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A COMPREHENSIVE REVIEW OF MEDICINAL PROPERTIES AND PHYTOCHEMISTRY OF *TINOSPORA CORDIFOLIA*

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ABSTRACT

Guduchi (Tinospora cordifolia) is a member of Menispermaceae family. It is also known as Giloe, Giloy, Gurcha (Hindi) and Amrta (Sanskrit). It is found almost everywhere in India and in Himalayas, even up to 1000 feet height. Its habitat ranges across a wide region in India spreading from Kumaon Mountains to Kanyakumari. It is also found in China, Myanmar, Sri Lanka, Thailand, Philippines, Indonesia, Malaysia, Borneo, Vietnam, Bangladesh, North Africa, West Africa and South Africa. *T. cordifolia* contains different classes of constituents such as alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, aliphatic compounds and polysaccharides etc. *T. cordifolia* is an important drug of Indian systems of medicine and used in medicines since ancient times. The drug is used in fevers, diabetes, dyspepsia, jaundice, urinary problems, skin diseases and chronic diarrhea and dysentery. It is also useful in the treatment of heart disease, leprosy, and helmenthiasis. The starch obtained from the stem is highly nutritive and digestive and used in many diseases. Objective of present review is summarization of the information about pharmacological and phytochemical aspect of *Tinospora cordifolia* plant which will be helpful for researchers.

KEYWORDS: *T. cordifolia*, botanical description, medicinal properties, pharmacology and phytochemistry.

INTRODUCTION

T.cordifolia (menispernaceae) is an ayurvedic medicinal plant distributed throughout the Indian subcontinent and china. India with it is vast bio-diversity and huge knowledge of ancient traditional system of medicine such as Ayurveda, Siddha, Unani, Amchi and provide strong base for utilization of a large number of plants in general healthcare and common alignment of people. Intense research on *T. Cordifolia* has been carried out from last four decades with special emphasis on the isolation of various compounds such as alkaloids, sesquitertenoids, diterpenoid, phenolics, steroids, aliphatic compound and polysaccharides along with discovery of wide spectrum of pharmacological properties like immunomodulation, anticancer, hepatoprotective and hypoglycemic. The plant is designated as rasayana in ayurveda is very well known for building of the immunosystem and body defense against definite infecting microorganism.[1]

COMMON NAMES

- English : Gulancha/ Indian tinospora.
- Latin : *T. cordifolia* (wild) Hook. F& Thomson.
- Sanskrit :Guduchi, Amrita, Tantrika, Kundalini.
- Hindi : Giloya, Guduchi.
- Marathi : Shindilakodi.
- Gujarathi : Galo.
- Telugu : Thippateega.
- Tamil : Shindilakodi.
- Bengali : Gulancha.
- Kannada : Amrita balli.

TAXONOMICAL CLASSIFICATION

- Kingdom : Plantae-Plants.
- Sub-Kingdom : Tracheophyta-vascular plants.
- Super-division : Spermatophyta-seed bearing plant.
- Division : Magnoliophyta-flowring.
- Class : Magnoliopsia-dicotiledons.
- Subclass : Polypeptalae- petals are free.
- Series : Thlamiflorae- many stamen and flower hypogynous.
- Order : Ranunculales.
- Family : menispermacieae- the moonsee family.
- Tribe : Tinosporeace.

- Genus : Tinospora.
- Species : Cordifolia.

BOTANICAL DISCRIPTION

T. cordifolia is a large, extensively spreading and climbing shrub with several elongated twinning branches different part of plant shows different type of morphology.

Steam: Stem of this plant is rather succulent with a long, filiform, fleshy and climbing nature. The branches are creamy white to grey in colour and deeply left spirally.

Leaves: Leaves are simple, alternate, long petioled, approximately 15 cm long, seven nerved and deeply cordate at the base and membranous, lamina is ovate.

Arial Roots: These roots are characterized by tetra to penta-arch primary structure, cortex of root is divided into outer thick walled and inner.

Flowers: They are unisexual, recemes, greenish yellow in colour, appearance when plant is leafless, male flower are clustered and female flower exist in solitary inflorescence. Flowering occurs from march to june. Flowers are small and unisexual. Male flowers are in clusters, female flowers are solitary. Six sepals arranged in two whorls, they are obovate and membranous.

Fruits: They are orange red in colour, fleashy, of 1-3 and ovoid, smooth, drupelets on thick stalk with a sub terminal style scars. Fruits develop during winters.

Seeds: curve seeds have been reported in this species hence family is name as moonseed family. The endocarp is variously ornamented and provides important taxonomical characters.[2]

GIOGRAFICAL DISTIBUTION AND GROWTH REQUIRMENT

1. Plant distributed throughout the tropical and subtropical region of India upto 1200 m above sea level from kumaon to assam.
2. North extending through west Bengal, bihar, deccan, Karnataka and kerala
3. Indigeneous area of india, Myanmar, srilanka, china, thialand, Philippines, Indonesia, borneo, Vietnam, Bangladesh, north Africa and south Africa.
4. Typically grows in deciduous & dry forest at elevation up to 1000ft.
5. It prefer warm climate, planting done in june – august known as NEEM GILOY has chemical constituent as similar as Neem [Azadirachta indica] and giloy hence shows better therapeutic properties .
6. T.cordifolia prefer Black or red soil which contain sufficient moisture and rich in organic matter.[2]

TRADITION AND CLAIM

1. In dahanu forest division of Maharashtra , tribal races, viz. agaris ,bhils, dhodias, dublas, khakaries, rimoshis, Thakurs, vardaris, vagharis and varlis use the stem decoction with cold or hot water [about 3-4 gm] in morning in an empty stomach as a tonic in general debility .
2. The tribals of Mumbai and its neighbouring areas and the fishermen along the sea coast use of *T. cordifolia* as drug in treatment of fever, jaundice, chronic diarrhoea and dysentery.
3. The Tribal of khedbhrahma North Gujarat use the plant in day to day life as food and medicines they use powdered root and stem bark of T.cordifolia with milk for the treatment of cancer ; decoction of root is use for the cure of desentry and diarrhoea and decoction of stem is use to treat periodic fever.
4. Decoction of stem is administered orally by the people of jammu and bigwada for the treatment of fever.
5. People of Bhuvaneshwar [Orisa] use warm juice of root for treatment of fever.[2]

6. People of patiyala generally use decoction of leaves with honey to treat fever.
7. To treat Daha (burning sensation) paste juice of *T. cordifolia* juice is used.
8. In the treatment of Ears juice if leaves of *T. cordifolia* is use by local people of patiyala.
9. Decoction of stem is use to treat skin diseases by people of Sivpuri.
10. Juice of stem is taken orally with honey for treatment of asthma by local people of Badala [UP].

PHARMACOLOGICAL REVIEW

Antidiabetic activity of *T. cordifolia*

NM Reddy investigated anti diabetic activity of aqueous and alcoholic extracts of *T. cordifolia* in streptozotocin diabetic rat at different dosage (200 and 400 mg/kg bw) and Latezinc insulin was used as standard. Drug administered orally for almost 10 to 30 days. The serum insulin level, activity of key enzyme of glucose metabolism and histology of endocrine pancreas, where studied. Results revealed that *T.Cardifolia* extracts shown better antidiabetic activity than insulin.[3] Kinkar SB and Patil KG investigated anti-diabetic activity in alloxan treated albino rats. The rats weighing 150-190gm were administered intraperitoneally with 180mg/kg body weight dose of alloxan monohydrate for the induction of diabetes. The oral dose of alcoholic extract of *T. cordifolia*, 20ml/kg of body weight from day 2 to 30 given to the animals; twice a day half an hour prior to feeding was given. Significant decrease in blood sugar level of animal was noticed after the treatment. The results showed that the extract possess hypoglycemic effect.[4] Callus of *T. cordifolia* and methanol extract of stem and leaf were evaluated for antidiabetic potential. Inhibition of glycosylation of heamoglobin and amylase inhibition was in a dose dependent manner and glucose transport differs with the sample and glucose concentration. The results of the work indicate that the both native plant extract and callus extract possessed considerable in vitro anti diabetic activity and can be applied as alternative in the treatment of diabetes and diabetic induced complication.

Immunomodulatory Activity

Vaibhav Ahera et al studied immunomodulatory action of *T. cordifolia* ethanolic extract (100 mg/Kg/p.o.) which showed increased the level of liver mitochondrial enzymes like GSH, CAT and SOD but decreased the level of LPO in liver as compared to the vehicle, sheep red blood cells and cyclophosphamide-treated groups. The secretion of melatonin, which is an integral part of the immune system, through exerting direct and/or indirect stimulatory effect on both cellular, and humoral immunity via pineal gland was enhanced. The extract also increased the spleen lymphocyte proliferation. Cytokine profile provides a useful method for the accurate study of cytokine such as IL-2, IL-10 and TNF-α and immunomodulatory effect was investigated through RT-PCR. Ethanolic extracts of *T. cordifolia* showed more fold changes in IL-2, IL-10 and TNF-α mRNA (17.63, 42.52 and 5.39 respectively) levels as compared to the vehicle, cyclophosphamide and sheep red blood cells sensitized groups. IL-2 shows immunomodulatory activities by T and B lymphocytes proliferation, natural killer cell activation and also increasing in the immunoglobulin G production whereas IL-10 promotes elevation of Th2 cells and TNF-α modulate the cytokine gene expression.[5]

Anticancer Activity

Anticarcinogenic and antimutagenic activity of T. cordifolia extract was used, in C57 Bl mice and Swiss albino mice respectively. In antimutagenic study at a dose of 200, 400 and 600 mg/kg dry weight, 24 hrs prior the i.p. administration of cyclophosphamide (at the 50 mg/kg), significantly prevented the micronucleus formation in bone marrow of mice, in a dose dependent manner. In melanoma assay, C57 Bl mice when received 50% methanolic extract of T. cordifolia at a dose 750 mg/kg body weight for 30 days showed increase in life span and tumor size was significantly reduced as compared to control.[6] Mishra and Kaur investigated the anti-brain cancer potential of 50% ethanolic extract of Tinospora cordifolia using C6 glioma cells, which showed significant reduction in cell proliferation in dose-dependent manner and induced differentiation in C6 glioma cells. Ethanolic extract treatment was seen to arrest the C6 cells in G0/G1 and G2/M phase, suppressing expression of G1/S phase specific protein cyclin D1 and anti-apoptotic protein Bcl-xL, thus supporting its anti-proliferative and apoptosis inducing potential.[7]

The anticancer and immunomodulatory activities of different extracts, fractions and isolated compounds were evaluated against four different human cancer cell lines, KB (human oral squamous carcinoma), CHOK-1(hamsterovary), HT-29(humancoloncancer) and SiHa (human cervical cancer) and murine primary cells respectively. Observations suggest that tinocordiside has shown significant cytotoxicity against KB and SiHa cells. Whereas, yangambin was found cytotoxic against KBcells. In a separate observation, Palmatine gave significant cytotoxicity values against KB and HT29 cancer cells.[8]

Antistress and Antidepressant activity

Partha Biwas performed a randomized double blind placebo control 8 weeks study was conducted. The antistress activities of the treatments were measured by different psychological rating scales as well as various biochemical parameters i.e. lipid profile, serum glucose concentration. Total 63 patient with mental stress were randomized into four groups. Results shown that following treatment with *T. cordifolia* associated with practice of yoga significantly reduced various stress induced psychological and biochemical parameters ($P < 0.001$).[9]

Sezal and vaibhav walia investigated antidepressant activity of *T. cordifolia*. Petroleum ether extract produces antidepressant-like effect by interaction with α1-adrenoceptors, dopamine D2-receptors, serotonergic and $GABA_B$ receptors, hence increasing the levels of norepinephrine, dopamine and serotonin; and decreasing the levels of GABA in brains of mice. It also reduces the mouse whole brain MAO-A and MAO-B activities as compared to control. Tinospora cordifolia extract provides protection against oxidative stress, pro-inflammatory mediator release and redox signaling.[10] Kalabharthi HLet.al. investigated antidepressant activity of fresh leaves of *T. cordifolia* in tail suspension method & forced swim test in albino mice.Decrease in total immobility period by leaves extract denoted antidepressant activity. The antidepressant activity of T. cordifolia is mostly due to increased levels of brain monoamines by its inhibition of metabolism of monoamines particularly serotonin and noradrenaline.[11]

Antioxidant Activity

Joshi and Kaur investigated anti-oxidant activity of various extracts of *T. cordifolia*. It reduces the regulation of lipid peroxidation process by reducing level of reactive free radical species in a diabetic rat model. It regulates anti-oxidant enzymes like catalase and glutathione indicating its anti-oxidant property. Antioxidant potential of two species of Tinospora viz *T. cordifolia* and *T. sinensis* on a comparative basis was studied. Aqueous and ethanolic extracts of both the species were subjected to in vitro antioxidant activity screening models such as DPPH, ABTS, nitric oxide and superoxide radical scavenging activity, inhibition of lipid peroxidation, reduction of ferric ions and total antioxidant capacity. Ascorbic acid was used as the standard. In all the models studied, both the plants showed nearly equal activities. Arabinogalactan is polysaccharide compound present in *T. cordifolia* show the activity against free radical in rat model shows anti-oxidant activity.[1]

Analgesic activity

Bhomic Goel investigated analgesic activity of *T. cordifolia.* extract by using the acetic acid-induced writhing test, hot plate test and tail-flick test. The abdominal writhing test is normally used to evaluate the peripheral analgesic effect of drugs and chemicals. *T. cordifolia* extract significantly ($p<0.05$) increased the response time and decreased the number of writhes in hot plate method and abdominal writhing method respectively, on comparison with the control group The response is thought to be mediated by peritoneal mast cells, acid sensing ion channels and the prostaglandin pathway.[12]

Antipyretic activity

Liaqat Hussain et.al. investigated the anti-pyretic activity of *T. cordifolia* by brewer's yeast-induced pyrexia method. The pyrexia was produce by injecting 10ml/kg of 20% suspension of dried brewer's yeast in normal saline. Rat developed fever about 38.71-39.9. the pyrexia was noted at 30, 60, 90, and 120 minutes after administration of standard drug Paracetamol and graded dose of aq. extract of *T. cordifolia* produced a significant reduction in temperature. It was clearly evident from this study that *T. cordifolia* extract produced the maximum anti-pyretic effect at a dose of 300 mg/kg. It has been reported that alkaloids and flavonoids have anti-pyretic potential are present in this plant.[13]

Anti-inflammatory

Anti-inflammatory activity of *T. cordifolia* was evaluated by using Carrageenan induced rat paw edema model. Rats were divided into six different groups. 1st group was treated with normal saline (5ml/kg of 0.9% Nacl). 2nd was treated with Diclofenac sodium 20mg/kg. 1.25gm/kg of aqueous extract of *T. cordifolia* was given to 3rd group. In other two groups different concentrations are given (2.5g/kg & 5g/kg). The constituent present in *T. cordifolia* show anti-inflammatory activity.[1] Parmar and Ghosh investigated anti-inflammatory activity of *T. cordifolia* by histamine induced hind paw edema. Histamine induced paw edema was induced using 0.1ml of 0.1% solution of histamine acid phosphate. The paw volume was recorded before and 1hr after the injection of *T. cordifolia*. anti-inflammatory cytokines (IL-4, IL-10) and pro-angiogenic factors (VEGF and EGF). The ECD pretreatment considerably increased the levels of PGE2, anti-inflammatory cytokines and pro-angiogenic factors.[14] Shwetha R.J. investigated antioxidant and anti-inflammatory activity of aqueous and methanolic extract of leaves of Tinospora cordifolia (Giloy) by in vitro methods. In vitro anti-inflammatory activity was evaluated using albumin denaturation assay, lipooxygenase inhibition, and membrane stabilization assay and proteinase inhibitory activity at different concentrations. The extract inhibited the lipoxygenase enzyme activity with an IC50 value of 389.3 µg/ml. Maximum inhibition of heat induced protein denaturation of 75% was observed at 400 µg/ml, IC50 237.6 µg/ml). Proteinase activity was also significantly inhibited (IC50 = 352.1 µg/ml). Membrane stabilization assay attributed minor protection by the leaf extract with an IC50 of 206.4.[15]

Antimalarial

Rajan kumar singh studied the effect of aqueous extract of Tinospora cordifolia along with chloroquine was studied in the treatment of three cases of hyper-reactive malarious splenomegaly. Aqueous extract (500mg) was added to chloroquine (CQ) base (300mg) weekly and CQ prophylaxis was observed up to six month. Improvement was gauzed by measuring spleen enlargement, Hb, serum IgM and well-being in three cases of hyper-reactive malarious splenomegaly. Addition of *T. cordifolia* aqueous extract to the treatment of Hyper-reactive malarious splenomegaly for initial six weeks accelerated the well-being with subsidence of haemolytic state besides marked reduction in spleen size and serum IgM as well as rise in Hb in all the three cases. Its beneficial

effect in HMS was perhaps shown due to its immumodulatory effect as well as additive effect on antimalarial activity of CQ.[16]

Antimicrobial activity

R. Jeyachandran et. al. investigated anti-microbial activity of *T. cordifolia*. The antibacterial activity of the aqueous, ethanol and chloroform extract of stem was studied using disc diffusion method against *Escherichia coil, Proteus vulgaris, Enterobacter faecalis, Salmonella typhi* (gram-negative), *Staphylococcus aureus* and *Serratia marcesenses* (Gram-positive). Results suggest that the ethanolic extract has significant antibacterial activity against tested bacteria.[17] Singh K et. al. synthesized silver nanoparticle from stem of *T. cordifolia* which showed good antibacterial activity against multidrug resistance stain of *Pseudomonas aeruginosa* isolated from burn patient.[18]

Antiasthmatic activity

Syed Ghori et. al. investigated anti-asthmatic activity of *T. cordifolia* root extract against citric acid induced asthmatic rat at dose of 100 and 200mg/kg. In-vivo models like histamine induced bronchospasm in rats, and acetylcholine induced contraction in rats preparations were used for evaluating anti-asthamatic activity of the drug. *T. cordifolia* contain tinosporine, tinosporol, tinosporide. Tinosporine extracted from root was responsible for bronchodilation hence show anti-asthmatic activity. Ach and Citric acid when inhaled causes hypoxia and leads to convulsion in rats and causes very strong smooth muscle contraction, profound hypotension, capillary dilation in cardio vascular system a prominent effect caused by histamine leads to severe bronchoconstriction in rats that causes asphyxia and death. Ethanolic extract of the drug showed a significant bronchodilatory and anti-histaminic, anti-inflammatory, mast cell stabilization, and anticholinergic activity in histamine induced bronchospasm in wistar rats.[19]

Gastroprotective activity

Paulrayer A et.al. evaluated the gastroprotective effect of epoxy clerodane diterpene (ECD), isolated from *T.cordifolia* on indomethacin-induced gastric ulcer in rats. Administration of indomethacin exibits extreme level of ulcer index and myeloperoxidase (MPO) activity. Indomethacin downregulated PGE2, anti-inflammatory cytokines (IL-4, IL-10) and pro-angiogenic factors (VEGF and EGF).The ECD pretreatment considerably increased the levels of PGE2, anti-inflammatory cytokines and pro-angiogenic factors. The ulcer-healing activity of ECD was inhibited by pre-administration of the specificCOX-1 inhibitor (SC560) and nonspecific NOS inhibitor (l-NAME), which indicates the involvement ofPGE2and NOS in ECD induced ulcer healing activity.

Neuroprotective activity

Prakash R et.al. investigated neuroprotective activity of ethanolic extract of *Tinospora cordifolia* on Lipopolysaccharide induced behavioral alterations, oxidative stress and neuronal damage in rats. After 14th day treatment, various behavioral assessments such as body weight, rectal temperature, locomotor activity, cognitive and memory assessment were carried out was done on 15th day onward. Rats were sacrificed, and brain was isolated and antioxidant levels (GSH, SOD, TBARS and CAT) was estimated and neuronal damage in the region of hippocampus were analyzed. Pretreated with Aspirin 200 mg/kg rats and ethanolic extract of *T. cordifolia* (200 and 400 mg/kg) rats significantly attenuated the LPS induced behavioral alteration, oxidative damage and neuronal damage. The presence of alkaloids and diterpenoid lactone contents exert an antistress activity. The central findings of the current study reveal that ethanolic extract attenuates LPS induced sickness behavior on rats. LPS can bind with TLR4 leading to the activation of NF-κB-dependent induction of pro-inflammatory cytokines such as TNF-α, IL-1β, IL-6 and COX which leads to sickness behavior.[20]

Antiulcer activity

Chandan NG et. al. investigated anti-ulcer activity of *T. cordifolia* aqueous extract against pylorus ligation, aspirin induced and ethanol induced gastric ulcer in rats at 400mg/kg body weight p.o. In pylorus ligated rats, extract has shown significant ($P<0.01$) reduction in gastric volume, total acidity & ulcer index as compared to control. There was also significant ($P<0.01$) reduction in ulcer index seen among extract treated rats of aspirin and ethanol induced models.[21] Bairy KL investigated antiulcer effects of alcoholic extract of *T. cordifolia* in different animal models of ulcers at the dose of 400 mg/Kg PO in pyloric ligation, ibuprofen and cold restraint induced gastric ulcer models. The antiulcer effects of the drugs were assessed on the parameters such as number, size and index of ulcers and the volume, acidity, and pH of gastric juice. The extract significantly ($p<0.05$) reduced ulcer index in the models employed. While the antiulcer effect of the extract was comparable to that of the standard drugs in ibuprofen and stress induced ulcer models, its effect was significantly ($p<0.05$) lesser than that of famotidine in pyloric ligation method.[21] Kaur M investigated antiulcer activity of ethanolic and aqueous extracts of T. cordifolia in rats in ethanol and pylorus ligation‐induced ulcer. Tissue antioxidant parameters such as reduced glutathione, catalase activity and lipid peroxidation level were also investigated. The antiulcer activity of the extracts was confirmed by a reduction in ulcer index along with the decrease in gastric volume, total acidity, and an increase in pH of gastric content in both the models. Extracts significantly increased the level of antioxidant enzymes like catalase and GSH providing the first line defense system against ROS induced gastric mucosal damage in both the ulcer models.[23]

Antidiarrheal activity

Gahlawat D. studied antidiarrheal activity of methanolic extract of the whole plant of *T. cordifolia* in castor-oil induced diarrhea model at 200mg/kg, 400mg/kg dose compared with the standard drug lopramide (3mg/kg). Result suggested that the methanolic extract at concentration of 400 mg/kg show maximum antidiarrheal activity.[24] Kaur M studied in vivo antidiarrheal activity of extracts by using castor oil and magnesium sulfate induced diarrhea by means of evaluating onset of diarrhea, frequency of wet and total stools, weight of wet stool and total weight of stools. Castor oil induces diarrhea by releasing nitric oxide (NO), stimulating prostaglandin synthesis and increasing peristalsis. While, magnesium sulfate prevents reabsorption of water and promotes cholecystokinin (CCK) release from the duodenal mucosa. Since, pretreatment with extracts provide significant protection against castor oil and magnesium sulfate‑induced diarrhea, the extracts may presumed to have antisecretory and preventive action towards CCK release.[23]

Radioprotective and cytoprotective activity

Patel A. et.al evaluated the radioprotective and cytoprotective potential of cordifolioside-A, a primary active constituent of n-butanol fraction of *T. Cordifolia* (NBTC) against 4 Gy-γ radiation in mice and cyclophosphamide induced genotoxicity at 80 and 120 mg/kg, intraperitoneal (i.p.) dose. NBTC administered 15 days prior to whole body radiation exposure and survival rate, change in body weight, hematology, spleen colony forming unit (CFU), and micronucleus (MN) expression was observed. Cytoprotective activity of NBTC was evaluated at 5, 10, and 15 mg/ml concentrations on Allium cepa root meristem growth against cyclophosphamide. Radiation causes breaks in DNA and generates free radicals that damage cell membranes, proteins, and organelles in biosystem consequently the highly dividing units such as RBCs and WBCs get majorly affected and there level decline. NBTC showed highly significant increase in WBC and RBC count as well as in Hb content signifying its hemopoietic effect.[25]

Antifertility effect

Gupta RS and Sharma A investigated anti-fertility activity of methanolic extract of *T. cordifolia*. stem at dose of 100 mg/rat/day for 60 days. Treatment decreases the weight of testes, epididymis, seminal vesicle and ventral prostate in a significant manner. Sperm motility as well as sperm density were reduced significantly which resulted in reduction of male fertility by 100%. The stem extract brought about an interference with spermatogenesis. The round spermatids were decreased by 73.12%. However, the population of preleptotene and pachytene spermatocytes were decreased by 47.60% and 52.85% respectively, followed by secondary spermatocytes (48.10%). Leydig cell nuclear area and mature Leydig cell numbers were significantly reduced when compared with controls. Serum testosterone levels showed significant reduction after Tinospora extract feeding. Seminiferous tubule diameter, Leydig cell nuclear area as well as cross sectional surface area of Sertoli cells were reduced significantly when compared to controls. Biochemical parameters i.e. protein, sialic acid, glycogen contents of testes decreased significantly. Seminal vesicular fructose also depleted whereas, testicular cholesterol was elevated significantly followed by a reduction in testosterone levels. These results suggested antifertility effects of the stem extract of T. cordifolia in male rats.[26]

Nootropic effect

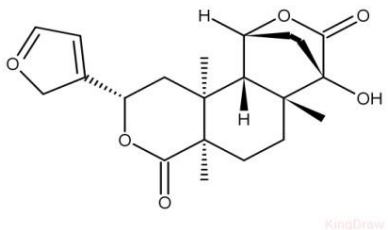
Une HD studied nootropic property of n-butanolic (TBF) fraction of ethanolic extract of *T. cordifolia* stem in different models like elevated plus maze, passive avoidance test and object recognition test model. Scopolamine (1 mg/kg) was used as amnesic agent and piracetam (250 mg/kg) was used as a standard nootropic drug. The results of the present study showed significant increase in transfer latency by TBF on day -2 and Day-9. The TBF also increases step down latency, object recognition index significantly. Scopolamine was used to produce amnesia significantly decreased transfer latency, step down latency, object recognition index. The TBF antagonised the amnesic effects of scopolamine in the above experimental models. Anti-cholinesterase activity of TBF was evaluated by estimation of acetylcholinesteras (AchE) concentration in mice brain after 7-days treatment with TBF. The result showed decreased in AchE concentration indicating involvement of cholinergic system in nootropic activity of TBF.[27]

PHYTOCHEMISTRY

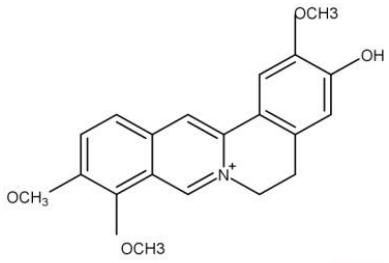
Class	Chemical constituent	Biological activity (in human being)	Plant part	Reference
Alkaloids	Berberin, magnoflorine, choline, tinosporine, tembetarine, isocolumbin,palmitine, aporphine alkaloid, jatrorrhizine, tetrahydropalmitin.	Anti-viral infection, neurological, immunomodulary, anti-diabetes, anti-cancer,	Stem and root	[28]
Glycosides	18-Norclerodane glucoside, furanoide diterpene glucoside, tinocordiside,tinocordifolioside, cordioside, syringin, pregnane glycoside, palmetoside ,cordifoloiside A,B,C,D and E	Immunomodulation, parikinsons, dementia, treat neurological disorder, anticancer activity, nitric oxide scavenger	Steam	[29]
Aliphatic	Octacosanol, heptacosanol, nonacosan-15-one dichloro methane	Anti-nociceptive, anti inflamentry, down regulate VEGF and inhibit TFN-α from binding to the DNA	Whole plant	[28]
Diterpenoid lactone	Furanolactone, tinosporon, tinosporoids, columbin, clerodane derivative [(5R,10R)-4R-8R-Dihydroxy-2S-3R:15,16-diepoxy-cleroda-13(16),14-dieno-17,12S:18,1S-dilactone]	Vasorelaxant, antimicrobial, antihypertensive, antiviral, anti-inflammentry.	Whole plant	[2]
sesquiterpenoid	Tinocordifoline	Antiseptic.	Stem	[2]
Miscellaneous compounds	3,(α,4-dihydroxyl-3-methoxy-benzyl)-4-(4-compounds hydroxyl-3-methoxy-benzyl)-tetrahydrofuran,Giloinin,Tinosporic acid, tinosporidine cordifoline,cardifelone, N-trans-furoloyltyramine as diacetate.	Protease inhibitor for HIV and drug resistant HIV.	Whole plant and root	[2]

STRUCTURES OF CHEMICAL CONSTITUENTS

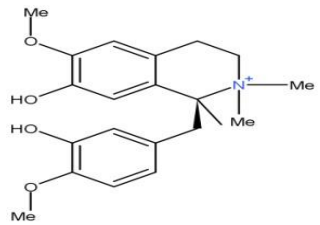
Alkaloids



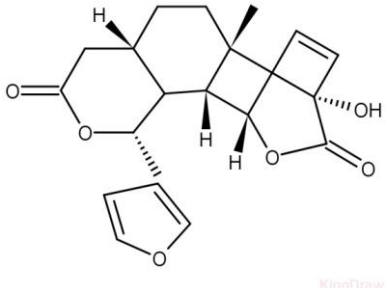
Tinosporinealkaloid



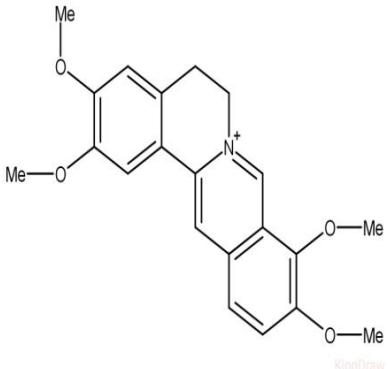
Jatrorrhizine alkaloid



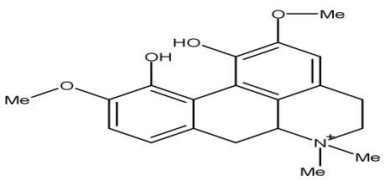
Tembetarine alkaloid



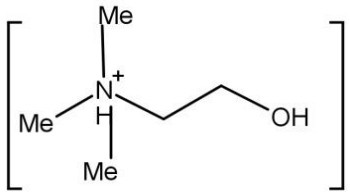
Isocolumbin alkaloid.



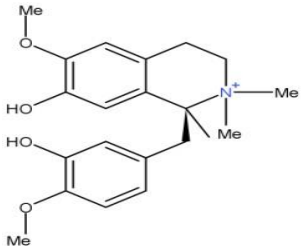
Palmitine alkaloid.



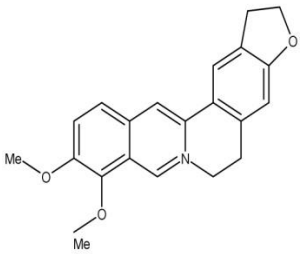
Magniflorine alkaloid.



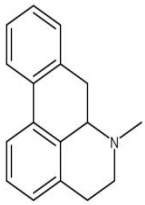
Choline alkaloid.



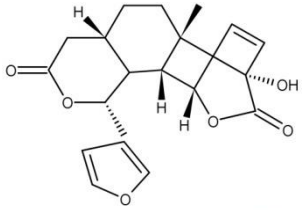
Tembetarine alkaloid.



Berberine alkaloid.

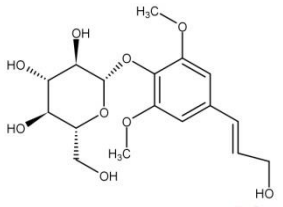


Aprophine alkaloid.

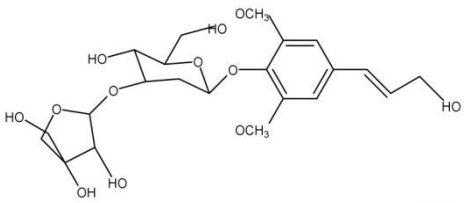


Isocolumbin alkaloid.

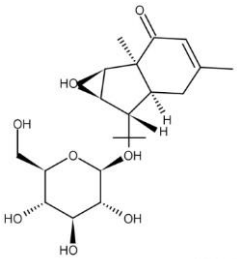
Glycosides



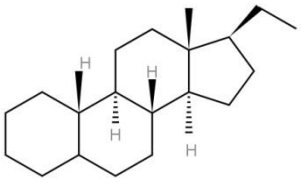
Syringin glycoside.



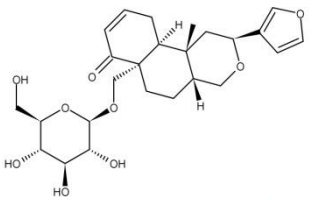
Cordifolioside A.



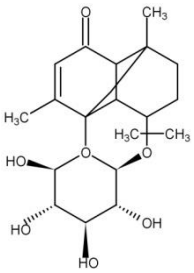
Tinocordiofolioside.



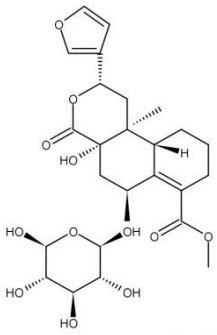
Pregane.



Palmetoside.

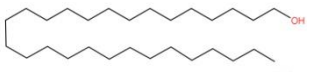


Tinocordiside.

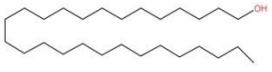


Cardioside.

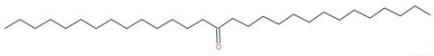
Aliphatic



Ocatacosanol.

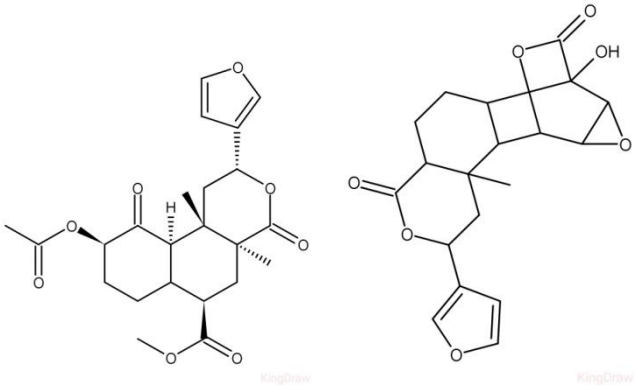


Heptacosanol.



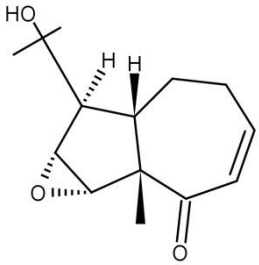
Nonacosan-15-one.

Diterpenoid lactone



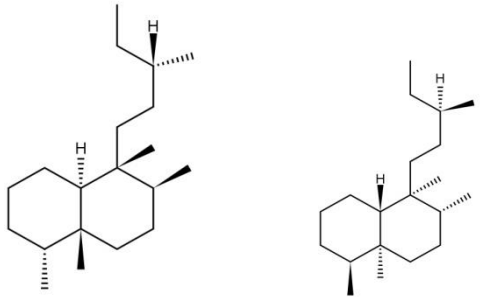
Furanolactone. **Tinosporide.**

Sesquiterpenoid



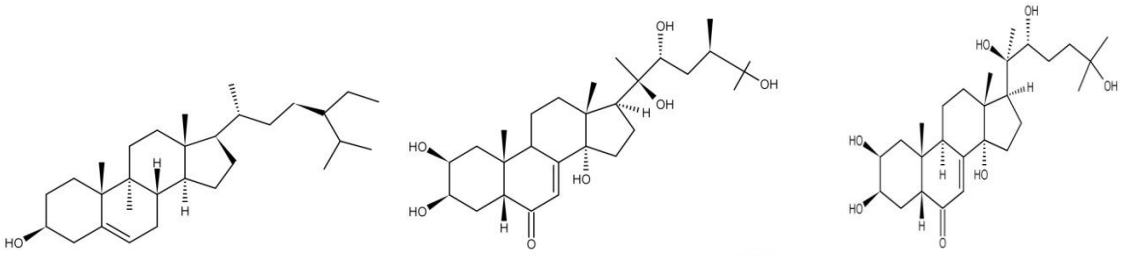
Tinocordifolin.

Miscellaneous compounds



Ent-neo-clerodane **neo-clerodane(ent-clerodane) (clerodane derivatives)**

Steroids



β-sitosterol **makisterone A** **20-Hydroxyecdyne**

CONCLUSION

The present review focuses on the phytochemical and phytopharmacological description and medicinal advantages of *T. cordifolia*. It is source of various types of compound having diverse chemical structure. This review show the various activities of *T. cordifolia* like antidiabetic, anticancer, immunomodulatory, antioxidant, antimicrobial, antipyretic, antimalarial, antiasthmatic, gastroprotective, antidepressant, neuroprotective, anti-ulcer, antidiarrheal, radioprotective, anti-fertility, nootropic and antibacterial. This review will be helpful for researcher in literature survey point of view for *T. cordifolia.*

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