

Tinospora cordifolia: An Optimistic Herb for Comprehensive Gesundheit

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ABSTRACT

The necessity for wellness and good habits that boost resistance to illness has come to light due to worries about possible health concerns. Because they are harmless, biologically active polysaccharides derived from plants are excellent substitutes for treating various illnesses. *Tinospora cordifolia* (Thunb.) Miers, an evergreen perennial climber, is known as "guduchi." This plant, which is dioecious and deciduous, is a member of the Menispermaceae family. In the Indian medical system, a plant named Rasayana is incredibly beneficial. Different extraction and purification techniques have been used to separate and characterise the polysaccharides from *Tinospora cordifolia*. In addition to hot-water extraction, other state-of-the-art techniques are used to extract the polysaccharides from *T. cordifolia*, such as Enzyme-Assisted Extraction (EAE), pulsed electric field, microwave-assisted extraction, ultrasound-assisted extraction, and supercritical fluid extraction. The modern healthcare system has also recognised its efficacy. The stem of the plant may be used medicinally. Because the stems contain more alkaloids than the leaves, the entire plant is utilised medicinally. This plant also offers many other benefits, including immunomodulation, hypoglycemia, antioxidants, anti-hyperglycemia, allergies, inflammation, and diabetic mellitus. Most of the plant's chemical makeup comprises alkaloids, glycosides, steroids, sesquiterpenoids, aliphatic, diterpenoid lactones, and other unidentified evidence. This study highlights the many traditional and ethnobotanical uses of *T. cordifolia* and the countless pharmacological, phytochemical, and clinical literature written about the plant.

Keywords: *Tinospora cordifolia*, Polysaccharides, Guduchi, Ethnobotanical, Phytochemical, Pharmacological.

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INTRODUCTION

The earth's bounty has gifted us with abundant medicinal plants, many lacking well-established uses or possessing unknown medical properties. Human society has employed plants as medical remedies since the dawn of time. Herbal medications are increasingly sought in both developed and developing countries because of their comprehensive biological and therapeutic qualities, more significant safety margins, cheaper cost, and a wide variety of applications in primary healthcare. Humans and the environment collaborate closely to address needs daily.^[1] Among other essentials, plants give humans food, shelter, and medicine. Plants are the best natural source of medications. Traditional medical systems, including Ayurveda, Siddha, Yunani, and Folk, are said to have their roots in medicinal plants. Approximately 3.3 billion of the 7.5 billion people on the earth use herbal products regularly. These medicinal plants serve as crucial markers of the

general health of the ecosystem. Throughout the world, many ethnic groups employ medicinal herbs in various ways to preserve their health.^[2] Guduchi, also known as Amrita, is a herbal cure that may be found in several Ayurvedic medical literature, such as Ashtanga Hridaya, Sushrut, Charak, and Dhanvantri Nighantu. This person has numerous more names: Vatsadani, Amara, Amritvalli, Chinmarshuha, and Chinnodebha.^[3,4]

Tinospora cordifolia is a member of the Ayurvedic plant family Menispermaceae. Succulent and glabrous, it is a climbing shrub native to the tropical Indian subcontinent. A long, meaty, filiform aerial root emerges from the humid, slightly succulent plant's branches. It features tiny blooms, grey-brown or creamy-white bark, and thin, membrane-like leaves. The plant appears yellow or greenish-yellow when it is leafless. In general, male flowers are clustered, and female flowers are solitary (Figures 1 and 2). This plant is widely used as a Rasayana in the Indian System of Medicine (Ayurveda) to treat various ailments, such as diabetes, gout, rheumatoid arthritis, jaundice, general weakness, infections, and skin disorders. It is known to have hepatoprotective, hyperlipidemic, and immunostimulatory properties. When treating arthritis, a decoction made from the leaves is utilized. Fresh leaves crushed in milk are also used as tonics and liniments



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for erysipelas when mixed with honey.^[5,6] *Tinospora cordifolia* stem is a constituent in several Ayurvedic treatments for urinary problems, fever, dyspepsia, and general debility.^[5]

Ayurvedic literature from antiquity, like Sushrut Samhita and Charak Samhita, acknowledge the herb *Tinospora cordifolia*, popularly known as Giloy.^[3,6] According to Ayurveda, *Tinospora cordifolia* has a harsh, bitter taste. Additionally, Giloy has several health benefits and is considered a general tonic due to its beneficial components.^[6,7] Diseases such as Vatrakta (gout), Javara (fever), and Kamala (jaundice) are mentioned in other remedies such as Charak Samhita and Ashtanga Hridaya.^[8-10] *Tinospora cordifolia* is a member of the Menispermaceae family, which has 450 species and roughly 70 genera native to tropical lowlands.^[11-13] They typically climb or twine rather than being shrubs. There are numerous terpenes and alkaloids in this family.^[11,14]

In Madagascar, Asia, Australia, the Pacific Islands, and tropical Africa, there are about 32 genera of *Tinospora* Miers, also referred to as *T. cordifolia*.^[11,15,16] The genus contains four species known to exist in India: *T. crispa* (L.) Hook. f. and Thomson and *T. glabra* (Burm.f.) Merr. are reported to be found in Northeast India and the Andaman Islands, while two species, *Tinospora cordifolia* (Thunb.) Miers and *Tinospora sinensis* (Lour.) Merr., are known to occur in South India.^[11] Concerning the ethnomedicinal, phytochemical, and pharmacological manifestations of *Tinospora cordifolia*, this research aimed to present a comprehensive summary of the most recent scientific findings.

Terrestrial dispensation

The plant grows in the tropical parts of India, from Kumaon to Assam, and then spreads northward through West Bengal, Bihar, Deccan, Kankan, Karnataka, and Kerala. It can be found up to 1,200 m above sea level. North Africa, South Africa, Vietnam, Bangladesh, China, Thailand, Philippines, Indonesia, Malaysia, Borneo, and India are among its native regions.^[10,17,18] It usually grows at heights of up to 1000 feet in dry and deciduous forests. Native to lower-elevation tropical parts of the Indian subcontinent, *T. cordifolia* is a climbing shrub that may climb on various trees.^[11,19] It prefers multiple soil types, from acidic to alkaline, and moderate soil moisture.^[11]

Taxonomical and botanical description

Tinospora cordifolia is a big climber miming a hedge or deciduous plant in its vast spread. They are often called Amrita, Guduchi, Giloy, and *Tinospora cordifolia*. It's meant to produce different flowers for ladies and males.^[11,20] The stem shrinks, and the bark pulls away from the wood as it dries. When the branch is young, its green succulent bark is studded with warty lenticels and covered in a thin coating of brown bark. The taxonomical classification of Giloy is showcased in (Table 1). The components have glabrous, pale, sometimes lustrous, tubercled bark, and their fleshy, pendulous, slender roots are terete and striate.

The heart-shaped or cordate leaves of the plant, are roundish, membranous, 7-9 nerved, and have a 2.5-7.0 cm petiole, giving rise to the name *cordifolia*. Elongating and somewhat loose racemes typically outlast leaves, with flowers blooming in July and measuring 5.0 cm in length. The male flowers are small and have a green or yellow hue. They are nestled in the axils of small subulate bracts. There are six sepals: three larger, membranous, roughly oval, concave, yellow internal sepals, and three outside, ovate-oblong, pointy ones. Each of the six evenly spaced, widely spatulate petals, which loosely enclose a stamen, has cuneate claws that are reflexed to the apex and pistillode. Reflexed borders, small, straight staminodes, and green sepals are characteristics female and male flowers share. They also tend to be alone a lot. Carpels 1-3 on the short, fleshy gynophores are red, widely spread, and dorsally convex. When the berry matures in winter, it takes on the shape and size of a giant pea and turns scarlet and mucilaginous.^[3,11] Synonyms and vernacular names of Giloy are displayed (Tables 2 and 3).

Ethnobotanical thoughts merged with aboriginal healing ideology

The World Health Organization (WHO) estimates that 80% of people worldwide rely on traditional medicine, often the first line of treatment for illnesses in many nations. Conventional medicine studies include ethnomedicine, the field of practice most commonly practiced by members of indigenous communities and rural areas. Various factors, including age, gender, socioeconomic status, migration, access to new herbal products and healthcare systems, and urbanization, influence ethnomedicinal practices. Worldwide, tribal, and rural populations use folk medicines and treatments extensively. These cultures' members know the customary uses of plants because their forefathers have imparted this knowledge to them.^[21]

Giloy is an ayurvedic herb whose ethnobotanical benefits are widely documented. The Ayurvedic properties of Giloy include Rasa, Guna, Veerya, Vipaka, Rogagnata, and Karma.^[22] The stems of the Guduchi (*Tinospora cordifolia*) and Bhatkatiya

Table 1: Taxonomical classification of *Tinospora cordifolia*.

Kingdom	Plantae
Subkingdom	Tracheophyta
Super-division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Polypetalae
Series	Thalamiflorae
Order	Ranales
Family	Menispermaceae
Genus	<i>Tinospora</i>
Species	<i>cordifolia</i>

(*Solanum Suratteuse*) roots are used to make paste by the Baiga tribe of tribal people who live in the interior parts of Naugarh and Chakia Block in the Varanasi district, Uttar Pradesh. They were ready and treated the fever with medication for three days.^[3,23] Tribal communities in Mumbai and its environs, as well as coastal fishermen, utilize *Tinospora cordifolia* as a medicine to cure fever, diarrhea, jaundice, and dysentery.^[24] The native inhabitants of North Gujarat's Khedbrahma region often use the plant for food and medicine. *Tinospora cordifolia* root and stem bark powder combined with milk is a cancer treatment. While old stem decoction is preferred for treating recurrent fever, root decoction is used to cure diarrhea and dysentery.^[3,25] In Bigwada, Rajasthan, Jammu, and Kashmir, people use an oral stem decoction to treat fever.^[3,26] In Rajouri, Jammu (Tawi), the Gujjar and Backwal Muslim tribal people utilized the herb to mend fractures.^[27] In the Dhanu forest region of Maharashtra, the tribal races of Agris, Bhils, Dhodias, Dublas, Khakharis, Rimoshis, Thakurs, Vardaris, Vagharies, and Varlis consume the stem decoction, which weighs around 3-5 grams, first thing in the morning on an empty stomach as a general debility tonic.^[3,8] Children with anorexia, known as balashosha, wear children's shirts colored with Giloy juice by the inhabitants of Banka (Bihar). Local application of Amrita leaf paste or juice and Sarshapa Beeja churna (*Brassica campestris* seed powder) is advised in the case of Daha (burning sensation). Every morning, Kasa (cough) is treated by hand using equal parts of powdered Haritaki (*Terminalia chebula*), Amrita, and Ajwain (*Trachyspermum ammi*). Residents of Dhurala now discover that the decoction relieves Kasa or cough best when taken in a 50 mL dosage (Haryana). Patients with raktapradar (Leucorrhea) are



Figure 1: Leaves of *Tinospora cordifolia*.

Table 2: Synonyms of *Tinospora cordifolia*.

<i>Menispermum crispum</i>	Linnaeus
<i>Tinospora gibbericaulis</i>	Handel-Mazzetti
<i>Tinospora mastersii</i>	Diels
<i>Tinospora rumphii</i>	Boerlage
<i>Tinospora thorelii</i>	Gagnepain.

given five seeds of Krishna Marich (*Piper nigrum*) and a paste of Guduchi orally thrice a day in the morning by the women of Arjunpura, Rajasthan Badala (India).^[6]

In India, there are more than 400 distinct tribal and ethnic groupings. Every tribe has customs, folklore, beliefs, and knowledge on applying natural resources as therapeutics.^[27] Particular attention is given to *T. cordifolia* since it is used in several regions of the nation in traditional or tribal medicine. According to ethnobotanical surveys by ethnobotanists, nearly every portion of the plant is helpful.^[6] *Tinospora cordifolia* is used in traditional and indigenous medicine to cure a variety of ailments, including fever, jaundice, diarrhoea, dysentery, general debility, cough, asthma, leucorrhoea, skin illnesses, fractures, eye abnormalities, and venomous snake bites. Table 4 highlights the different uses of the plant's stem bark, which is also powdered and valuable for ethnobotany.^[15,25,28-33]



Figure 2: Fruit and flower of *Tinospora cordifolia*.

Table 3: Vernacular names of *Tinospora cordifolia*.

Arabic	Gilo
Assamese	Amarlata
Bengali	Gadancha, Guluncha, Giloe
Chinese	K'uanchuHsing
French	Culantha
English	Tinospora
Gujarati	Gado, Galo, Gulo
Hindi	Giloe, Gulbel, Gurcha
Malayalam	Amrytu, Sittamrytu
Marathi	Ambarvel, Giroli, Gulvel
Nepal	Garjo
Odisha	Gulantha
Persian	Gulbel
Punjabi, Kashmiri	Gilo
Sanskrit	Amrita, Guduchi
Sikkim	Gurjo
Tamil	Amridavalli, Niraidarudian
Telugu	Thippa Theega
Urdu	Guruch

Phytochemical assets laid out

Among the several components isolated from *Tinospora cordifolia* are alkaloids, glycosides, steroids, sesquiterpenoids, phenolics, aliphatic compounds, and polysaccharides.^[34] Tinosporone, diasporic acid, cordifolisides A to E, syringin, berberine, giloin, gilenin, crude giloininand, arabinogalactan polysaccharide, picrotene, bergenin, gilosterol, tinosporol, tinosporidine, sitosterol, cordifol, heptacosanol, octacosanol, tinosporide, columbin, chasmanthin, palmarin, palmatosides C and F, amritosides, cordioside, tinosponone, ecdysterone,

makisterone A, hydroxyecdysone, magnoflorine, tembetarine, syringine, glucan polysaccharide, syringin-aposyl-glycoside, isocolumbin, palmatine, tetrahydropalmatine, jatrorrhizine. The chemical composition of Giloy are shown in Figure 5.^[6,35] It also contains some flavonoids, glycosides, saponins, and phytosterols. Together or alone, these active substances may be responsible for the reported antioxidant activity.^[15] This family has a large number of terpenes and alkaloids. The leaves of this plant have a decent amount of calcium and phosphorus, together with a high protein level of 11.2%.^[36] Terpenoids, polysaccharides, and protoberberine alkaloids are the three main classes of chemicals

Table 4: Indigenous system of remedies with ethnobotanical insights.

Sl. No.	Plant part	Ethnobotanical uses
1	Leaves	Used in the treatment of gout and ulcer.
2	Stem	The stem is diuretic, bitter, and stomachic, increases bile output, improves blood quality, treats jaundice, and helps with skin conditions. Juice from the stem is beneficial for treating diabetes, urethral and vaginal discharges, mild fevers, and enlarged spleen (stem as an infusion). It can also be consumed as a vermifuge, jaundice, and to fight intestinal worms (contained as a decoction). It can also be used as an antipyretic and antimalarial. Stem-derived starch (statue) treats intestinal issues, enhances digestion, and treats persistent diarrhea and certain types of intractable chronic dysentery.
3	Stem and root	Combination with other drugs as an antidote to snake bite and scorpion sting.
4	Fruit	Dried fruit with ghee or honey is used as a tonic and treatment for jaundice and rheumatism.
5	Bark	Anti-allergic, anti-spasmodic, anti-leprotic.

Table 5: Chemical components of *Tinospora cordifolia*.

Part	Chemical type	Active principle
Stem	Alkaloids	Berberine, palmatine D, choline D, Tinosporine, Magnoflorine, Tetrahydropalmatine, Isocolumbin, 18-norclerodane glycoside.
	Glycosides	Furanoid diterpene glycoside, Tinocordioside, Syringin, Syringin-aposylglycoside, Tinocordifolioside, Cordioside, Cordifolioside A, Cordifolioside B, Palmatoside C31, Palmatoside F31, Cordifolioside B2, Cordifolioside D2, cordifolioside.
	Sesquiterpenoid	Tinocordifolin.
Root	Alkaloid	Palmatine.
Aerial parts	Steroids	β -sitosterol, δ -sitosterol, γ -sitosterol β -hydroxyecdysone, ecdysterone, Makisterone, giloinsteroljateorine, Columbin.
Whole plants	Diterpenoid lactones	Furanolactone, Tinospora, Columbin.
	Aliphatic compound	Octacosanol, Heptacosanol.
	Miscellaneous compound	Nonacosan-15-one 3, (a,4-dihydroxy-3-methoxy-benzyl)-4-(4-hydroxy-3-methoxybenzyl)-tetrahydrofuran, Tinosponidine, 6 Cordifol, 6 Cordifelone, 6 Jatrorrhizine.

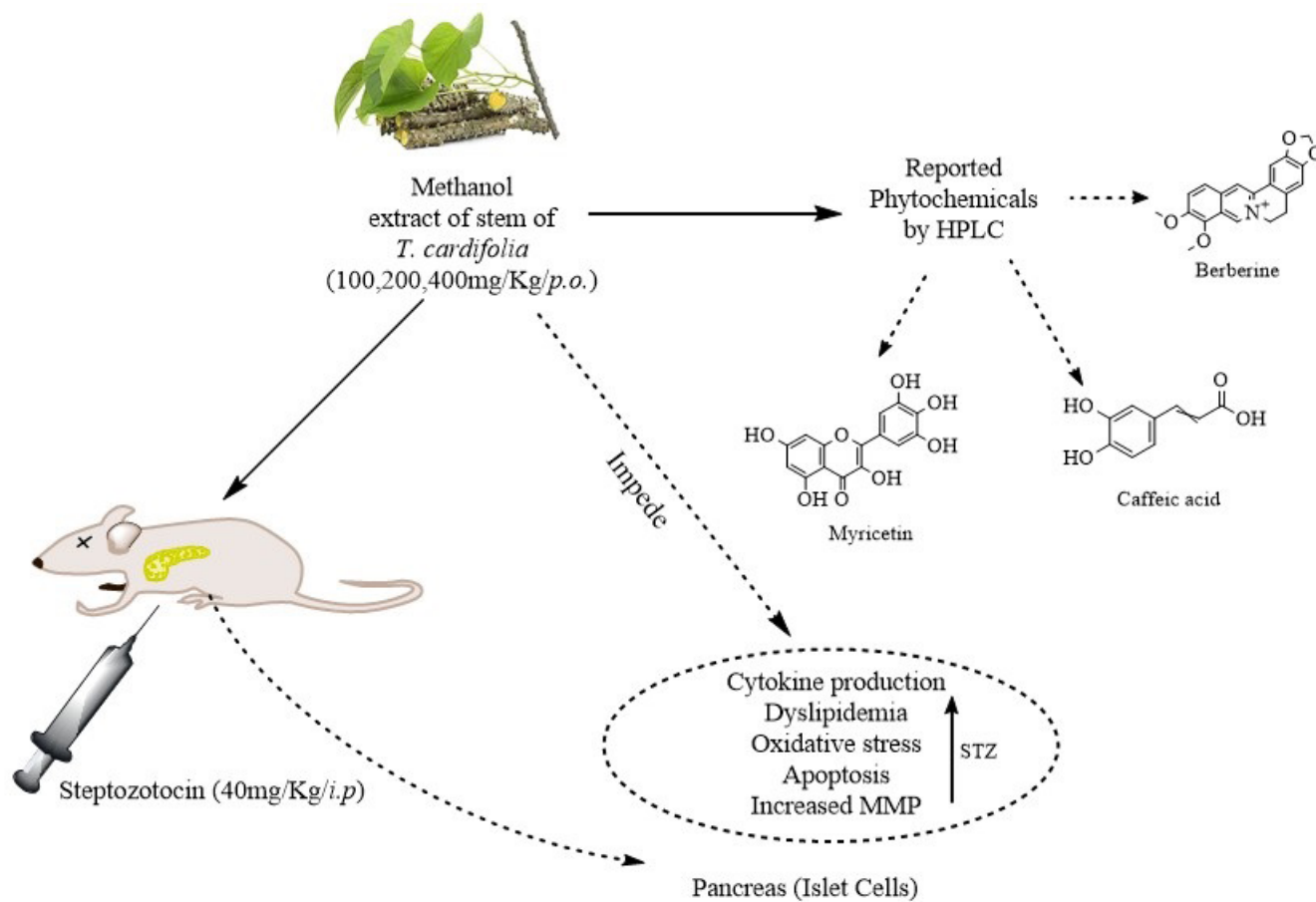


Figure 3: Schematic diagram of Protective efficacy of *Tinospora cordifolia* against streptozotocin induced pancreatic islet cell injuries of diabetic rats.

considered potential active ingredients in *T. cordifolia*. Chemical components of Giloy listed in Table 5.^[37-54]

The pharmacological aspect culminated

Tinospora cordifolia has been the most commonly used herb in traditional medicine for centuries due to its spasmolytic, allergen-free, and anti-diabetic characteristics. The plant significantly strengthens the immune system. This plant has a lot of beneficial qualities. Its stem is utilized as a diuretic and bitter stomachic, while its root is recognized for its antimalarial and stress-relieving qualities. It improves blood quality, increases biliary output, and treats jaundice.^[55] The following are some of *Tinospora cordifolia* principal biological activities:

Anti-cancer/anti-tumor potential

The anti-cancer properties of the herb Guduchi have been demonstrated using a variety of animal experiment types. This plant is an excellent example of radioprotective vegetation since it significantly raises body weight and the weight of different tissues. Furthermore, it protects against sub-lethal range gamma radiation that is emitted from the testes of Swiss Albino mice. When

cultivated HeLa cells were subjected to varying concentrations of *T. cordifolia* dichloromethane extracts, demonstrated a dose-dependent increase in cell death or killing compared to untreated cultured cells (control).^[56] According to a study, the hydroalcoholic extract of *T. cordifolia* aerial roots, when applied at 50 and 100 mg/kg body weight to the liver and extrahepatic organs of Swiss Albino mice, increased the levels of GSH and other metabolizing enzymes. Moreover, a notable drop in MLD synthesis indicates a reduction in the generation of free radicals and an antioxidative state in the cell.^[57] When Guduchi hexane extract is applied to mice with Ehrlich ascites tumors, it inhibits the tumor cells' G1 phase proliferation while also upregulating the expression of the pro-apoptotic "Bax" gene, which primarily causes caspases to trigger apoptosis.^[58] It reduces papillary tumors' weight, frequency, and size while concurrently raising phase-II enzyme levels in the therapy group.^[59] When mice were given cultured Ehrlich cells, *Tinospora cordifolia* showed an additive effect via lowering GSH levels, which led to oxidative damage to the malignant cells.^[60] In a skin cancer model used by the researchers, Guduchi extract has been demonstrated to delay micronuclei formation in bone marrow cells and lengthen mice's survival times.

Nevertheless, *T. cordifolia* and cyclophosphamide medication show a cumulative effect on the percentage of survivors and the tumor inhibitory rate, respectively.^[61] A research investigation on Swiss Albino mice using a Dimethylbenzanthracene-induced skin cancer model has demonstrated the anti-cancer efficacy of an extract of the identified active ingredient palmatine of *T. cordifolia*.^[62] Guduchi exhibits a protective impact by modifying various hormone and mineral levels and may be able to scavenge free radicals. According to reports, *T. cordifolia* can restore the toxicity that aflatoxin causes in the kidneys of Swiss albino mice. It does this by significantly raising hormone levels (like glutathione) and enzyme activity (like catalase and glutathione reductase); it also lowers Reactive Oxygen Species (ROS). And this plant's alkaloids are principally responsible for this anti-toxin action.^[63] Lead nitrate toxicity in Swiss albino mice is manifested by a reduction in the blood serum's erythrocyte and leucocyte counts. However, Guduchi leaf and stem extract counteract these alterations by surpassing the hematological value of lead-induced poisoning.^[64] Oral administration of this herbal plant extract has also been shown to mitigate the harmful effects of lead nitrate on the livers of Swiss albino mice. According to the study, there is an increase in the enzyme catalase, which scavenges free radicals, and a drop in the levels of enzymes such as GPT, ALT, and AST.^[65] Guduchi identified compounds with anti-diabetic properties, including alkaloids, cardiac glycosides, saponins, flavonoids, tannins, and steroids. Thus, it enables a broad range of experimental and clinical research applications. Alkaloids from Guduchi are said to have effects mediated by insulin and to have an impact similar to that of insulin hormone.^[66] Increases in GSH and other reactive species can pose a risk to both the mother and the fetus in cases of gestational diabetes. However, according to a study, *T. cordifolia* has a protective effect by lowering the oxidative load and preventing the relative occurrence of illnesses and congenital disabilities when fed to a diabetic-pregnant rat (streptozocin-induced diabetes).^[67]

Cytotoxic pursuit

Guduchi exhibits a protective impact by modifying various hormone and mineral levels and may be able to scavenge free radicals. Following reports, *T. cordifolia* can restore the toxicity that aflatoxin causes in the kidneys of Swiss albino mice. Subsequently, it does this by significantly raising hormone levels (like glutathione) and enzyme activity (like catalase and glutathione reductase); it also lowers ROS and this plant's alkaloids are principally responsible for this anti-toxin action.^[63] Lead nitrate toxicity in Swiss albino mice is manifested by a reduction in the blood serum's erythrocyte and leucocyte counts. However, Guduchi leaf and stem extract counteract these alterations by surpassing the hematological value of lead-induced poisoning.^[64] Oral administration of this herbal plant extract has also been shown to mitigate the harmful effects of lead nitrate on the livers of Swiss albino mice. According to the study, there is an

increase in the enzyme catalase, which scavenges free radicals, and a drop in the levels of enzymes such as GPT, ALT, and AST.^[68]

Anti-diabetic recreation

Alkaloids, cardiac glycosides, saponins, flavonoids, tannins, and steroids are among the chemicals identified from Guduchi with anti-diabetic properties. Thus, it enables a broad range of experimental and clinical research applications. Alkaloids from Guduchi are said to have effects mediated by insulin and to have an impact similar to that of insulin hormone.^[66] Increases in GSH and other reactive species can pose a risk to both the mother and the fetus in cases of gestational diabetes. However, according to a study, *T. cordifolia* has a protective effect by lowering the oxidative load and preventing the relative occurrence of illnesses and congenital disabilities when fed to a diabetic-pregnant rat (streptozocin-induced diabetes).^[69] Guduchi root extracts demonstrate their anti-diabetic and cholesterol-lowering properties by attenuating the brain-mediated lipid level and downregulating blood and urine glucose levels in a diabetic rat model.^[70] In an alloxan-induced diabetes model, the Guduchi root extract exhibits antihyperglycemic action by bringing the excess glucose level in the blood and urine down to a typical range.^[71] Ilogen Excel's effects have been shown to lower blood glucose levels and improve insulin utilization by raising the amount of the hormone in the systemic circulation. The antidiabetic mechanism of Guduchi is shown in (Figure 3). Hyponidid is said to sustain the oxidative load by lowering the hemoglobin count mediated by glucose and reactive species. In a streptozotocin-induced diabetes model, "Dihar" reduced blood levels of urea and creatinine during a 1.5-month test, followed by an increase in enzyme activity.^[72-74]

Immunomodulatory diversion

According to a clinical investigation, isolated chemical components, including cordifolioside A and Guduchi syringin, are immunomodulating agents.^[75] The stem of *T. cordifolia* changes the concentration of enzymes like catalase and activates lymphocyte cells to sustain immunological vigor, underscoring the shrub's immuno-protective function.^[76] When macrophage cells are exposed to *T. cordifolia* extract, they produce more of several enzymes, such as "myeloperoxidase," which strengthens their antimicrobial activity and boosts immunity.^[77] Conversely, it also makes macrophages more active during phagocytic processes. It also activates macrophages and splenocytes. Due to increased nitric oxide synthesis, which has immuno protection and anti-tumor properties.^[78] According to a clinical investigation, *T. cordifolia* lotion lowers interleukin levels, such as IL-1 and IL-6, in an animal model of scabies. Its anti-scabies action inhibits hyperkeratosis and inflammatory cell infiltration into scabietic ash.^[79] Furthermore, the published research showed that giving alcoholic extracts of *Tinospora cordifolia* to groups of rats increased the cellularity and α -esterase activity of

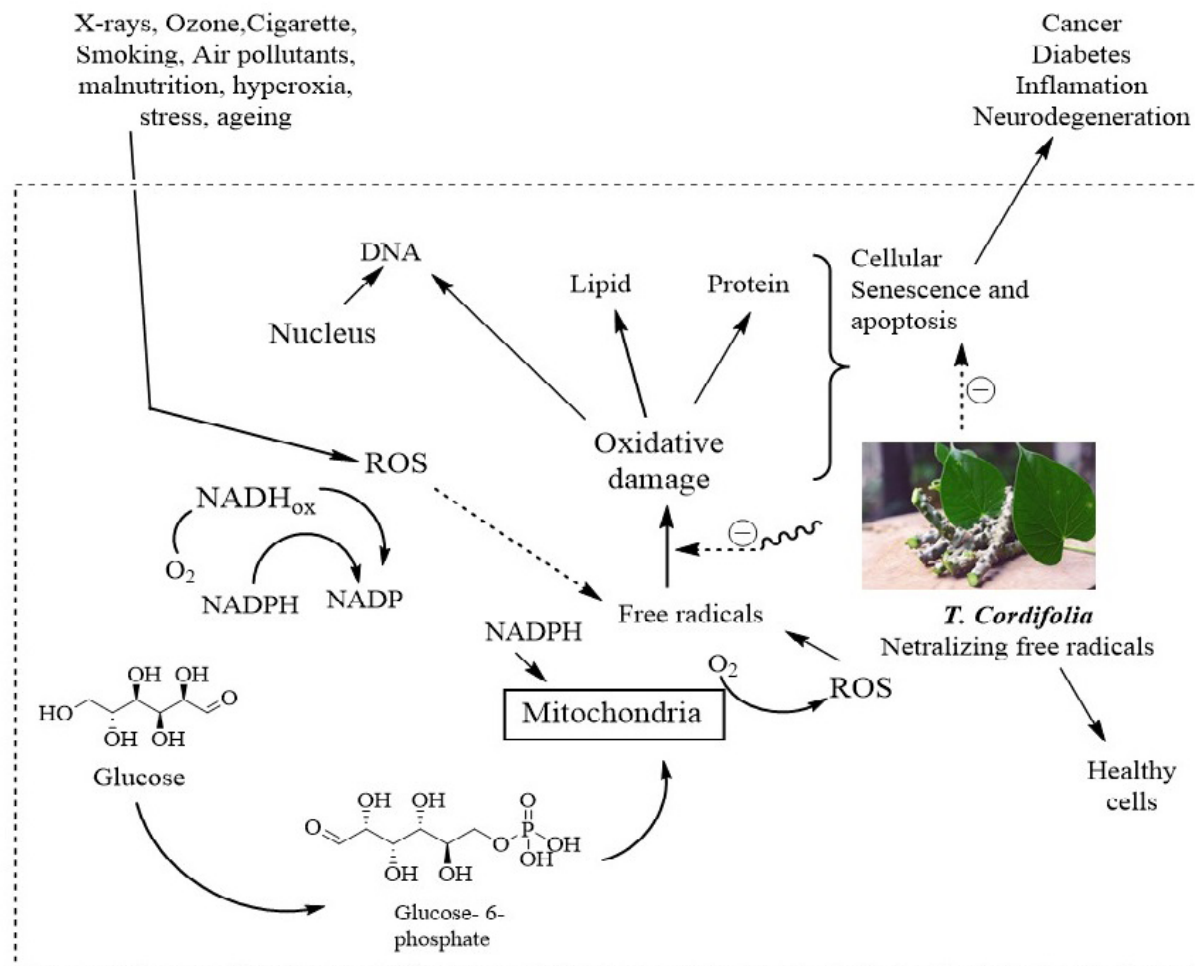


Figure 4: Schematic mechanism of *Tinospora cordifolia* against oxidative stress-related diseases.

their bone marrow. As a result, the items mentioned above are immunomodulatory.^[80]

Anti-microbial endeavor

According to a study, silver nanoparticles from *T. cordifolia* stems had good anti-bacterial action against *Pseudomonas aeruginosa*, identified in burn damage patients.^[81] When tested against *T. cordifolia* extracts, several bacterial strains, including *S. typhi*, *K. pneumoniae*, *E. coli*, *Aeruginosa*, and others, demonstrated possible anti-bacterial activity by either preventing their growth or lessening their very existence.^[82-84] According to reports, an active chemical compound from *T. cordifolia* stems was recently discovered to be efficient against fungi like *T. Simii* and *T. rubrum* and bacteria like *E. faecalis* and *B. subtilis*. In,^[85] Granulocyte activity was increased by a hydroalcoholic extract of *T. cordifolia*, which effectively reduced breast inflammation in a bovine model. An *S. aureus* infection causes mastitis; hence, the plant's ability to prevent inflammation indicates its antimicrobial activity.^[85,86]

Antispasmodic and Antipyretic exploit

Tinospora cordifolia dried bark has antispasmodic qualities.^[87] Investigation on the soluble fractions of *Tinospora cordifolia* stem in hexane and chloroform has not yielded any antipyretic qualities.^[88]

Anti-inflammatory potential

In albino rats, the anti-inflammatory effects of a stem water extract from *Tinospora cordifolia* have been investigated. Orally and intraperitoneally, it has significantly decreased the acute inflammatory reaction triggered by carrageenin.^[89] Recent studies show that Giloy enhances immunostimulant and acetylcholine synthesis, which improves cognitive function. As a result, it increases choline levels, proving that it can improve memory in normal and memory-impaired animals.^[90] *Tinospora cordifolia* significantly impacts inter-abdominal sepsis, which contributes to the understanding of the host's defensive systems against infectious stresses. According to the findings mentioned above, *Tinospora cordifolia* may have immunomodulatory properties.^[91]

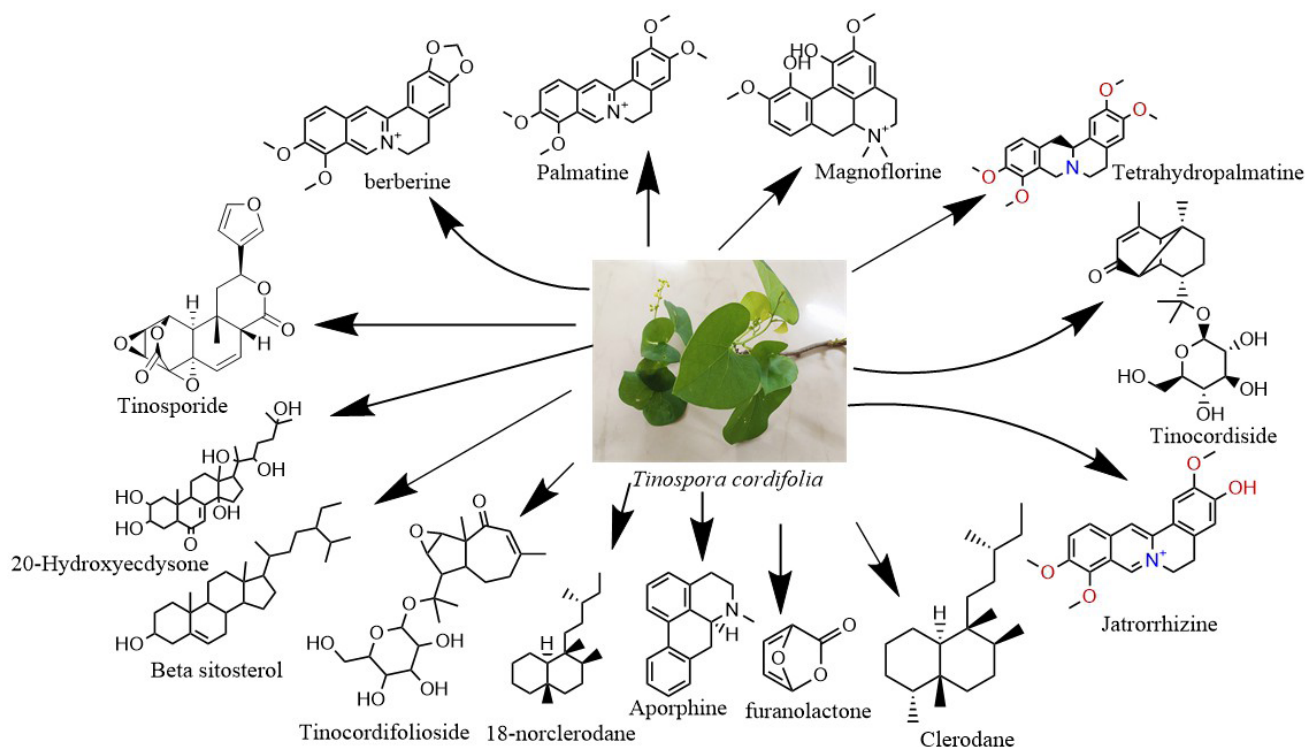


Figure 5: Various chemical composition of *Tinospora cordifolia*.

Hepatosuppression activities

Plant material from *Tinospora cordifolia* uses protein synthesis or CCl₄'s bioactivation and quick detoxification to guard against CCl₄-induced hepatocellular alterations. Because *Tinospora cordifolia* plant material can reduce the effects of free radicals, particularly peroxy radicals, and inhibits lipid peroxidation while exhibiting antioxidant activity, it can be classified as a hepatoprotective agent. Micronutrients and the components of the plant material cooperate rather than depending only on free radical movement.^[92]

Antioxidant probable

By scavenging free radicals and other reactive species, respectively, several *T. cordifolia* preparations demonstrate their antioxidant activity.^[9] In a diabetic rat model (alloxan-induced diabetes), *T. cordifolia* considerably lowers the regulation of the lipid peroxidation process, lowering the amount of reactive free radical species. It also upregulates antioxidant enzymes, such as glutathione and catalase, demonstrating its antioxidant activities.^[24,79] According to a clinical study, the extract has an antioxidant effect by increasing GSH levels and decreasing the gene expression that produces nitric oxide synthase. It also acts as a cataract treatment by blocking the enzyme aldol reductase.^[93,94] According to a study, as compared to methanol extracts, bark extracts (ethanol) exhibit higher phenolic content and more excellent free radical scavenging action.^[95] In a rat model, the plant-derived polysaccharide molecule known as "arabinogalactan" has antioxidant activity by protecting against

free radicals.^[96] The mechanism of action of Giloy against oxidative stress-related disease is shown in Figure 4.

Toxicology latent

Very little is known about *Tinospora cordifolia* toxicity to humans. No adverse effects were observed when rats were given 1,000 mg/kg of the complete plant extract from *Tinospora cordifolia* stem extract. In contrast, rabbits were given the maximum oral dose of 1.6 g/kg. Nonetheless, 40% of the mice administered 500 mg/kg body weight of *Tinospora* stem extract perished.^[97]

CONCLUSION

Tinospora cordifolia has an abundance of biological potential, according to scientific research. The polysaccharides in *T. cordifolia* have a wide range of recognized pharmacological and physiological effects. Polysaccharides from *T. cordifolia* exhibit potential as adjuvants and in the creation of pharmaceuticals. Along with their anti-diabetic, anti-cancer, immunomodulatory, and antioxidant qualities, they also possess hepatoprotective and radioprotective qualities. Furthermore, compared to aqueous extract, methanolic extract is biologically active, indicating that the extraction process significantly affects the biological activity of *T. cordifolia* polysaccharides. Further research is needed to determine innovative, more sustainable and efficient ways to extract and purify this substance for application in food and medicine. Further research is necessary to understand the molecular mechanisms and effectiveness of *T. cordifolia* polysaccharides. Comprehensive data on the extracts'

phytochemical and diverse biological characteristics, as provided in this review, may offer complete support for the application of this plant in many therapeutic applications.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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ABBREVIATIONS

Cm: Centimeter; **WHO:** World Health Organization; **Cc:** Cubic centimeter; **Mg:** Milligram; **Kg:** Kilogram; **GSH:** Glutathione; **MLD:** Malonaldehyde; **ROS:** Reactive oxygen species; **GPT:** Glutamic pyruvic transaminase; **ALT:** Alanine aminotransferase; **AST:** Aminotransferase; **IL-1:** Interleukin -1; **IL-6:** Interleukin -1; **S. typhi:** *Salmonella typhi*; **K. pneumoniae:** *Klebsiella pneumoniae*; **E. coli:** *Escherichia coli*; **E. faecalis:** *Enterococcus faecalis*; **B. subtilis:** *Bacillus subtilis*; **T. rubrum:** *Trichophyton rubrum*; **T. cordifolia:** *Tinospora cordifolia*; **S. aureus:** *Staphylococcus aureus*; **CCl₄:** Carbon tetrachloride; **STZ:** Streptozotocin; **METS:** Methanol extract of stem; **MMP:** Matrix Metalloproteinases; **HPLC:** High-performance liquid Chromatography; **NADPH:** Nicotinamide adenine dinucleotide phosphate hydrogen; **NADP:** Nicotinamide adenine dinucleotide phosphate; **DNA:** Deoxyribonucleic acid.

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