

Pharmacological Profile and Therapeutic Potential of *Tinospora cordifolia*: Traditional Uses, Bioactive Compounds, and Future Directions in Integrative Medicine

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ABSTRACT:

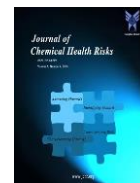
Tinospora cordifolia, also known as Guduchi or Amrita, is a revered medicinal plant in Ayurveda, classified as a "Rasayana" herb for its rejuvenating properties. This member of the Menispermaceae family thrives across Asia and India, where it is traditionally used to boost immunity and treat conditions like fever, diabetes, and immune-related disorders. The plant exhibits a unique morphology with heart-shaped leaves, small yellow flowers, and orange-red drupes, and it contains a wealth of bioactive compounds such as alkaloids, glycosides, and terpenoids. Pharmacologically, *T. cordifolia* demonstrates antioxidant, antidiabetic, antipsychotic, analgesic, hepatoprotective, cardioprotective, and antimicrobial properties. Additionally, it shows anticarcinogenic potential and radioprotective effects, particularly in animal models for skin cancer, highlighting its capacity to prevent tumor growth and genetic mutations. Current research suggests *T. cordifolia* can aid in managing asthma, fertility, malaria, and cardiovascular diseases. Future research directions include improving bioavailability via nanoparticle encapsulation, investigating synergy with other medicinal herbs, and developing targeted delivery formulations. These advancements, alongside clinical trials, may enhance *T. cordifolia*'s potential as a natural therapeutic agent in integrative and preventive healthcare.

1. Introduction

Tinospora cordifolia, a member of the Menispermaceae family and commonly known as Guduchi or Amrita in Ayurveda, is a well-established traditional medicinal plant recognized for its broad therapeutic applications. It is used to manage various health conditions, such as fevers, diabetes, and immune-related disorders. Native to India and parts of Asia, *T. cordifolia* thrives in diverse tropical climates and is found across the Indian

subcontinent, from the lowland forests to the Himalayan foothills.

In Ayurvedic medicine, *T. cordifolia* holds special significance as a "Rasayana," a category of herbs revered for their rejuvenating qualities. This classification highlights its role in promoting vitality, enhancing immunity, and supporting overall health and longevity. Its esteemed position in traditional medicine reflects its ability to enhance resilience to disease and contribute to long-term wellness.



Modern pharmacological research has substantiated its therapeutic potential, identifying multiple bioactive compounds with antioxidant, anti-inflammatory, and anticancer properties, which reinforce its reputation in both folk and scientific contexts.^[1]

2. Morphological and Botanical Description

This herbaceous vine exhibits distinctive morphological traits including large, heart-shaped leaves, greenish-yellow flowers, and fleshy, orange-red drupes. Botanically classified under the order Ranales, it belongs to the Menispermaceae family, known as the "moonseed family" due to its characteristic curved seed structure. *T. cordifolia* is a deciduous, climbing shrub that grows up to 12 meters, favoring a wide range of soil types from acidic to alkaline ^[2].

The plant's leaves are simple, alternate, and ovate with a length of 10-20 cm. Its flowers, unisexual and racemose, appear when the plant is leafless, with male flowers in clusters and female flowers solitary. Fruits are typically aggregate of 1-3 drupes and contain a curved embryo, adding taxonomic importance to its identification within the Menispermaceae family. ^[3]

3. Phytochemical Composition and Bioactive Compounds

Phytochemical analyses of *T. cordifolia* have revealed an impressive array of bioactive compounds, including alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, and polysaccharides. Studies utilizing advanced techniques such as HPLC/QTOF MS/MS have documented the presence of 36 metabolites, highlighting the bioactive constituents jatrorrhizine, magnoflorine, palmatine, and tetrahydropalmatine. Notably, these alkaloids exhibit substantial antioxidant, anticancer, and immunomodulatory activities, distinguishing *T. cordifolia* as a vital resource for medicinal applications ^[4].

4. Therapeutic Applications

Tinospora cordifolia (TC), commonly known as Guduchi, is a revered herb in traditional medicine, known for its wide range of therapeutic benefits. It has been extensively studied for its antioxidant, antidiabetic, hepatoprotective, and other health-promoting activities, showing promise in managing conditions such as

oxidative stress, diabetes, liver toxicity, and neuropsychiatric disorders (Fig 1). Modern research continues to explore TC's potential as a natural remedy, supporting its role in holistic health and wellness.

4.1. Antioxidant Activity

Tinospora cordifolia has significant antioxidant properties, which can neutralize free radicals and reduce oxidative stress. One study demonstrated TC's capacity to inhibit lipid peroxidation and reactive oxygen species like superoxide and hydroxyl radicals. This antioxidant potential has practical applications in ameliorating cyclophosphamide-induced toxicity in mice, reducing damage in hematological systems by enhancing white blood cell count and bone marrow health. Another study explored TC's protective role against lead-induced hematological toxicity in mice, where it counteracted decreases in RBC, Hb levels, WBC, and PCV due to lead exposure^[5].

In another investigation, Pepticare, a formulation including TC, demonstrated significant antioxidant effects. Pepticare increased levels of antioxidants like superoxide dismutase, catalase, and glutathione while reducing lipid peroxidation in rat models, thus substantiating TC's role in reducing gastric mucosal injury and ulcer formation^[6]

4.2. Antidiabetic Activity

Tinospora cordifolia's hypoglycemic properties make it a popular supplement for diabetes management. In a study on diabetic rats, TC was shown to decrease oxidative stress and improve glucose metabolism. TC's effects include lowering blood glucose, stimulating insulin secretion, and inhibiting gluconeogenic enzymes, which collectively regulate blood glucose levels. Further research on an alkaloidal fraction of TC identified active compounds that mimic insulin effects, reduce blood glucose, and inhibit gluconeogenesis in rat hepatocytes, emphasizing TC's hypoglycemic potential.^[7]

Additional studies have focused on TC's inhibitory effect on α -amylase and α -glucosidase, enzymes critical for carbohydrate breakdown. This inhibition helps control postprandial glucose spikes, making TC an effective natural option for managing diabetes mellitus (PPA inhibition study).^[8]

4.3. Antipsychotic Activity



TC has shown potential as an adjunct therapy in managing certain neuropsychiatric conditions. In studies using amphetamine-challenged mice models, TC's aqueous ethanolic extract demonstrated a capacity to modulate dopamine DAD2 receptor binding. Although it did not display antipsychotic activity comparable to haloperidol, TC's extract exhibited a notable decrease in hyperactivity and increased receptor binding, indicating possible antipsychotic potential.^[9]

4.4. Analgesic Activity:

Guduchi's analgesic effects stem from its ability to modulate central and peripheral pain pathways, making it a potential natural painkiller. Research has demonstrated that extracts from the plant can inhibit pain through interactions with key receptors involved in pain modulation. Studies conducted on animal models, like the hot plate and abdominal writhing tests, show that Guduchi reduces pain sensations, which can be attributed to its anti-inflammatory properties as well. These effects make Guduchi promising in treating various types of pain and inflammation-associated discomfort, providing a potential alternative or complementary approach to synthetic analgesics^[10]

4.5. Hepatoprotective Effects:

Guduchi's hepatoprotective properties have been widely recognized in studies focused on liver health. It helps protect liver cells from damage due to toxins, drugs, and infections. Animal studies involving liver damage models, such as those induced by carbon tetrachloride (CCl₄), highlight Guduchi's ability to reduce oxidative stress and enhance liver function by regulating liver enzymes like ALT and AST. The herb's antioxidant compounds scavenge free radicals, minimizing cellular damage. In traditional medicine, Guduchi is used to support liver health, treating jaundice, and other liver-related disorders, as it helps detoxify and rejuvenate liver tissues^[11].

4.6. Cardioprotective Effects:

Guduchi also exhibits significant cardioprotective effects, particularly in conditions related to oxidative stress and inflammation, which are risk factors for cardiovascular diseases. Animal studies indicate that Guduchi can reduce lipid peroxidation, a process that contributes to artery damage, while boosting the activity of antioxidant enzymes like SOD and catalase, thus

preventing cellular damage in the heart. By enhancing antioxidant defense mechanisms and lowering cholesterol levels, Guduchi promotes overall heart health, offering a natural intervention to prevent or manage heart diseases, especially when combined with a healthy lifestyle^[12].

4.7. Anti-asthmatic Effects:

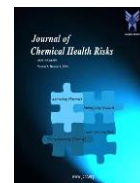
Guduchi has shown promise in asthma management by modulating immune responses and reducing airway inflammation. Studies suggest that Guduchi extract reduces the release of histamine and other inflammatory mediators, which play a key role in asthma symptoms such as bronchoconstriction and mucus buildup. Furthermore, it decreases oxidative stress in the respiratory system, improving lung function. Traditional medicine practitioners have long recommended Guduchi for respiratory ailments, and its incorporation in asthma treatments is now being explored for its potential to ease breathing, reduce exacerbations, and enhance overall quality of life for asthma patients^[13].

4.8. Antifertility Effects:

Some studies highlight Guduchi's antifertility effects in male reproductive health, showing that it can influence sperm quality and testosterone levels. In animal models, Guduchi has been found to disrupt spermatogenesis (sperm production), reduce sperm motility, and decrease overall testosterone levels, which could provide insight into its potential applications in male contraception. However, the mechanism behind these effects is not fully understood, and more research is needed to establish safe and controlled use in humans, especially for those exploring non-hormonal methods of contraception or those managing fertility issues^[14].

4.9. Antibacterial and Antimicrobial Activity:

Guduchi is effective against a variety of bacterial pathogens, including *Escherichia coli* and *Staphylococcus aureus*. Research indicates that Guduchi's antibacterial activity may be due to its active compounds, which can disrupt bacterial cell walls, inhibit growth, and even prevent biofilm formation. These properties make Guduchi a promising candidate for natural antimicrobial treatments. Its effectiveness against both gram-positive and gram-negative bacteria supports its traditional use in treating infections and suggests potential applications in modern antimicrobial



therapies, especially as antibiotic resistance continues to be a global health challenge [15].

4.10. Anti-malarial Properties:

Guduchi has shown anti-malarial potential by inhibiting the growth of the malaria-causing parasite *Plasmodium falciparum*. Laboratory studies reveal that Guduchi extracts can effectively reduce parasitemia, the concentration of parasites in the blood, thus limiting the spread of infection. This activity may be attributed to certain compounds like epoxy clerodane diterpene, which has shown promise as a chemopreventive agent. Guduchi's anti-malarial effects are gaining attention as researchers explore plant-based alternatives to conventional malaria treatments, especially in endemic regions where access to medication is limited and resistance to synthetic anti-malarial drugs is increasing [13].

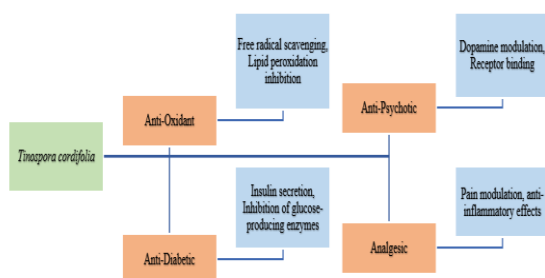


Figure 1: Therapeutic Applications of *Tinospora cordifolia*

5. Therapeutic research in Cancer studies:

Studies have investigated Guduchi's efficacy against various forms of cancer and its protective abilities against radiation-induced damage.

5.1. Chemopreventive Potential in Skin Carcinogenesis

Guduchi exhibits antitumor activity in skin carcinogenesis models. Mice treated with Guduchi extract at different stages (pre-initiation, post-initiation, or both) during skin cancer induction with DMBA and croton oil showed significant tumor reduction. Tumor weight, incidence, yield, and burden decreased notably, alongside an increase in phase II detoxifying enzymes and a reduction in lipid peroxidation in both liver and skin. These results suggest that Guduchi has strong

chemopreventive potential, particularly in inhibiting tumor promotion in multi-stage carcinogenesis models [13].

5.2. Anticarcinogenic and Antimutagenic Effects

Guduchi also displays anticarcinogenic and antimutagenic properties. In studies involving C57 Bl mice, Guduchi extract administered at doses of 200, 400, and 600 mg/kg reduced micronucleus formation in bone marrow, indicating its protective effect against genetic mutations. Moreover, in melanoma models, treatment with a 50% methanolic extract of Guduchi resulted in a longer lifespan and reduced tumor size, highlighting its antineoplastic activity. These effects underscore Guduchi's efficacy in both preventing mutations and reducing tumor growth, which could have significant implications for cancer treatment and prevention. [16]

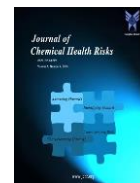
5.3. Radioprotective Effects on Intestinal Mucosa

The plant's radioprotective properties were evident in studies examining radiation-induced damage to intestinal mucosa. In Swiss albino mice, Guduchi pretreatment (5 mg/kg) administered before whole-body gamma radiation helped preserve villus length, cell populations, and mitotic activity, all of which are usually diminished by radiation. Pretreatment also helped maintain goblet cell levels within normal ranges, suggesting that Guduchi protects the structural integrity of intestinal tissues and supports cellular recovery post-radiation. [17]

5.4. Broader Radioprotective Potential

Guduchi's radioprotective benefits extend to several physiological parameters. For instance, when male mice were administered Guduchi extract (200 mg/kg) prior to whole-body gamma radiation, survival rates improved dramatically, with 76.3% survival compared to 100% mortality in untreated mice. Guduchi treatment also mitigated radiation-induced weight loss, enhanced spleen colony-forming unit (CFU) counts, restored total lymphocyte counts, and decreased radiation-induced micronuclei, all indicators of improved resilience against radiation exposure. The increase in CFU counts and stabilization of blood parameters suggest that Guduchi strengthens immune functions and promotes recovery from radiation damage [18].

To summarize the therapeutic potential of Guduchi in cancer treatment, particularly in terms of its



chemopreventive and radioprotective effects, a table outlining the experimental models, treatment doses, and key findings is presented below (Table 1).

Table 1: Therapeutic Research on *Tinospora cordifolia* in Cancer Studies

Study Focus	Guduchi Treatment	Key Findings and Mechanism/ Effects
Chemo preventive Potential in Skin Carcinogenesis	Guduchi extract at pre-initiation, post-initiation, or both stages	Significant tumor reduction (tumor weight, incidence, yield, burden), increased phase II detoxifying enzymes, reduced lipid peroxidation in liver and skin. Tumor inhibition via antioxidant effects and phase II detoxifying enzymes activation.
Anticarcinogenic and Antimutagenic Effects	Guduchi extract (200, 400, 600 mg/kg)	Reduced micronucleus formation, longer lifespan, reduced tumor size in melanoma models. Antimutagenic and anticarcinogenic effects through DNA protection and tumor size reduction.

Radioprotective Effects on Intestinal Mucosa	Guduchi pretreatment (5 mg/kg)	Preservation of villus length, cell populations, and mitotic activity, protection of goblet cells. Structural protection of intestinal tissues, supports recovery from radiation damage.
Broader Radioprotective Potential	Guduchi extract (200 mg/kg)	Increased survival rates, reduced weight loss, restored spleen CFU, increased lymphocyte count, reduced micronuclei. Immune function strengthening, improved resilience to radiation exposure, recovery from damage.

6. Pharmacological Validation and Future Research Directions for *Tinospora cordifolia*

Pharmacological research has demonstrated that *Tinospora cordifolia* offers a wide range of therapeutic benefits, including anticancer, anti-inflammatory, liver-protective, and immune-supporting effects. These benefits make *T. cordifolia* a valuable prospect in integrative medicine, opening various directions for expanding its applications and maximizing its impact (Fig 2). To fully realize *T. cordifolia*'s potential in clinical settings, ongoing research must address its bioavailability challenges, synergistic interactions with



other herbs, and advancements in formulation technologies.

6.1. Enhanced Bioavailability for Greater Efficacy

Although *T. cordifolia* has shown promise in preclinical studies, its low bioavailability, particularly of active compounds like magnoflorine and jatrorrhizine, limits its effectiveness. These compounds have low solubility and are quickly metabolized, reducing their absorption. Future research could focus on improving the bioavailability of *T. cordifolia*'s active ingredients, potentially enhancing its therapeutic impact.^[19]

A promising approach is encapsulating *T. cordifolia* extracts in nanoparticles, which can protect its bioactive compounds, improve absorption, and allow a controlled release within the body. This could enhance bioavailability, reduce required dosages, and minimize side effects, making *T. cordifolia* more suitable for chronic conditions like diabetes.^[20]

6.2. Exploring Synergy with Other Medicinal Herbs

In Ayurvedic medicine, *T. cordifolia* is often combined with other herbs to create complementary effects. For example, it is used with *Phyllanthus niruri* for liver health and *Withania somnifera* (Ashwagandha) for immune support and stress relief. Studying these combinations may provide insights into how *T. cordifolia* interacts with other herbs, potentially leading to optimized formulations with enhanced results.

Research could also explore how *T. cordifolia* might improve the effects of modern medications, such as those used for cancer or autoimmune disorders. Certain plant compounds can prevent the rapid breakdown of medications, increasing their effectiveness. Such research could bridge the gap between traditional herbal systems and modern pharmacotherapy, offering a holistic approach to health management.

6.3. Advancing Formulations for Targeted Therapy

Targeted delivery systems offer exciting possibilities for *T. cordifolia*, particularly in treating conditions like cancer, liver disease, and autoimmune disorders. Future research could focus on developing specialized formulations, such as liposomes or microspheres, to deliver *T. cordifolia* extracts directly to affected areas, maximizing efficacy while reducing side effects.

For instance, in cancer treatment, targeted delivery could focus *T. cordifolia*'s anticancer effects directly on tumor cells, minimizing harm to healthy tissue. For liver issues, targeted formulations could direct *T. cordifolia*'s liver-protective compounds precisely to the liver, potentially offering more effective and safer treatment options.

6.4. Immune Modulation and Antioxidant Effects: Clinical Trials and *In Vivo* Studies

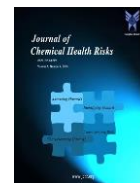
While preclinical studies support *T. cordifolia*'s immune-modulating and antioxidant effects, larger human trials are necessary to validate these findings. *T. cordifolia*'s ability to regulate cytokines and support immune cell activity could be beneficial for conditions involving immune dysregulation, such as rheumatoid arthritis and lupus. Conducting clinical trials with standardized *T. cordifolia* extracts could help determine safe dosages, identify potential side effects, and confirm its effectiveness.

Further research could also explore *T. cordifolia*'s role in reducing oxidative stress, which is implicated in aging, cardiovascular disease, neurodegenerative disorders, and metabolic issues. By measuring oxidative stress markers and tracking patient outcomes, researchers could better understand *T. cordifolia*'s role as a natural antioxidant, positioning it as a valuable option in integrative and preventive healthcare.

6.5. Standardization and Quality Control for Consistent Therapeutic Outcomes

A challenge in herbal medicine research is the variability in quality and concentration of bioactive compounds, which affects product safety and efficacy. Future research on *T. cordifolia* should prioritize standardization to ensure consistent levels of active ingredients. This may involve developing reliable methods for measuring compounds like cordifolioside-A and magnoflorine, known for their immune and antioxidant effects.

Standardization can improve the reliability of clinical studies, boost consumer confidence, and support regulatory approval of *T. cordifolia* products. Regulatory bodies like the FDA and EMA require specific quality control measures for herbal products, including potency and stability testing. As *T. cordifolia* gains international recognition, standardized production will be key to



meeting these regulatory requirements and ensuring safe, effective products for consumers.

6.6. Expanding Use in Integrative and Preventive Medicine

Given *T. cordifolia*'s wide-ranging health benefits, there is significant potential for its use in integrative and preventive medicine. Its adaptogenic qualities make it suitable for managing stress-related disorders, while its immune and antioxidant effects support chronic disease prevention. Future research could explore its applications in managing autoimmune diseases, aiding cancer recovery, and enhancing general wellness.

Additionally, as interest in preventive healthcare grows, *T. cordifolia* could play a role in personalized medicine tailored to individual needs and genetic profiles. For example, people with genetic predispositions toward immune or oxidative stress issues may benefit from *T. cordifolia* supplementation. Precision medicine studies could investigate how specific genetic markers affect *T. cordifolia*'s effectiveness, allowing for more targeted use.

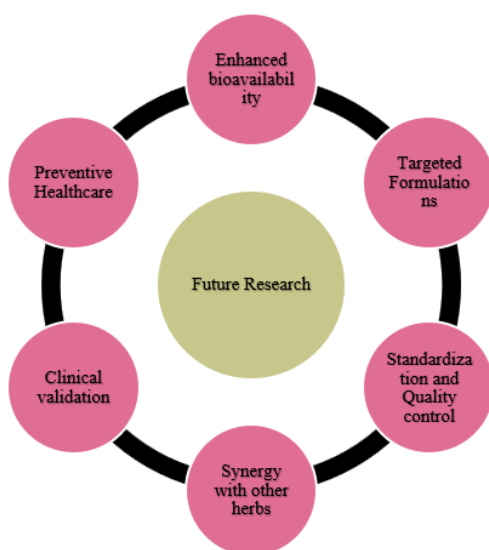


Figure 2: *T. cordifolia*'s Future Research

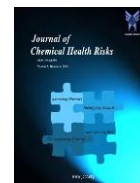
7. Conclusion

Tinospora cordifolia stands as a potent medicinal plant with diverse therapeutic applications, validated through traditional use and modern pharmacological studies. Its antioxidant properties mitigate oxidative stress, contributing to enhanced liver function, cardiovascular

health, and cellular resilience, while its hypoglycemic activity supports diabetes management by regulating blood glucose levels. The plant's anticancer and radioprotective properties underscore its potential in cancer prevention and therapy, while its antimicrobial, anti-inflammatory, and hepatoprotective effects make it suitable for managing infections, liver conditions, and inflammation-related disorders. Despite these promising findings, the limited bioavailability of *T. cordifolia*'s active compounds restricts its clinical efficacy. Future research should focus on enhancing bioavailability through innovative delivery systems, such as nanoparticles, which may improve absorption and enable controlled release. Furthermore, exploring *T. cordifolia*'s synergy with other medicinal herbs could yield optimized formulations that harness complementary effects, bridging traditional Ayurvedic wisdom with modern pharmacology. Targeted delivery technologies may also allow for more effective treatment of specific ailments, such as localized cancer therapies. Finally, clinical trials are essential to substantiate preclinical findings, validate safe dosages, and confirm its effectiveness in human populations. With continued research, *T. cordifolia* could emerge as a valuable resource in integrative healthcare, contributing to the development of natural, sustainable treatment options for various chronic and acute conditions.

References

1. Sinha A. Phyto-Chemical Studies of Methanol Extracts of *Tinospora Cordifolia* Stem By Gc-MS. *World J Pharm Res* 2017;(April 2017):1319–26.
2. Mittal J, Sharma MM, Batra A. *Tinospora cordifolia*: a multipurpose medicinal plant-A review. *Journal of Medicinal Plants Studies Year Journal of Medicinal Plants Studies* 2014;2(2):32–47.
3. Bhattacharyya C, Bhattacharyya G. Therapeutic potential of Giloe , *Tinospora cordifolia* (Willd .) Hook . f . & Thomson (Menispermaceae): The Magical Herb of Ayurveda. 2013;4(4):558–84.
4. Bajpai V, Singh A, Chandra P, Negi MPS, Kumar N, Kumar B. Analysis of phytochemical variations in dioecious *Tinospora cordifolia* stems using HPLC/QTOF MS/MS and UPLC/QqQLIT-MS/MS. *Phytochemical Analysis* 2016;



5. Jayaprakash R, Ramesh V, Sridhar M, Sasikala C. Antioxidant activity of ethanolic extract of *Tinospora cordifolia* on N-nitrosodiethylamine (diethylnitrosamine) induced liver cancer in male Wister albino rats. *J Pharm Bioallied Sci* 2015;7(5):40.
6. Bafna PA, Balaraman R. Antioxidant activity of Pepticare, a herbomineral formulation, in experimentally induced renal and cardiac damage. *J Herb Pharmacother* 2006;6(1):1–12.
7. Sangeetha MK, Balaji Raghavendran HR, Gayathri V, Vasanthi HR. *Tinospora cordifolia* attenuates oxidative stress and distorted carbohydrate metabolism in experimentally induced type 2 diabetes in rats. *J Nat Med* 2011;65(3–4):544–50.
8. Kajaria D, Ranjana, Tripathi J, Tripathi Y, Tiwari S. In-vitro α amylase and glycosidase inhibitory effect of ethanolic extract of antiasthmatic drug - Shirishadi. *J Adv Pharm Technol Res* 2013;4(4):206.
9. Jain BNG, Jain VK, Shete A. Antipsychotic activity of aqueous ethanolic extract of *tinospora cordifolia* in amphetamine challenged mice model. *J Adv Pharm Technol Res* 2010;1(1):30–3.
10. Goel B. Clinical Evaluation of Analgesic Activity of Guduchi (*Tinospora Cordifolia*) Using Animal Model. *Journal Of Clinical and Diagnostic Research* 2014;8(8):1–4.
11. Sharma V, Pandey D. Protective role of *Tinospora cordifolia* against lead-induced hepatotoxicity. *Toxicol Int* 2010;17(1):12–7.
12. Sharma AK, Kishore K, Sharma D, Srinivasan BP, Agarwal SS, Sharma A, et al. Cardioprotective activity of alcoholic extract of *Tinospora cordifolia* (Willd.) Miers in calcium chloride-induced cardiac arrhythmia in rats. *J Biomed Res* 2011;25(4):280–6.
13. Upadhyay A, Kumar K, Kumar A, Mishra H. *Tinospora cordifolia* (Willd.) Hook. f. and Thoms. (Guduchi) - validation of the Ayurvedic pharmacology through experimental and clinical studies. *Int J Ayurveda Res* 2010;1(2):112.
14. Gupta RS, Sharma A. Antifertility effect of *Tinospora cordifolia* (Willd.) stem extract in male rats. *Indian J Exp Biol* 2003;41(8):885–9.
15. EZHILARASU K. The Antibacterial Effect of *Tinospora Cordifolia* (Guduchi) and Its Role in Combating Antimicrobial Resistance. *Medeni Med J* 2023;38(3):149–58.
16. Chaudhary R, Jahan S, Goyal PK. Chemopreventive Potential of an Indian Medicinal Plant (*Tinospora cordifolia*) on Skin Carcinogenesis in Mice. *Journal of Environmental Pathology, Toxicology and Oncology* 2008;27(3):233–43.
17. Nair GG, Nair CKK. Radioprotective Effects of Gallic Acid in Mice. *Biomed Res Int* 2013;2013:1–13.
18. Rao SK, Rao PS, Rao BN. Preliminary investigation of the radiosensitizing activity of guduchi (*Tinospora Cordifolia*) in tumor-bearing mice. *Phytotherapy Research* 2008;22(11):1482–9.
19. Bala M, Pratap K, Verma PK, Singh B, Padwad Y. Validation of ethnomedicinal potential of *Tinospora cordifolia* for anticancer and immunomodulatory activities and quantification of bioactive molecules by HPTLC. *J Ethnopharmacol* 2015;175:131-137.
20. Vamsi Krishna BV, Tirupathi Rao P, Durga Lakshmi B, Vasudha K, Esub Basha Sk, Putra Kumar B, et al. Green fabrication of *tinospora cordifolia*-derived MgO nanoparticles: Potential for diabatic control and oxidant protection. *Next Materials* 2024;3:100171.