animal studies have shown that the beta-ecdysone (Ecd) extracted from *T. cordifolia* may eliminate osteoporosis and lead to a significant increase in joint ligament thickness. Isolated 20-OH—Ecd from *T. cordifolia* has been credited with an anti-osteoporotic effect, suggesting the plant may be useful in the treatment of osteoarthritis and osteoporosis [40].

Anti-Cancer: Animal studies have demonstrated that the plant *T. cordifolia* has anti-cancer effects. In a mouse model of skin cancer generated by 7,12-dimethylbenz(a)anthracene (DMBA), the anticancer potential of the alkaloid palmatine extracted from *T. cordifolia* utilizing response surface methodology (RSM) is very obvious. Mice that had been given cyclophosphamide (50 mg/kg) intraperitoneally had micronuclei in their bone marrow considerably reduced in number after receiving a single application of *T. cordifolia* extract at 200, 400, or 600 mg/kg dry weight 24 hours beforehand.

T. cordifolia (50%) methanolic extract was given to C57 Bl mice at a dosage of 750 mg/kg body weight for 30 days, and the mice lived longer and had less tumors than the controls. Using C6 glioma cells, researchers looked into whether or not a 50% ethanolic extract of *T. cordifolia* (TCE) has anti-brain cancer properties. Dose-dependently, TCE inhibited cell proliferation and promoted differentiation in C6 glioma cells. Using KB (human oral squamous carcinoma), CHOK-1 (hamster ovary), HT-29 (human colon cancer), and SiHa (human cervical cancer) human cancer cell lines and murine primary cells, scientists assessed the efficacy of eight secondary metabolites from *T. cordifolia*. All of the extracts and fractions showed activity against KB and CHOK-1 cells, whereas

palmatine and HT-29 showed activity among the pure molecules, and tinocordiside and yangambin showed activity against KB and CHOK-1 cells, respectively. The plant *T. cordifolia* contains two compounds, T1 and T2, which are extracted in hexane and methanol, respectively. In MCF-7 cells, T1 treatment dramatically reduced proliferation, migration, and invasion compared to T2. E-cadherin transcription was upregulated whereas Twist and Snail, genes involved in the epithelial-mesenchymal transition, were downregulated by T1 [41].

Anti-Toxic: L-DOPA is now the medicine of choice for the treatment of Parkinson's disease, however several studies have shown that it actually causes the death of any remaining dopaminergic neurons in the central nervous system. When compared to a Sham-operated control group, dopaminergic neurons were better preserved after being co-administrated with *T. cordifolia* crude powder. As an alternative treatment for Parkinson's disease, *T. cordifolia* crude powder may mitigate some of the side effects of L-DOPA.

Choline, tinosporine, isocolumbin, palmetine, tetrahydropalmatine and magnoflorine are only few of the alkaloids found in *T. cordifolia* that have been shown to reduce the nephrotoxicity caused by aflatoxin. The free radicals produced by aflatoxicosis may be neutralized by using extracts from the plant *T. cordifolia*. The levels of thiobarbituric acid reactive substances (TBARS) were reduced, and GSH, ascorbic acid, protein and the activities of anti-oxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), and glutathione reductase (GR) were increased in the kidney, demonstrating protective effects.

In addition to lowering glutathione levels in the bladder and the liver, cyclophosphamide, an anti-cancer medication, has been shown to raise pro-inflammatory cytokine TNF- levels. When treated with *T. cordifolia*, this effect disappeared, demonstrating the effectiveness of this herb in mitigating the side effects of cyclophosphamide for cancer patients. The hepatoprotective activity of *T. cordifolia* leaf and stem extract against lead nitrate induced toxicity in male albino mice has been found. Similarly, a plant extract taken orally prevented the liver damage caused by lead nitrate [42].

CONCLUSION: *T. cordifolia*'s chemical diversity has been reviewed here. Antioxidant, antibacterial, anti-HIV, analgesic, anti-fungal, antiproliferative, and anti-epileptic are a few of the many possible effects. Its curative qualities have been well recognized. Potential future treatments for a variety of clinical disorders may include isolating pure lead compounds from the plant portion or from endophytic fungi separated from various areas of the plant. As a result, this evaluation serves both a scientific and clinical function in the quest for new therapeutics.

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