



Review Article

PHYTOPHARMACOLOGY OF *TOONA CILIATA*: A REVIEW

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ABSTRACT

Toona ciliata is the plant mainly distributed in sub Himalayan tract. Traditionally, it is useful in chronic dysentery, leprosy, cures fever, headache, blood complaints, cardiogenic, aphrodisiac, and ulcer. *Toona ciliata* is traditionally used in menstrual disorders. The phytoconstituents present in the plants including triterpenoids, cedrelone, polyynes, limonoids, siderin, steroids etc. Pharmacologically the plant *Toona ciliata* has been investigated for its anti-ulcer activity, analgesic activity, antifungal activity, antimicrobial activity and antitumor activity. The plant also possesses gastro-protective and cytotoxic activity. Steroids can be used medicinally as cardiogenic, growth promoter, anti-tumor, antifungal, hepatoprotective, antimicrobial, anti-tussive etc. Terpenoids presents in *Toona ciliata* were evaluated for the cytotoxic & anti-inflammatory activity in human cancer cell lines. Coumarin containing plants were tested for their antimicrobial and phototoxic activities. Coumarins have a variety of bioactivities including anticoagulant, estrogenic, dermal photosensitizing, anti-microbial, vasodilator, molluscicidal, antihelminthic, sedative and hypnotic, analgesic and hypothermic activity. Polyphenols are most abundant anti-oxidant in human diet. The phenolic compounds are divided into phenolic acids, flavonoids, lignans and stilbenes. Tannins may be employed medicinally in antidiarrheal, haemostatic, and antihemorrhoidal compounds. They have been also reported to have anti-viral, antibacterial, and antiparasitic effects. Flavonoids exhibit several biological effects such as anti-hepatotoxic, anti-inflammatory and anti-ulcer activity.

Keywords: *Toona ciliata*, Phytoconstituents, limonoids & nor-limonoids, polyynes, steroids, anti-oxidant, terpenoids, anti-microbial

INTRODUCTION

Medicinal Plants of Uttarakhand

India is a country of different culture, tradition and traditional knowledge of medicine. Himalayan region is the well known part of the India, enriched with the variety of medicinal plants¹. This has a great wealth of medicinal plants and traditional medicinal knowledge. Medicinal plants of Himalayas are primary health care system among the local people of Himalayan region². Himalayan region is a store house of variety of herbs, medicines and aromatic plant species¹. In primary health care, about 80% of traditional medicines are used which derived from plants.

Traditional medicines are widely being accepted from the ancient time to treat the various diseases. The different parts of plants are used in different ratio to cure disease¹. Historically plants have played a vital role in medicine system³. Due to unique geographical location and different climatic condition in Himalayan region, it is enriched with variety of plant species².

Uttarakhand is the state falls in Himalayan region. It consists of two words "UTTAR" + "KHAND" (meaning NORTH + PART). This state has different kind of geographical condition and vast bio-diversity ranging from the snow bound peaks of the Himalayas to the sub-tropical Terai region. Five major tribal community lives in Uttarakhand, namely Bhotia, Jaunsari, Raji, Tharu and Buksa³. Uttarakhand is separated into two administrative divisions, Garhwal (GARH +WAL meaning TERRITORY + name of the king) and Kumaon³.

The plants used for medicinal purposes in the primary health traditions are slowly becoming extinct due to development activities, population explosion, impact of tourism, deforestation and many more².

Natural Products/ Traditional Plants in Medicinal Use

Natural plants constitute one of the major raw materials of drugs for treating various human diseases. The modern society has been interested in drugs of natural origin due to their harmonious nature with our biological system⁴. Natural plants contain many compounds which help in the treatment of various diseases. Pharmacists are interested in these compounds because of their therapeutic performance and low toxicity⁵.

Natural product research is one of the most promising sources of medicine for the future. The interest in the study of medicinal plants and their traditional use has been increased during last few decades⁶. Phytochemicals are plant-based non-nutrient secondary metabolites, which provide many positive health effects. These secondary metabolites are recognized as efficacious components of plants which can be used in the prevention and management of chronic disease, such as cancer, diabetes and cardiovascular diseases⁷. In earlier studies it is reported that 19 indigenous medicinal plants belonging to 15 families were chosen for investigation of their antimicrobial properties⁸. A large number of Indian medicinal plants possess various pharmacological activities, because it contains number of phytochemicals⁸.

The mahogany (meliaceae) family comprises more than fifty genera with about 1400 species, which are distributed in tropical and subtropical regions. The family is represented by 17 genera and 72 species of which 12 species and two varieties endemic in India⁴.

A number of wild medicinal plants are being cultivated because of their increased popularity and greater demand for medicinal plants. Ethnopharmacological surveys conducted among herbal practitioners have revealed that as a source of herbal therapy the large number of indigenous plants species are being used⁹. Natural medicinal plants have been used to treat human diseases for thousands of years because they have vast and diverse assortment of organic compounds that can produce a definite physiological action on the human body⁵.

Most important of such compounds are alkaloids, tannins, flavonoids, terpenoids, saponins and phenolic compounds². Polyphenols have received a great deal of attention in recent years due to their powerful antioxidant properties. Polyphenols are present at high concentration in a variety of fruits and vegetables. Many studies suggested that consumption of fruits and vegetables rich of polyphenols is related to a reduced risk of coronary heart diseases, neurodegenerative diseases, and certain forms of cancer¹⁰. Drugs obtained from natural sources are believed to have good efficacy, least risk and low side effects. Recently the search for novel pharmacotherapy from medicinal plants for psychiatric illness has progressed significantly. Therefore herbal therapies should be considered as alternative or complementary medicines¹¹. In the search for new therapeutic medicinal plant research has also contributed significantly by demonstrating pharmacological effectiveness of different herbs in various animal models¹².

Quercetin, a bioflavonoid found in apples, berries, onions, tea, and *Brassica* vegetables, has a wide range of biological activities. Like many other polyphenols, quercetin is reported to possess free radical scavenging, iron chelating, and anti-inflammatory properties¹³.

Approximately, 25% of drugs in the pharmaceutical market have in their composition extracts originating from plant sources.

Among 252 drugs considered as basic and essential by the World Health Organization, 11% is exclusively originating from plants such as Taxol (*taxus brevifolia*), etoposide and teniposide (*podophyllum peltatum*), irinotecan, topotecan and camptothecin (*camptotheca acuminata*), vinblastine and vincristine (*catharanthus roseus*), digoxin (*digitalis sp.*)¹⁴.

Toona ciliata Plant Distribution

The genus *Toona* (Meliaceae) consists of upland trees that are widely distributed at the higher altitude. It is found in high altitude of India, Nepal, China, Burma, Thailand, Malaysia, Java to Europe. About 15 species found in tropical Asia and Africa, among them 4 species are found in India and 4 species are distributed in China. 2 species of *Toona* namely, *Toona serrata* and *Toona hexandra*, are found in North West Himalaya¹⁵. The genus *Toona* (Meliaceae) contains a group of traditionally important medicinal plants.

Toona ciliata Plant Description

Common name of the plant is Red cedar, Toon or *Toona* or Tuni, Australian red-cedar, Burma cedar, Indian cedar, Moulmein cedar or the Queensland red cedar¹⁶. Botanical name of the plant Red cedar is *Toona ciliata* belongs to the family Meliaceae. The plant is found in Sub Himalayan tract of India, Assam and through-out hilly regions of central and southern India. The plant of *Toona ciliata* is a medium sized to large deciduous tree. The bark of plant is brown to grey and leaves are 15–45 cm long, usually paripinnate but sometimes with a terminal leaflet in juvenile growth. Apex is acuminate, Base is strongly asymmetric, with entire margin (\pm toothed in saplings), mostly glabrous, Petals are 5–6 mm long and white in colour, seed of *Toona ciliata* is encapsulated in a ellipsoid capsule (10–20 mm long, 6–8 mm diameter), Seeds are winged at both ends.

The seeds, leaves, and stems of *Toona ciliata* & *Toona sinensis* are used as traditional Chinese medicine for the treatment of diarrhea, dysentery and ringworm¹⁷.

Table 1: Description and activities of plant

Common name	Botanical name	Phytochemicals	Pharmacological activities
Toon, Toona, Tun, Tuni, Red cedar, Australian cedar, Indian Mahogany,	<i>Toona ciliata</i> Family- Meliaceae (Mahogany)	1. Coumarin 2. Phenolics & Polyphenols 3. Terpenes & Terpenoids 4. Steroids 5. Flavonoids 6. Limonoids & nor-limonoids 7. Polyynes 8. Tannins	1. Anti-oxidant 2. Anti-diabetic 3. Anti-inflammatory 4. Anti-fungal 5. Anti-microbial 6. Anti-inflammatory 7. Anti-ulcer 8. Cytotoxic

The plant *Toona ciliata* possesses many important biological properties that accounts for its traditional uses in medicinal treatments and dye preparation etc. The flowers are used to produce dye and bark is useful in chronic dysentery, ulcer, leprosy, fever, headache and blood complaints etc¹⁶. The flowers of the plant *Toona ciliata* are used as emmenagogue, used in menstrual disorders. Bark is powerful astringent, used in various forms of ulceration and also in rheumatism¹⁸. The ethanolic leaf extract of *Toona ciliata* was studied for its inhibitive effects on protein non-enzymatic glycation¹⁶.

Leaf extract of *Toona ciliata* has beneficial effect on decreasing blood glucose levels and also decrease hyperlipidemia which is produced due to diabetes. *Toona ciliata* M. Roem. *sensu lato*, is the dominant species in India, this species further extend its

range to eastern Australia where it is commonly known either as *Toona australis* or *Toona ciliata* var. *australis*¹⁹.

Phytochemistry of *Toona Ciliata*

Leaves of *Toona ciliata* - The *Toona ciliata* leaves are important source of some aromatic components like coumarin glycoside, tannins, flavonoids, phenolic compounds, triterpenoids and steroids. From the leaves and twigs of *Toona ciliata*, three new norlimonoids, two new triucallane-type diterpenoids, and a new pimaridine-type diterpenoid, along with two known limonoids and eight known triucallane-type triterpenoids were isolated¹⁶.

Bark of *Toona ciliata* - The bark of *Toona ciliata* contains tetra- nor-triterpenoids, including Toonacilin¹⁶.

Phytochemical studies reported the presence of cedrelone, quercetin, β -sitosterol, gallic acid, protocatechnic acid, p-hydroxy benzoic acid, chlorogenic acid, caffeic acid, vanillic acid, syringic acid, sesquiterpine, cycloartene stigmaterol, campesterol, apotirucallene, tirucallene, catechin, proanthocyanidin, leucoanthocyanidin, Toonacilin, 6-acetoxy Toonacilin, Toonacilid, geranylgeranil, δ -cadinene, calamenene, siderin, deoxy-cedrelone, 1,2-dihydrocadrelone, steroids and C-methyl coumarins, 12 α -hydroxystigmat-4-en-3-one (new bioactive steroid from *Toona ciliata*)¹⁸.

Isolation of the constituents of *Toona ciliata* revealed the presence of 12 limonoids (*Toona yunnanins* A-L) and 11 known compounds, (a) cedrelone, (b) epoxyazadiradione, (c) Toonacilin, (d) Toonaciliatin E, (e) Toonaciliatin H, (f) dysobinin, (g) 12deacetoxytoonacilin, (h) 17-hydroxyazadiradione, (i) dihydroniloticin, (j) dehydroodoratol and (k) 21- α -methylmelianodiol¹⁷.

Chemical Constituents Present in Ethanolic Extract of Leaves and Stem of *Toona Ciliata*

Several studies isolated the compounds and identified 23 compounds from the 95% ethanol extract of the leaves and stems of *Toona ciliata*²⁰. The isolated compounds are- Siderin (1), 4, 6, 7-trimethoxy-5-methylcoumarin (2), isoscapoletin (3), scopoletin (4), 6, 7-dimethoxycoumarin (5), 7-hydroxy-6, 8-dime- thoxycoumarin (6), dehydrodicoumaril alcohol (7), (-)-lariciresinol (8), *thero*-2, 3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxy-propa- nol (9), cycloeculenol (10), 8(14), 15-isopimaradiene-2, 3, 19-triol (11), 3*S*, 5*R*-dihydroxy-6*R*, 7-megstigmadien-9-one (12), (-)-loliolide (13), (+)-catechin (14), dimethyl malate (15), diisobutyl phthalate (16), dibutyl phthalate (17), 1, 3, 5-trimethoxybenzene (18), syringic acid (19), syringaldehyde (20), vanillic acid (21), vanillin (22), and 3, 3', 5, 5'-tetra-tert-butyl-2, 2'-dihydroxybiphenyl (23).

Different pharmacologically active constituents of *Toona Ciliata*

Coumarin

Coumarins are secondary metabolites widely spread in nature, being found in green plants, fungi, bacteria, in some animal species, fruits, green tea and other food and spices²¹. Coumarin is a naturally occurring compound belonging to a large class of phenolic substances which present an aromatic ring fused to a condensed 6-member lactone ring²².

Coumarins are derivatives of cinnamic acid with a benzo- α -pyrone skeleton that are widely distributed in the plant kingdom. More than 1300 coumarins have been isolated and reported from natural sources, particularly from the families Rutaceae, Apiaceae, Fabaceae and Asteraceae²³. There are 4 main subtypes of coumarins: the simple coumarin, furanocoumarins, pyranocoumarins and the pyrone-substituted coumarins. Coumarin and its derivatives are principle oral anticoagulants²⁴.

Coumarin containing plants were tested for their antimicrobial and phototoxic activities. Coumarins have a variety of bioactivities including anticoagulant, estrogenic, dermal photosensitizing, anti-microbial, vasodilator, molluscicidal, anthelmintic, sedative and hypnotic, analgesic and hypothermic activity²⁵.

Three known coumarins, siderin, scopoletin and isofraxidin were isolated from *Toona ciliata*²⁶. Siderin, was isolated from the *Toona ciliata* and the effect of isolate on photosynthesis was tested. Sederin was reported to inhibit both ATP synthesis and electron flow²⁷.

Phenolic

Phenolic compounds are ubiquitous components of fruits, vegetables, and grains. The term phenolic is used for distinct class of compounds including low molecular flavonoids, phenolic esters and acids, as well as high molecular weight polyphenols known as tannins²². Polyphenol or phenolic are the compounds which contains phenol ring in their chemical structure. Anthocyanins that give the purple color to grapes are the phenolic compounds. Tannins that give astringency to tea are also phenolics.

Polyphenols are most abundant anti-oxidant in human diet. The phenolic compounds are divided into phenolic acids, flavonoids, lignans and stilbenes²¹.

Tannins

Tannins are astringent, bitter plant polyphenols that either bind and precipitate or shrink proteins. The term is widely applied to any large polyphenolic compound containing sufficient hydroxyls and other suitable groups (such as carboxyls) to form strong complexes with proteins and other macromolecules. Tannins may be employed medicinally in antidiarrheal, haemostatic, and antihemorrhoidal compounds. They have been also reported to have anti-viral, antibacterial, and antiparasitic effects²⁸.

Tannins also possess other biological activities. Ellagic acid was reported to accelerate blood clotting and used to control hemorrhage in animals and humans. Agrimoniin also shows the beneficial effect to improve immune response²⁹. Tannins present in *Eucalyptus rostrata* shows the antioxidant activity. The *Eucalyptus rostrata* was investigated for tannins and flavonoids. These constituents were then evaluated to estimate the anti-oxidant activity³⁰.

The tannins presents in *Toona ciliata* are ellagic acid, gallic acid, protocatechnic acid, chlorogenic acid, caffeic acid, vanillic acid, syringic acid, catechin¹⁸.

Flavonoids

Flavonoids are formed in plants from the aromatic amino acids phenylalanine and tyrosine, and malonate³¹. Flavonoids are structurally derived from benzo- γ -pyrone displaying a diphenylpropane basic structure, which possess two aromatic rings (A & B rings) along with an oxygen containing heterocyclic ring (C ring)²².

Flavonoids are divided into eight different groups-

- (a) Flavanols or catechins
- (b) Flavandiols
- (c) Flavanones
- (d) Dihydroflavanols
- (e) Flavones
- (f) Isoflavones
- (g) Flavonols
- (h) Anthocyanidins

Flavonoids exhibit several biological effects such as anti-hepatotoxic, anti-inflammatory and anti-ulcer activity. They also inhibit enzymes such as aldose reductase, cyclooxygenase, Ca ATPase, xanthine oxidase, phosphodiesterase and lipoxigenase³². Quercetin, a bioflavonoid found in apples, berries, onions, tea, and *Brassica* vegetables, has a wide range of biological activities. Like many other polyphenols, quercetin is reported to possess free radical scavenging, iron chelating, and anti-inflammatory properties¹³.

Several studies reported the anti-oxidant action of flavonoids. The mechanism of anti-oxidant action can include- (1) suppression of ROS (2) scavenging reactive oxygen species, (3) up-regulating or protecting anti-oxidant defenses³¹.

Steroids

The petroleum ether extract of *Toona ciliata* was investigated and a new hydroxyl steroidal ketone was isolated. The isolated steroid was named as- 12 α -hydroxystigmast-4-en-3-one³³.

The *Toona ciliata* was studied and reported to contain five pregnane steroids³⁴.

(1)-Toonasterone A, (2)-Toonasterone B, (3)- (Z)-Aglawone, (4)- (Z)-Toonasterone C, (5)-(E)- Toonasterone C.

Plant steroid plays a crucial role in the development of the human body. These steroids can be used medicinally as cardiostimulant, growth promoter, anti-tumor, antifungal, hepatoprotective, anti-microbial, anti-tussive etc. The examples of these steroids are- bufadinolides, cardinolides, cucurbitacins, steroidal alkaloids, saponin/ steroid saponins, withasteroid/withanolides³⁵.

Terpenes & terpenoids

The terpenes are large and diverse class of organic compounds, produced by variety of plants. Terpenes are often strong smelling and thus may have had a protective function. Steroids are derivatives of the triterpene squalene³⁶. When terpenes are modified chemically (such as by oxidation or rearrangement of the carbon skeleton) the resulting compounds are generally called as terpenoids.

Terpenes and terpenoids are the primary constituents of essential oils of many types of plants and flowers. Vitamin A is an example of terpene. The fragrance of rose and lavender is due to monoterpenes³⁶. Terpenoids presents in *Toona ciliata* were evaluated for the cytotoxic & anti-inflammatory activity in human cancer cell lines³⁷. The plant to *Toona ciliata* (Meliaceae) is a rich source of structurally intriguing limonoids with diverse bioactivities. The chemical constituents of the leaves of *Toona ciliata* have been investigated to give limonoids and triterpenoids³⁸.

Diterpenoids- A new pimarane-type diterpenoid was isolated from the leaves and twigs of *Toona ciliata* and identified as-Toonaciliatin M³⁹.

Triterpenoids- Several studies reported that Terpenoid was obtained as a colorless oil & its molecular formula was determined as C₃₆H₅₆O₆. Eg.- *Toonaciliatone* A and *Toonaciliatine* A³⁸. Two new tetrane-type triterpenoids were identified as- *Toonaciliatin* K & L³⁹.

Tetra-nor-tri-terpenoids-The *Toona ciliata* was reported to contain two Novel B-seco-Tetranortriterpenoids and was reported to exhibit anti-feeding activity. The B-seco-Tetranortriterpenoids are Toonacillin and 6-AcetoxyToonacilin⁴⁰.

The Ether extract of leaves of *Toona ciliata* was used to isolate the tetranortriterpenoid B-lactone. The isolated terpenoid compound was known as Toona folin. Toona folin is the first tetranortriterpenoid B-lactone found in meliaceae⁴¹.

Penta-nor-tri-terpenoids- the methanolic extract of *Toona ciliata* was reported to contain two pentanortriterpenoids, 5 α , 6 β , 8 α -trihydroxy-28-norisoToonafolin and 5 α , 6 β , 8 α , 12 α -tetrahydroxy-28-norisoToonafolin⁴².

Limonoids

Isolation of the constituents of *Toona ciliata* revealed the presence of 12 limonoids (Toona yunnanins A-L) and 11 known compounds, (a) cedrelone, (b) epoxyazadiradione, (c) Toonafolin, (d) Toonaciliatin E, (e) Toonaciliatin H, (f) dysobinin, (g) 12-deacetoxy-toonacilin, (h) 17-hydroxyazadiradione, (i) dihydroniloticin, (j) dehydrodoradol and (k) 21- α -methylmelianodiol¹⁷.

Two novel limonoids were isolated from the dichloromethane extract from the seeds of *Toona ciliata*, 12-deacetoxyToonacilin and 6 α - acetoxy- 14 β , 15 β - epoxyazadirone^{42,43}. An investigation of *Toona ciliata* has led to the identification of two novel meliacin butenolides, 21-hydroxycedrelone and 23-hydroxycedrelone. Two known limonoids, cedrelone and 23-hydroxytoonacilide. Three known coumarins, siderin scopoletin and isofraxidin were isolated²⁶. An unusual 9, 11-*seco* limonoid had been isolated from the bark of *Toona ciliata* and named as toonasecone⁴⁴.

Norlimonoids

The *Toona ciliata* extract was isolated and two new norlimonoids was identified as-5 α ,6 β ,8 α -trihydroxy-28-nor-iso-toonafolin and 5 α ,6 β ,8 α ,12 α -tetra-hydroxy-28-nor-iso-toonafolin⁴⁵.

Polyynes

Toona ciliata was evaluated to contain series of bioactive compounds especially limonoids. Three new polyynes, (1)-(9S,10E,16R)-octadec-10-ene-12,14- diyne-1,9,16-triol, (2)-(9S,10E,16R)-9,16-dihydroxyoctadec-10-ene-12,14-diyne-1-yl acetate, and (3)- (3R,8E,10S)-heptadec-8-ene-4,6-diyne-3,10-diol were isolated from the leaves of *Toona ciliata* var. *ciliata*⁴⁶.

Pharmacological Activities

Antidiabetic activity

Toona ciliata leaves extract has beneficial effect on decreasing blood glucose levels and also decrease hyperlipidemia which is produced due to diabetes (monika rana et al;2016).

STZ was dissolved in citrate buffer (pH 4.5) to induce diabetes⁴⁷.

The previous studies reported that flavonoids are responsible for hypoglycemic action of a plant extract^{48,49,50,51}. The antidiabetic action of extract of *Toona ciliata* might be due to the flavonoids presents in it which was indicated in the preliminary phytochemical screening.

Anti-ulcer activity

In aspirin plus pylorus ligation induced gastric ulcer the ethanolic extract showed the significant reduction in gastric volume, free acidity, total acidity and ulcer score. In terms percentage ulcer inhibition the ethanol extract of *Toona ciliata* showed 100% activity as compared to control. HCL-ethanol induced gastric damage in mice possibly through leukotrienes production and also involvement of 5-lipoxygenase in the formation of ulcer lesion. So the protective effect of the extract *Toona ciliata* against the gastric 5-lipoxygenase or Leukotriene pathway². The anti-ulcer activity of *Toona ciliata* heartwood in this experimental model may be due to the terpenoids and steroids².

Anti-oxidant activity

The *Toona ciliata* leaf was extracted and chemical constituents were isolated. It was concluded that aqueous and acetone extract of *Toona ciliata* shows anti-oxidant activity (Praveen Sharma et al; 2009). Tannins and flavonoids presents in plants can be the chemical to prevent oxidation. The tannins and flavonoids presents in *Eucalyptus rostrata* possess the antioxidant activity³⁰.

Anti-inflammatory activity

The ethanolic leaf extract of *Toona ciliata* shows the anti-oxidant and anti-inflammatory activity (hemayet hossain et al; 2014). The plant shows the presence of phenolic compounds which can be the responsible for both anti-oxidant and anti-inflammatory activity. *Toona ciliata* was evaluated for cytotoxic

and anti-inflammatory activity of triterpenoids presents in it. The new isolates were evaluated for their cytotoxicities using six human cancer cell lines and also for their inhibitory effects on lipopolysaccharide- induced nitric oxide production in cells⁴⁶.

Antimicrobial activity

The methanolic extract of *Toona ciliata* exhibited maximum inhibition against test human and phyto-pathogens (Kumara shanthamma kavitha and Sreedharamurthy Satish; 2013). Antimicrobial and fungicidal activity of the plant extract was also evaluated and reported^{52,53,54}. The extract of *Toona ciliata* (stem bark) and amoorah rohituka (stem bark), along with siderin, a major coumarin from *Toona ciliata*, exhibited significant in vitro antibacterial activity. The extract also demonstrated mild anti-fungal effect⁵⁵.

Antifungal activity

Cedrelone is the natural tetraterpenoid from *Toona ciliata* which exhibits antifungal activity. Cedrelone from *Toona ciliata*, azadiradione from *Azadirachta indica*, limonin, limonol and nomilinic acid from *Citrus medica* were tested for antifungal activity. Cedrelone from the *Toona ciliata* was most effective among the all in reducing rust pustule emergence (T.R. Govindachari et al; 2000)⁵⁶. All parts of *Toona ciliata* (stem, leaf and fruit) exhibit significant reduction in growth of the fungus (I. Siddiqui et al; 2015)⁵⁷.

CONCLUSION

The *Toona ciliata* leaf extract shows the mycotoxic and antifungal activity. The active bioactive compound can be isolated from it and it can be further used as alternate to the synthetic fungicidal. *Toona ciliata* has the anti-ulcer activity so the extract can be used as alternate to synthetic anti-ulcer drugs. The previous studies suggested some pharmacological activities of different extracts of plant *Toona ciliata*. The activities include- Antidiabetic activity, Anti-ulcer activity, Anti-oxidant activity, Anti-inflammatory activity, Antimicrobial activity, Antifungal activity.

Phenolic content present in *Toona ciliata* shows the anti-oxidant and anti-inflammatory activity therefore, it can be effective in the treatment of stress and free radical balancing. The extract of *Toona ciliata* was reported to contain bioactive chemical moieties which include- coumarin, tannins, terpenoids, flavonoids, phenolics and polyphenols, steroids, polyynes etc. which can be used to treat diseases like stress, depression, Alzheimer's disease, Huntington's disease. Previous studies reported the anti-diabetic, anti-fungal, anti-microbial, anti-inflammatory, anti-ulcer and anti-oxidant activities which were possibly due to the bioactive constituent present in it.

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