Journal of Advanced Pharmacy and Drug Development
www.japdd.com

Review Article

An Updated Review on the Pharmacological Potential of *Clitoria ternatea* L.

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Received on: 20 August 2025
Revised on: 14 September 2025
Accepted on: 30 September 2025

DOI:
https://doi.org/10.64842/4x7yhf37

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Abstract

Clitoria ternatea, a perennial twining herb indigenous to tropical Asia, flourishes optimally in well-drained soil and is adaptable to conditions ranging from full sunlight to partial shade. Various components of *Clitoria ternatea* have been utilized as active constituents in numerous Ayurvedic formulations for the treatment of diverse disorders. Several traditional Ayurvedic ' Medha ' (cognitive-enhancing) preparations incorporate *C. ternatea* in conjunction with other medicinal plants. The plant has a long-standing history of use in traditional medicine, particularly for its memory-enhancing and anxiolytic properties. Different plant parts contain a variety of bioactive compounds, including tannins, resins, starch, taraxerol, taraxerone, alkaloids, flavonoids, saponins, proteins, anthocyanins, and carbohydrates. Traditionally, *Clitoria ternatea* has been used to treat a wide range of ailments, including jaundice, migraines, throat and eye infections, skin diseases, asthma, joint inflammation, earaches, eruptions, fever, urinary tract infections, constipation, snake bites, headaches, indigestion, leprosy, and central nervous system disorders. It has also been utilized in the management of gonorrhea, stress, and infertility, and is commonly used as a natural food colorant. In Ayurveda, this plant is highly esteemed for its therapeutic benefits. Pharmacological studies have corroborated several of its medicinal properties, including anti-inflammatory, analgesic, antimicrobial, and anxiolytic activities.

Keywords: *Clitoria ternatea,* Pharmacological potential, Ayurvedic medicine – Phytochemistry, Antidiabetic activity.

Introduction

Clitoria ternatea, commonly referred to as Asian pigeonwings, bluebell, blue pea, butterfly pea, cordofan pea, and Darwin's pea, is a species of the Fabaceae family. It is also known by the synonym, Clitoria principissae. This plant exhibits two flower color variations: blue and white [1]. Indigenous to tropical and subtropical regions, the visually striking blue-flowered *Clitoria ternatea* has historically attracted the attention of traditional healers and herbalists because of its purported medicinal properties. With an increasing scientific interest in plant-based remedies, this botanical is now at the forefront of research, receiving renewed attention for its potential therapeutic benefits [2]. In southern India, the plant is referred to as 'Shankhapuspi' Although Aparajita is prevalent in Maharashtra, its application as a Medhya (nootropic) drug remains

insufficiently explored [3]. The plant can attain a height of up to 3 m and is characterized by its pinnate leaves, each consisting of 5–7 elliptical leaflets. The flowers are typically solitary and axillary, displaying a vibrant blue hue, although white variants are also available. Its fruit is a flat, dehiscent pod that generally contains six to ten seeds. This species thrives in well-drained soil and flourishes under conditions ranging from full sun to partial shade [4]. Various parts of *Clitoria ternatea* have been utilized as active components in numerous Ayurvedic formulations for the treatment of a broad spectrum of disorders. Several traditional Ayurvedic 'Medha' (cognitive-enhancing) preparations incorporate *C. ternatea*, in conjunction with other medicinal plants. Scientifically, this plant has been investigated for its diverse pharmacological properties, including antihistaminic, anthelmintic, hypoglycemic, antidepressant, and sedative effects. *Clitoria ternatea*, known as Aparajita in Bengali, is a prominent plant used in Ayurvedic medicine. All parts of the herb are used for therapeutic purposes. It has been traditionally used for centuries in Ayurveda for its extensive range of benefits, including memory enhancement, nootropic effects, stress relief, anxiety reduction, depression treatment, seizure prevention, and as a natural sedative and tranquilizer [5].

Taxonomy: [6].

Subkingdom	Viridaeplanta
Infrakingdom	Streptophyta
Division	Tracheophyte
Subdivision	Spermatophytina
Infrodivision	angiosperms
Class	Magnoliopsida
Main order	Rosanae
Order	Fabale
Family	*Fabiaceae*
Genus	*Clitoria L.*
Species	*Clitoria ternatea*

Vernacular names:
English: Conch flower, Winged leaved Clitoria, Butterfly pea flower
Guajarati: Garani, Koyal ni vel
Hindi: Khagin, Kalizer, Khajina, Koyal
Kannada: Koyala, Koyila, Girikarnike
Marathi: Gokarni, Gokarnika
Tamil: Karuvilai, Kakkanam

Morphology: **Macroscopic characters**:
The leaves are arranged alternately and are imparipinnately compound, with each leaflet positioned oppositely. The total length from the base of the petiole to the leaflet apex ranged from 10.4 to 12.5 cm. The terminal (apical) leaflet measured between 4.3 and 5.0 cm in length and 2.6 to 3.4 cm in width. The lower leaflets range from 4.2 to 4.8 cm in length and 2.3 to 2.5 cm in width, respectively. Each leaf is supported by a petiole, and each leaflet is attached via a petiolule, with stipules at its base. The leaflets possess an ovate lamina with a symmetrical base, entire margin, and mucronate apex. The venation was unicostate and reticulate. The lamina surface was smooth and hairy. The upper surface was dark green, whereas the lower surface was light green. The leaves emit a characteristic Odor and possess a bitter taste [7].

Microscopic characters:
In the transverse section, the leaf revealed a dorsiventral structure. The epidermis is differentiated into an upper and lower layer, both of which are unilayered and covered with a thick cuticle. The cuticle is striated, imparting a lobed appearance to the cut section, particularly at the midrib. The mesophyll is differentiated into palisade and spongy tissue. In the midrib region, the vascular bundle is situated within the cortex. The stele is of the haplostele type, with xylem elements encircled by the phloem. Stomata are present on both surfaces of the leaf and are of the

anomocytic and anisocytic types, with surrounding epidermal cells exhibiting wavy walls. The petiole exhibited a triangular outline, with its upper two angles extending into multicellular lobe-like structures. The stem has a circular outline. The epidermis consists of small, compactly arranged cells with 6–8 angles, each projecting into a multicellular, lobular structure. The petiole shows a circular outline, with the outermost phloem composed of 12 to 25 rows of thin-walled, longitudinally elongated cells, some of which are compressed and a few exfoliating [8].

Phytochemistry:

The plant *Clitoria ternatea* comprises a diverse array of compounds, including proteins, alkaloids, anthraquinones, anthocyanins, cardiac glycosides, phenols, tannins, phlobatannins, carbohydrates, saponins, triterpenoids, flavonoids, flavonol glycosides, volatile oils, and steroids. The seeds of *Clitoria ternatea* contain fatty acids, such as palmitic, stearic, oleic, linoleic, and linolenic acids. Additionally, the seeds are characterized by the presence of water-soluble mucilage, delphinidin 3, 3', 5'-triglucoside, beta-sitosterol, anthoxanthin glucoside, and a small basic protein known as finotin. Furthermore, *Clitoria ternatea* is rich in phytochemical constituents, including pentacyclic triterpenoids such as taraxerol and taraxerone. Phytochemical analysis of its roots has revealed the presence of terpenes, alkaloids, flavonoids, saponins, tannins, carbohydrates, proteins, resins, starch, taraxerol, and taraxerone [9].

Pharmacological Activity:

Antidiabetic activity:

The diuretic properties of the dried whole roots and powdered ethanol extract were assessed. A single intravenous (I.V.) administration of the extract significantly increased the urinary excretion of sodium (Na^+) and potassium (K^+) and decreased chloride (Cl^-) levels without affecting urine volume. A comparable effect was observed with oral administration [10]. The hypoglycemic effect of a methanolic extract of *Clitoria ternatea* leaves at doses of 200 and 400 mg/kg was examined in alloxan-induced diabetic rats. The extract significantly reduced blood glucose levels ($P < 0.001$) in diabetic rats 12 hours post-administration [11]. Oral administration of *Clitoria ternatea* (CT) leaves and flowers at a dose of 400 mg/kg body weight for 84 d led to significant improvements in various biochemical parameters in diabetic rats. Treatment with both CT leaves and flowers resulted in reductions in serum glucose, glycosylated hemoglobin (HbA1c), total cholesterol, triglycerides, urea, creatinine, and the activity of the gluconeogenic enzyme glucose-6-phosphatase. Conversely, serum insulin, HDL cholesterol, total protein, liver and skeletal muscle glycogen content, and the activity of the glycolytic enzyme glucokinase were increased. Among the two, CT leaf treatment exhibited slightly superior effects compared to CT flower treatment. These findings support the potential of *Clitoria ternatea* as an antidiabetic agent [12-14]. Diabetes is a chronic metabolic disorder characterized by persistent hyperglycemia and impaired metabolism of carbohydrates and lipids [15].

Antimicrobial Activity

The antimicrobial properties of *Clitoria ternatea* have been extensively studied against various pathogenic microorganisms. Extracts derived from different plant parts, including flowers, leaves, and roots, have demonstrated significant inhibitory effects against both bacterial and fungal strains. These findings suggest that *Clitoria ternatea* possesses potential as a natural antimicrobial agent, with possible applications in the pharmaceutical, food preservation, and cosmetic industries [16].

Antidepressant Activity

Oral administration of methanolic extracts of *Clitoria*

ternatea at dosages of 100 and 400 mg/kg produced significant antidepressant effects in mice, as indicated by a reduction in immobility time during the tail suspension test. Notably, the 400 mg/kg dosage exhibited greater efficacy than fluoxetine [17]. Furthermore, ethanolic extracts of *C. ternatea* roots at dosages of 150 and 300 mg/kg also demonstrated significant antidepressant activity. Previous research has identified two bioactive compounds in the roots—(Z)-9,17-octadecadienal and n-hexadecanoic acid—which are potential selective monoamine oxidase A (MAO-A) inhibitors. These findings suggest that *C. ternatea* may provide promising herbal alternatives for the management of psychiatric disorders such as depression and anxiety [18].

Neuropharmacological Activity

Clitoria ternatea possesses neuroprotective properties, which are attributed to its antioxidant and anti-inflammatory activities. This plant has demonstrated potential in preventing neurodegenerative disorders and enhancing cognitive function. Traditionally, it is considered a brain tonic, particularly for improving mental clarity and overall mental health. Experimental studies have shown that intraperitoneal administration of alcoholic extracts from the stem, flower, leaves, and fruit of *C. ternatea* induces sedation and reduces alertness in animal models, such as rats and mice. Furthermore, root extracts administered at doses of 300–500 mg/kg enhanced memory by mitigating electroshock-induced amnesia. These effects are associated with increased acetylcholine levels and modulation of acetylcholinesterase activity in various brain regions, including the cerebral cortex, midbrain, medulla oblongata, and cerebellum [19].

Antioxidant activity

Antioxidants are essential for neutralizing free radicals, inhibiting lipid peroxidation, and mitigating oxidative stress, thereby preventing various diseases. *Clitoria ternatea* is rich in phenolic compounds, including tannins, coumarins, xanthones, and procyanidins, all of which exhibit dose-dependent free radical scavenging activity. These bioactive constituents are linked to a range of health benefits, including cardiovascular protection, cancer prevention, and a reduction in oxidative damage to lipids and low-density lipoprotein cholesterol [20].

Anticonvulsant Activity

Seizures result from an imbalance between excitatory and inhibitory neurotransmissions in the brain. Agents that elevate gamma-aminobutyric acid levels frequently exhibit anticonvulsant activity. The maximal electroshock test is a widely recognized experimental model used to evaluate the efficacy of antiepileptic drugs, particularly in the context of generalized tonic-clonic seizures. Methanolic extracts derived from the aerial parts of *Clitoria ternatea*, when administered orally at a dosage of 100 mg/kg, demonstrated anticonvulsant activity in mice. The extract significantly delayed the onset of seizures and reduced tonic hind limb extension in both MES- and pentylenetetrazol-induced (PTZ)-induced seizure models. However, the same extract did not confer protective effects against MES- and PTZ-induced seizures in rats, indicating species-specific variability in response [21].

Anti-inflammatory, Antipyretic, and Analgesic Effects

Clitoria ternatea exhibits significant anti-inflammatory, antipyretic, and analgesic properties in various experimental models. The ethanol extract of the root, when administered intraperitoneally at doses of 100, 125, and 150 mg/kg in mice, demonstrated substantial anti-histaminic activity. Notably, both chlorpheniramine maleate and ECTR significantly inhibited clonidine-induced catalepsy but had no effect on haloperidol-induced catalepsy. The methanol

extract of the root of the blue-flowered variety was assessed for antipyretic activity in albino rats. Administered orally at doses of 200, 300, and 400 mg/kg, the extract significantly reduced both normal and yeast-induced elevated body temperatures in a dose-dependent manner, with effects persisting for up to 5 h post-administration. Its efficacy was comparable to that of paracetamol.

In anti-inflammatory models, methanolic root extract inhibited carrageenan-induced paw edema and acetic acid-induced vascular permeability in rats. It also reduced yeast-induced pyrexia and significantly decreased writhing in mice subjected to the acetic acid-induced writhing test. Petroleum ether (60–80°C) extracts of *C. ternatea* flowers demonstrated significant anti-inflammatory and analgesic activity in carrageenan-induced paw edema and hot plate models in rats and mice. Similarly, the methanolic leaf extract exhibited strong analgesic effects in mice using the acetic acid-induced writhing test, with inhibition rates of 82.67% and 87.87%, respectively, which were comparable to that of diclofenac sodium. Central nervous system depressant activity was also observed through decreased locomotor activity in the open-field and hole cross tests. Further mechanistic studies using hot plate, tail-flick, and formalin-induced pain models, along with naloxone (an opioid receptor antagonist), indicated that both root and leaf extracts possessed central and peripheral antinociceptive properties. Root extracts acted at both spinal and supraspinal levels, whereas leaf extracts primarily acted at the supraspinal level. These effects suggest the involvement of the opioid system in mediating the analgesic effects of *C. ternatea* [22].

Wound Healing Activity

The wound healing efficacy of *Clitoria ternatea* seed and root extracts was assessed using excision, incision, and dead-space wound models in rats. Both oral administration and topical application of the extracts significantly enhanced wound healing in all models. The observed effects were comparable to those produced by the standard cotrimoxazole ointment. The study further indicated that *Clitoria ternatea* positively influenced all key phases of the wound healing process—namely, the inflammatory, proliferative, and remodeling phases [23]

The wound healing potential of the standardized *Clitoria ternatea* leaf extract was evaluated using various enzymatic models pertinent to skin repair. The inhibitory activity of the methanolic extract and its fractions against hyaluronidase, elastase, and matrix metalloproteinase-1 (MMP-1) was assessed using oleanolic acid as a reference standard. Reverse-phase high-performance liquid chromatography (RP-HPLC) was employed to standardize the extract and its fractions based on the isolated biomarker taraxerol, which was present at a yield of 5.27% w/w.

The methanolic extract demonstrated significant inhibitory activity against hyaluronidase (IC_{50}: 18.08 ± 0.46 µg/mL, $P < 0.001$) and MMP-1 ($P < 0.05$), although the inhibition of elastase was not significant (IC_{50}: 42.68 ± 0.46 µg/mL). Among the tested fractions, the ethyl acetate fraction exhibited strong inhibition of hyaluronidase (IC_{50}: 28.01 ± 0.48 µg/mL, $P < 0.001$) and MMP-1 ($P < 0.01$) activities. HPLC analysis confirmed enrichment of taraxerol in both the crude methanolic extract (5.32% w/w) and the ethyl acetate fraction (4.55% w/w), supporting their bioactivity in wound healing [24].

Anti-asthmatic Activity

The ethanol extract of *Clitoria ternatea* root (ECTR) was assessed for its anti-asthmatic properties using various experimental models. Administered intraperitoneally at doses of 100–150 mg/kg, ECTR significantly mitigated milk-induced leukocytosis

and eosinophilia in mice. Additionally, it effectively prevented egg albumin-induced mast cell degranulation and reduced blue dye leakage in a passive cutaneous anaphylaxis model in rats. These results suggest that *Clitoria ternatea* root extract demonstrates significant antiallergic and anti-asthmatic activity by stabilizing mast cells and suppressing allergic inflammatory responses [25]. The anti-asthmatic efficacy of the ethanol extract of *Clitoria ternatea* roots was further evaluated using a histamine aerosol-induced bronchospasm model in Wistar rats. Oral administration of the extract at a dose of 400 mg/kg provided 47.45% protection against histamine induced bronchoconstriction in mice. The findings indicate that the aqueous extract of *C. ternatea* not only exhibits bronchodilatory effects but also reduces bronchial hyperreactivity in vivo. This effect is attributed to decreased infiltration of inflammatory cells in the airways and the stabilization of mast cells, thereby inhibiting the release of histamine and other inflammatory mediators [26].

Conclusion

This review highlights *Clitoria ternatea* as a promising medicinal plant with a wide range of pharmacological activities. Its demonstrated efficacy and safety profiles indicate its significant potential for various therapeutic applications. The plant exhibits numerous pharmacological effects, including antioxidant, antidepressant, neuropharmacological, anticonvulsant, wound healing, anti-asthmatic, anti-inflammatory, analgesic, antipyretic, antidiabetic, and antimicrobial activities. Overall, *Clitoria ternatea* is a valuable plant with a rich pharmacological profile, making it an important component of natural healing systems and a potential subject for further scientific research to explore its benefits.

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How to cite this article:
Meghana BP, Tejas SU, Varsha CN, Sinchana DM, Nischith SS. An updated review on the pharmacological potential of the plant *Clitoria ternatea*. J Adv Pharm Drug Dev. 2025;1(1):55–61. doi:10.64842/4x7yhf37