**ABSTRACT**

Clitoria ternatea (L.) native to tropical Asia is a perennial, twining herbal medicinal plant, has a long tradition of use as a memory enhancer and anxiolytic agent. Various constituents are found in different parts of the plant. The active chemical constituents reported from this plant are tannins, resins, starch, taraxerol, taxerone, alkaloids, flavonoids, saponins, proteins, anthocyanins and carbohydrates. In traditional medicine, the plant is used in treatment of jaundice, migraine, throat, eye infections, skin diseases, asthma, swollen joints, ear-aches, eruptions, fever, urinary tract infections, constipation, snake-bites, head-ache, indigestion, leprosy and central nervous system disorders. Its various extracts possess reported number of pharmacological activities such as nootropic, anxiolytic, anti-convulsant, sedative, anti-pyretic, anti-inflammatory, anti-diabetic, anti-oxidative, anti-stress, immunomodulatory, larvicidal, proteolytic, anti-helmintic, diuretic, anti-microbial and memory enhancing. The present review is therefore, an effort to give a detailed survey of the literature on its pharmacognosy, phytochemistry, and its traditional uses along with special emphasis given on pharmacological activities.

**Key words:** Clitoria ternatea, Fabaceae, Butterfly pea, Biological activities, Phytochemistry.

**INTRODUCTION**

Clitoria ternatea commonly known as Butterfly pea belonging to the family Fabaceae and sub-family Papilionaceae is a perennial leguminous twiner, which originated from tropical Asia and later was distributed widely in South and Central America, East and West Indies, China and India, where it has become naturalised. Clitoria ternatea commonly also called Clitoria, blue-pea, kordofan pea (Sudan), cunha (Brazil or pokindong (Philippines) is a vigorous, summer growing, legume of old world origin. Clitoria L. comprises 60 species distributed mostly within the tropical belt with a few species found in temperate areas. The mostly frequently reported species is Clitoria ternatea. It is characterised as a woody genus with showy, papilionaceous flowers, an infundibuliform calyx with persistent bracteoles, stipules and stalked ovaries. People use different species of Clitoria as a medicinal agent to enhance fertility, to control menstrual discharge, to treat gonorrhea and as a sexual stimulant. Fantz reported economic uses for 23 species of Clitoria as antihelmintic, diuretic, refrigerant etc. This plant is known as Aparajit (Hindi), Aparajita (Bengali), and Kokkattam (Tamil) in Indian traditional medicine. It has several synonyms in ayurvedic scriptures like: Sanskrit names: Aparajita, Girikarnu, Asphota and Vishnukranta. English names: Butter-fly pea, Mazerion. Gorani (Guj), Girakarni (Mar) and Buzrula (Arabic).

The plant is mainly used as a forage as it is highly palatable for live-stock and it is well adapted to various climates. Native to the island of Ternate in the Molucca archipelago, this species is now widely grown as ornamental, fodder or medicinal plant. It is found commonly as an escape in hedges and thickets throughout India to an altitude of 15cm and in Andaman Islands. It can be grown as a forage legume either alone or with perennial fodder grasses in Punjab, Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Madhya-Pradesh, Andhra-Pradesh and Karnataka. The plant is also suitable as a green manure and cover crop. Besides suppressing many perennial weeds, it enriches the soil by fixing nitrogen. Clitoria ternatea is now widely distributed throughout the humid, lowland tropics occurring both naturally and in cultivations although no improved pasture cultivars have been developed. Clitoria ternatea is cultivated throughout India but is naturalized in the more tropical regions occurring both naturally and in cultivations although no improved variety has been developed.

**HISTORY**

From ancient times “Shankpushpi” is known as reputed drug of Ayurveda and reported as a brain tonic, nerve tonic and laxative. It is considered as a MEDHYA-RASAYANA in Ayurvedic texts. It comprises of entire herb with following botanicals viz Convolvulus pluricaulis (Convolvulaceae), Evolvulus alsinoides (Convolvulaceae), Clitoria ternatea (Papilionaceae) and Conscoria decussata (Gentianaceae). It is an Ayurvedic drug used for its action on the CNS, especially for boosting memory and improving intellect. The flowers of the plant Clitoria ternatea resemble a conch shell; therefore it is commonly called “SHANKPUSHPI” in the Sanskrit language where it is reported to be a good “MEDHYA” (brain tonic) drug and, therefore, used in the treatment of “Masasika Roga” (mental illness). Extracts of this plant have been used as an ingredient in MEDHYA-RASAYANA, a rejuvenating recipe used for treatment of neurological disorders.

**CULTIVATION**

Clitoria ternatea is a deep-rooted, tall slender, climbing legume with five leaflets and a deep blue flower. It is well adapted to a variety of soil types (pH 5.5-8.9) including calcareous soils. It is surviving in both the extended rainfall regions and prolonged periods of drought. Propagation is done through seed. It exhibits excellent regrowth after cutting or grazing within short period and produce high yields also. Clitoria ternatea L. is well adapted to heavy cracking clay soils in northern Australia. It is also used as a cover crop and green manure. The seeds are normally sown from the beginning until the middle of the wet season. It persists best when grazed lightly during the wet season.

**DESCRIPTION**

Clitoria ternatea has twinng fine stems, 0.5-3 m long. The leaves are pinnate, with 5-7 elliptic to lanceolate leaflets, 3-5 cm long and shortly pubescent underneath. Flowers are solitary, deep blue to blue mauve; very short pedicelate and 4-5 cm long. Pods are flat, linear, beaked, 6-12 cm long, 0.7-1.2 mm
PHYTOCONSTITUENTS

Roots, seeds and leaves are the reported plant part used from ancient times.[5] The major phytoconstituents found in Clitoria ternatea are the pentacyclic triterpenoids such as taraxerol and taraxerone.[17,22] Phychochemical screening of the roots shows the presence of tannins, alkaloids, flavonoids, saponins, tannins, carboxydrates, proteins, resins, starch, taraxerol and taraxerone.[21] A new simple, sensitive, selective and precise High Performance Thin Layer Chromatography method has been developed for the determination of taraxerol in Clitoria ternatea Linn. which was being performed on Thin Layer Chromatography aluminium plates.[21] A wide range of secondary metabolites including triterpenoids, flavonol glycosides, anthocyanins and steroids has been isolated from Clitoria ternatea.[19,20] Four kaempferol glycosides I II, III and IV were isolated from the leaves of Clitoria ternatea L. Kaempferol-3-glucoside (I), kaempferol-3-rutinoside (II) and kaempferol-3-neohesperidoside (III) were identified by Ultra Violet, Protein Magnetic Resonance and Mass Spectrometry. (IV), C₁₃H₁₂O₆, mp: 198, was characterized as Kaempferol-3-o-rhamnopyranoside in spectral data and was named clitorin.[20] The seeds contain nucleoprotein with its amino-acid sequence similar to insulin, delphinidin-3,3,5-triglucoside, essential amino-acids, pentosan, water-soluble mucilage, adenosine, an anthoxanthin glycoside, greenish yellow fixed oil.[21] a phenol glycoside, 3,5,7,4-tetrahydroxy-flavone-3-rhamoglycoside, an alkaidol, ethyl D-galactopyranoside, p-hydroxyacinnamic acid polypeptide, a highly basic protein-finitin, a bitter acid resin, tannic acid, 6% ash and a toxic alkaidol.[19,20] According to Yogaransamhnan seeds contain γ-sitosterol, β-sitosterol, and hexacosanol and anthocyanin glucosides.[20,21] It also contains anti-fungal proteins and has been shown to be homologous to plant defensins.[19,21] Aabgeena et al. reported a lectin present in the seeds of Clitoria ternatea agglutinated trypsin-treated human B erythrocytes.[21] Since the purified lectin was found to be potential tool for cancer studies so an attempt was made for the alternate high yield purification method for Clitoria ternatea lectin designated C TL, present in the seeds of this member of leguminose family.[21] Another study demonstrated that minor delphinidin glycosides, eight anthocyanins (tannins C1, C2, C3, C4, C5 and D3 and preternatins A3 and C4) were isolated from the young Clitoria ternatea flowers.[17] Recent study showed that malonylated flavonol glycosides were isolated from the petals of Clitoria ternatea with different petal colors using LC/MS/MS. It was also reported that five new anthocyanins, tannatans A3, B3, B4, B2 and D2 were isolated from Clitoria ternatea flowers.[21]

Pharmacological studies have confirmed that Clitoria ternatea exhibit a broad range of biological effects, some of which are very interesting for promising future development.

Memory enhancement activity studies

The oral treatment of Clitoria ternatea roots extract at doses significantly increased memory in rats.[12,19] The alcoholic extracts of aerial parts and roots of CT was reported to attenuate electroshock induced amnesia. The acetylcholine (AcH) content of the whole brain and acetyl cholinesterase activity at different regions of the rat brain viz cerebral cortex, mid-brain, medulla oblongata and cerebellum was evaluated.[21,22] It was suggested that an increase in (AcH) in rat hippocampus may be the neurochemical basis for improved learning and memory.[14,15] Rai et al by using passive avoidance test and spatial learning T-maze have also shown that the aqueous root extract of Clitoria ternatea enhances memory in rats.[16] In another reported study the effect of aqueous root extract on the dendritic cytoarchitecture of neurons of the amygdale was studied.[23] This improved dendritic arborisation of amygdaloidal neurons correlates with the increase passive avoidance learning and memory in the Clitoria ternatea treated rats.[23]

Anti-epileptic activity studies

Methanol extract from the aerial parts of Clitoria ternatea was screened by using pentylenetetrazol (PTZ) and maximum electroshock (MES) – induced seizures in mice at the dose of 100 mg/kg p.o. CT significantly delayed the onset of convulsions and also delayed the duration of tonic hind limb exten- sion in MES-induced convulsions.[21]

Anti-inflammatory, analgesic and anti-pyretic activity studies

The study was obtaining the anti-inflammatory activity of the methanolic extract from the roots of Clitoria ternatea Linn. using rat models. In the same study the ethanolic extract was also evaluated for analgesic activity in mice with the acetic acid-induced writhing response and mechanical stimulus by tail clip method. In another study, the methanol extract of CT was evaluated for its anti-pyretic potential in albino rats and the anti-pyretic effect of the extract was comparable to that of paracetamol (PCM) (150 mg/kg b.w. p.o) a standard anti-pyretic agent.[20] Anti-oxidative studies

It has been established that oxidative stress is among the major causative factors of many chronic and degenerative diseases.[24] CT petals have been recognised to possess anti-oxidant activity.[19,25] Extracts of Clitoria ternatea flowers are used in Thailand as a component of cosmetics and the chemical composition of the flowers suggest that they may have anti-oxidant activity. Aqueous extracts were shown to have stronger anti-oxidant activity than ethanol extracts.[26] The antioxidant potential of aqueous leaf extracts of
**Clitoria ternatea** were evaluated by determining the levels of enzymatic and non-enzymatic antioxidants. In vitro antioxidant capacity was also determined using different assays such as Ferric reducing power assay (FRAP), reducing activity assay, diphenyldicarboxylhydrazine (DPPH) assay and Hydroxyl radical scavenging activity and the results were comparable with standard antioxidants such as butylated hydroxyl toluene (BHT), ascorbic acid and rutin. [10]

**Blood platelet aggregation inhibition studies**
An anthocyanin ternaits D1 isolated from petals of Clitoria ternatea was evaluated for in vitro platelet aggregation inhibitory activity in rabbits and the results of various reported studies showed significant inhibition of collagen and adenosine diphosphate (ADP) induced aggregation of platelets. [11, 16, 67]

**Anti-diabetic studies**
Oral administration of aqueous extract of CT leaves (400mg/kg body weight) and flowers (400mg/kg body weight) for 84 days showed significantly reduced serum glucose, glycosylated hemoglobin, total cholesterol, triglycerides, urea, creatinine and the activity of gluconeogenic enzyme glucose-6-phosphatase, but increased serum insulin, HDL-cholesterol, protein, liver and skeletal muscle glycogen content and the activity of glycolytic enzyme glucokinase. For all the above biochemical parameters investigated, Clitoria ternatea leaves treated rat showed a little better activity than Clitoria ternatea flowers treated diabetic rats. [13, 61, 68]

**Local anaesthetic activity studies**
The local anaesthetic effect of an alcoholic extract of Clitoria ternatea aerial part was studied by Kulkarni et al using corneal anesthesia in rabbits and plexus anesthesia in frogs. The results were almost as effective as xylocaine in inducing local anesthesia. [18, 190]

**Anxiolytic activities**
In another study the effect of alcoholic extract of aerial parts of Clitoria ternatea on spatial discrimination in rats followed by oral treatment with alcoholic extract at a dose of 460 mg/kg significantly prolonged the time taken to traverse the maze, which was equivalent to that produced by chlorpromazine. [111] The oral administration of CT (100–400mg/kg) dose dependently increased the time spent in the open arm, the time spent in the lit box and decreased the duration of time spent in the dark box. The oral administration of CT (30mg/kg) failed to show any significant effect in both animal models of anxiety. The animals treated with CT (100mg/kg) showed a significant increase in the inflexion ratio and discrimination index which provides evidence for the species nootropic activity. [192]

**CNS depressant activity studies**
The Clitoria ternatea was studied for its effect on cognitive behavior, anxiety, depression, stress and convulsions induced by (PTZ) and (MES). The extract decreased time required to occupy the central platform (transfer latency, TL) in the elevated plus maze (EPM) and increased discrimination index in the object recognition test, indicating nootropic activity. It decreased the duration of immobility in tail suspension test, reduced stress induced ulcers and reduced the convulsing action of PTZ and MES. The extract exhibited tendency to reduce the intensity of behavior mediated via serotonin and Ach. The effect on DA and noradrenalin mediated behavior was not significant. In tendency to reduce the intensity of behavior mediated via serotonin and Ach. The effect on DA and noradrenalin mediated behavior was not significant. In short, the extract was found to possess nootropiy, anxiolytic, antidepressant and anti-stress activities. [210] The nootropic drugs facilitate intellectual performance, learning and memory. [139]

**Anti-stress activities of Clitoria ternatea**
The anti-stress activity of aerial parts was assessed using cold restraint stress (CRS) induced ulcers, lithium-induced head twitches, clonidine-induced hypothermia, sodium nitrite-induced respiratory arrest and haloperidol-induced catalepsy in rat and mice. [71]

**Effect of Clitoria ternatea on general behaviour**
Ethanol extract of the root of Clitoria ternatea was evaluated for different neuropharmacological actions in rats and mice, such as general behavior, exploratory behavior, muscle relaxant activity and phenobarbitone induced sleeping time. The ethanol extract at doses of 100 and 150 mg/kg caused reduction in spontaneous activity, decrease in exploratory behavioral pattern by the head dip and Y-maze test, reduction in the muscle relaxant activity by rotarod, 30°C inclined screen and traction tests indicating significant neuropathological activity. [171]

**Immunomodulatory effects**
This study evaluated the immunostimulatory activities of aqueous extracts of Clitoria ternatea leaf and flower. The studies were conducted on oral administration of aqueous extract of CT to allodoxan-induced diabetic rats for a duration of 60 days which significantly decreased the in serum glucose and cholesterol levels. The total white blood cells, red blood cells, T-lymphocytes and B-lymphocytes were significantly increased in treated animals, while monocytes and eosinophils showed an opposite trend. These results further indicate that these plant extracts have immunomodulatory effects that strengthen the immune system. [71]

**Larvicidal activities**
The methanol extracts of Clitoria ternatea seed extract was effective against the larvae of all the three species with LC₅₀ values 65.2, 154.5 and 54.4 ppm, respectively for A. stephensi, A. aegypti and C. quinquefasciatus. CT was showing the most promising mosquito larvicidal activity. [71, 154]

**Proteolytic activities**
The activities of endopeptidases (hemoglobin pH 3.5 and azocasein pH 6.0), carboxypeptidase benzoyl carbonyl (CBZ-Phe-Ala Ph 5.2), and arylamidases lysophosphatidic acid and a-N-benzoyl-L-arginine P-nitro-analide (LPA 7.0 and RAPA 7.6) were assayed in extracts of cotyledons and axis of resting and germinating seeds of Clitoria ternatea but the endopeptidases at pH 3.5 and the arylamidases at 7.0 were high in cotyledons. The activities of carboxypeptidase and the arylamidase increased in cotyledons reaching a maximum at pH 9, while the endopeptidases showed an increase at the day 9 followed by a decrease. In the axial tissue the endopeptidases and carboxypeptidase activities showed an increase until the day 9 followed by a decrease and arylamidases were low. The increase of acidic endopeptidases and carboxypeptidase activities in germinating cotyledons is an indication of their participation in the degradation of the storage proteins. [73, 75-79]

**Antihelmintic activities**
There were so many studies which have been reported on antihelminthic activity of Clitoria ternatea. It was indicated that crude alcoholic extract of CT and its ethyl acetate and methanol fractions significantly demonstrated paralysis and also caused death of worms especially at higher concentration of 50 mg/ml as compared to standard reference piperazine citrate. [210] Inhibition effect of CT leaves on free-living nematodes was evaluated using aqueous and methanol extract. [211] In another study, flowers, leaves, stems and roots of CT were evaluated for anti-helmintic activity on adult Indian earthworms Pheretima posthuma. Methanol extract of root is most potent and required very less time to paralysis and death of worms as compared to other extracts. The potency increases from flowers, leaves, stems to roots. [212]

**Diuretic activity**
The powdered form of dried whole root and ethanol extract were evaluated for diuretic activity and only single I.V. dose of extract produce moderate increase in urinary excretion of Na, K and decrease in Cl but no change in urine volume. Also so appreciable effect seen on oral dosing. [81]

**Anti-microbial activities**
The methanolic extracts of the leaves and root of Clitoria ternatea were tested for their antibacterial activity against different pathogenic drug resistant Gram-positive and Gram-negative clinical isolates and minimum inhibitory concentration was determined by agar dilution technique followed by estimation of zone of inhibition against the selected strains by disc diffusion technique and comparison was done with reference to the standard antibiotic ciprofloxacin. The leaf was found to possess powerful antibacterial activity against E. coli and V. cholera, known for causing dysentery, and S. aureus, causative agent of fever. The leaf extract showed stronger antibacterial activity than root extract. Both extracts were shown to be bactericidal in their mode of action. Quercetin may contribute to the activity of leaf extract. [84]

In another study, it was reported that crude extract from seeds of CT showed maximum zone of inhibition (22±0.5 mm) against E. coli at 0.75 mg concentration and minimum with M. flavus (14±1 mm) and the callus extract showed maximum zones of inhibition (16±2mm) against S. typhi while the lowest with E. coli and S. aureus (12±1 mm and 12±0.9mm) respectively. [213] Alcoholic and Aqueous extracts from in vitro raised calli were tested for antibacterial activity by agar well diffusion method against Gram-negative bacteria. Antibacterial activity was shown against Salmonella spp. and Shigella dysenteriae, organism causing enteric fever. [87] In addition, the methanol crude extracts showed anti-bacterial activity against K. pneumonia and P. aeruginosa. [197]
The crude extract from seeds of CT showed strong antifungal activity on the test fungus A. niger and A. ochraceous followed by other organisms. The presence of small molecular weight, cys-rich protein, finotin obtained from seeds of the plant CT has been demonstrated for its antifungal property. The extract which was prepared from CT leaves, was assessed for antifungal activity against selected fungi (Aspergillus niger) by method. The extract showed a favorable antifungal activity with a minimum inhibitory concentration (MIC) 0.8 mg/ml and minimum fungicidal concentration (MFC) 1.6 mg/ml respectively.

Miscellaneous
The plant of interest was found to be active as nitrogen supplements to Napier grass basal diet in relation to the performance of lactating Jersey cows.[11,10,01] Polar (ethanol) and non polar (benzene) extracts of Clitoria ternatea seeds at doses of 75 and 100 mg/kg, i.p. was evaluated on milk induced leucocytosis and milk induced eosinophilia in mice and found to have significant inhibitory action. The ethanol and benzene extracts showed milk induced leucocytosis in dose dependent manner. But in milk induced eosinophilia ethanol extracts showed inhibition eosinophilia in dose dependent manner while benzene extract does not showed dose dependent inhibition. This inhibition of leucocytosis and eosinophilia indicates the anti-allergic potential of Clitoria ternatea.[90]

CONCLUSION
Major thrust by whole of the pharmaceutical industry is focused towards design and development of new plant based drugs through investigation of leads from traditional system of new plants. In the study of Clitoria ternatea alcoholic extracts of roots, leaves and flowers gives different pharmacological activities like anti-inflammatory, antiheimetic, immunomodulatory, antithromasthmatic, antidespressant, anticonvulsant, analgesic, antipyretic, anti-fungal, proteolytic and antihypertensive. Many important phytocosmetitens responsible for the activity were isolated. The scientific research on Clitoria ternatea suggests a huge biological potential of this plant. Though the reported evidences supports the safety and efficacy of CT, but the quality of the evidence is limited in respect to its bioactive secondary metabolites, bioavailability, pharmacokinetics and therapeutic importance including clinical trials, which are not known with sufficient details. It is strongly believed that detailed information as presented in this review might provide detailed evidence for the use of this plant in different medicines. At the same time, the original and aqueous extracts of Clitoria ternatea could be further explored in the future as a source of useful phytochemicals for the pharmaceutical industry.

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