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In-Depth Review on Phytochemistry and Pharmacological significance of *Clitoria Ternatea*

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ABSTRACT

Since they are powerful and have few negative effects, medicinal and aromatic herbs have been utilized for centuries. Research is at its pinnacle as a result. The Fabaceae family climbing plant Clitoria ternatea, also known as the "Butterfly Pea" and Shankpushpi, has been utilized in Conventional Ayurvedic Medicine in response to this phenomenon. It has been used for centuries as a nootropic, memory enhancer, antistress, anxiolytic, depression medication, anticonvulsant, tranquilizing, and sedative agent. From Clitoria ternatea Linn, a variety of secondary metabolites, including as triterpenoids, flavonol glycosides, anthocyanins, and steroids, have been identified. Its extracts have a broad spectrum of pharmacological effects, such as the ability to suppress blood platelet aggregation, be antibacterial, antipyretic, anti-inflammatory, analgesic, diuretic, local anesthetic, antidiabetic, and insecticidal. They may also be used to relax vascular smooth muscle. Traditional uses for this plant are longstanding. Numerous disorders have been treated using Ayurvedic medicine, and scientific research has proven which are still relevant today.Numerous active ingredients, including alkaloids, glucosides, flavonoids, saponins, tannins, and sugars, are present in the pants. The goal of this review is to examine the phytochemical components and pharmacological research on Clitoria ternatea, a plant species that has been used in Ayurvedic medicine for a long time. It also critically evaluates the plant's potential for future ethnopharmacology in light of numerous significant recent discoveries regarding it.

KEY-WORDS

Phytochemistry, Shankpushpi, *Clitoria ternatea,* Antihyperlipidmic, Ayurveda

INTRODUCTION

Herbs and medicinal plants are used by a growing number of people worldwide for therapeutic purposes. Consequently, scientific evaluation of their biological characteristics, safety, and therapeutic potential will be helpful in determining the best course of action.[1,2] Hundreds of important pharmaceuticals and physiologically active substances have been created from traditional medicinal herbs. Numerous pharmacological properties were demonstrated by the plant, including those that were antibacterial, antioxidant, anticancer, hypolipidemic, cardiovascular, neurological, respiratory, immune system, anti-inflammatory, analgesic, and antipyretic.[3–10] Clitoria ternatea L., often known as the butterfly pea, is a plant in the Fabaceae family. It is commonly grown in Southeast Asia and other tropical locations. India has been using the well-known and ancient Ayurvedic medical system for millennia. In this system, medicinal plants are utilized to treat a range of illnesses and can also be a source of pharmaceuticals. Medhya medicines are a class of herbal medications designed to enhance brain function that are administered in the Ayurvedic medical system. Extracts from Clitoria ternatea, Celastrus paniculatus, Acorus calamus, Centella asiatica, and Areca catechu are among these herbal medications. Among the many plants and herbal remedies described in Ayurveda, Clitoria ternatea is a well-known remedy used to cure a wide range of ailments. It can be applied to color food or other items, depending on the purpose. One of the plants that is good for us in every aspect is the butterfly pea (Clitoria ternatea L.). Ternatins, a kind of flavonol glycoside, and polyacylated anthocyanins are present in the blooms. Antioxidants, antidiabetic, antiobesity, anti-inflammatory, anticancer, antihyperlipidemic, and antiasthmatic compounds are a few of these. It is beneficial to one's health. This is consistent with the fact that the chemical structure of anthocyanins makes them readily soluble in water.Flavonoids are among the many phytochemical substances found in Clitoria ternatea flowers; anthocyanins, on the other hand, are primarily responsible for the flowers' color. Anthocyanins, found in butterfly pea blossoms, are naturally occurring antioxidants that slow down aging. helps the skin and keeps it from aging. The blue tint of Clitoria ternatea flowers is frequently utilized in cooking

as a natural coloring agent. Antioxidants, diabetes inhibitors, inflammatory reducers, and anti-cancer compounds are just a few of the health advantages of flowers.[11–16]

TAXONOMIC CLASSIFICATION [17-21]

Kingdom	Plantae
Subkingdom	Viridaeplanta
Infrakingdom	Streptophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Infrodivision	Angiospermae
Class	Magnoliopsida
Superorder	Rosanae
Order	Fabales
Family	Fabaceae
Genus	Clitoria L.
Species	*Clitoria ternatea*

COMMON NAME[22,23]

English	Blue-Pea
Hindi	Aparajita
Sanskrit	Girikarnika, Vishnukranta
Arabic	Mazerion Hidi, Baslat El-Zuhoor
Chinese	Die Dou
Bengali	Aparajita
French	Honte
German	Blaue Klitorie
Portuguese	Clitória-Azul, Clitória
Telugu	Dintena
Punjabi	Koyal
Tamil	Kakkanam
Swedish	Himmelsärt
Spanish	Conchitas Papito, Azulejo,

MORPHOLOGICAL DESCRIPTION

Clitoria ternatea has 0.5–3 m long, twining delicate stems. Pinnate leaves with 5-7 elliptic to lanceolate leaflet that are 3-5 cm long and have a little pubescence underneath. Flowers are solitary, 4-5 cm long, very short pedicellate, and deep blue to blue mauve in color. With up to ten seeds, the flat, linear, beaked pods are 6–12 cm long, 0.7–1.2 mm diameter, and somewhat pubescent. The seeds are 4.5-7 mm long and 3-4 mm broad, with an olive, brown, or black hue that is frequently speckled. [24] Clitoria ternatea has a somewhat thick taproot has a few branches and a large number of thin lateral roots. There are multicellular trichomes that have two basal cells that are smaller than the terminal cells. A dorsiventral structure is visible in the transverse section leaf. Prism-like calcium oxalate crystals are seen throughout the veins. The palisade ratio is 6.0 and the vein-islet number is 7.5. The flat, 5–10 cm long pods contain 6–11 seeds. [25, 26] The cortex is made up of ten to twelve layers of elongated, almost polygonal, thin-walled cells that are largely filled with complex starch grains. [27] Few calcium oxalate crystals can be seen within the starch grains that fill every ray cell.

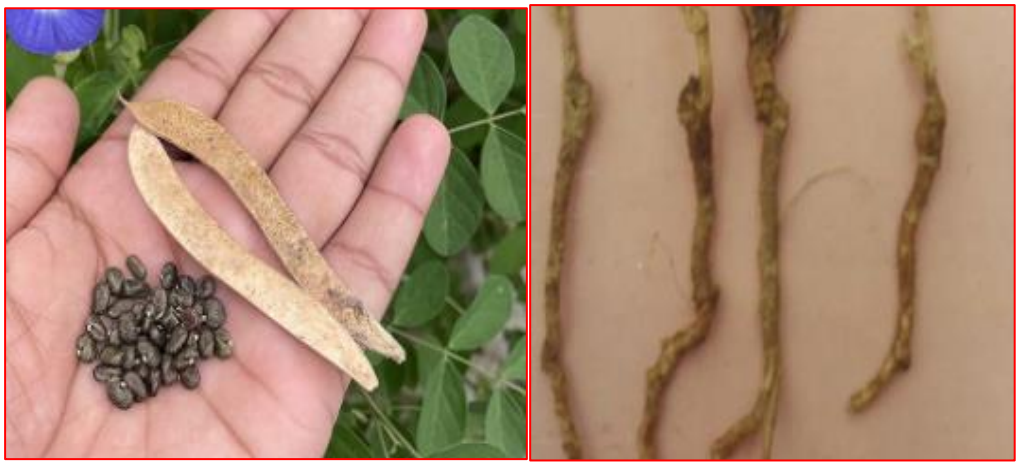

Fig 1: Different parts of Clitoria ternatea

MICROSCOPIC CHARACTERS

The root exhibits 10–20 layers of tangentially elongated, rectangular, thin-walled, exfoliating cork cells; the secondary cortex is made up of 10–12 rows of large, polygonal, thin-walled cells filled with starch grains; certain cells throughout this region include prismatic calcium oxalate crystals; the lower half of the cortex is made up of single or groups of 2–10 lignified cortical fibers; the supplementary phloem is made up of typical elements; phloem fibers 2–8 in categories,xylem fibers similar to phloem fibers, with a few displaying slit-like pits; vessels pitted in oblong, bordered pits and have short conical tail at one end; a few solitary fibers also present, very long, thin-walled, with narrow lumen and pointed tips; secondary xylem consists of usual elements; Medullary 10 rays, 1–5 cells broad, oblong, and pitted; xylem parenchyma, uneven in form and with pitted walls; starch granules, both simple and complex, with 2–6 components, single grains, 3–13 μ in diameter, present in phloem, xylem parenchyma, and intermediate cortex.Powder: Yellowish-brown, displaying both simple and complex starch grains with diameters ranging from 3 to 13 μ, together with vessels featuring oblong-bordered pits and fiber pieces.[28]

DISTRIBUTION

Clitoria ternatea, or the C. ternatea plant, is a widely distributed plant that grows in many different places. Many tropical Asian nations, including Bhutan, Bangladesh, Sri Lanka, Nepal, India, the Philippines, and the Maldives, are home to it. It may also be found in parts of Madagascar, the Caribbean, and South and Central America. In addition, the plant is found in China, Taiwan, Indonesia, Singapore, Malaysia, Cambodia, Laos, Myanmar, Thailand, and Vietnam, as well as in several

regions of the Middle East, such as Saudi Arabia, Yemen, Iran, and Iraq. C. ternatea is widely distributed, indicating that it can adapt to a variety of environmental conditions in these areas. [29]

AGRONOMIC CHARACTERISTICS [30-32]

Soil: The Clitoria is particularly suited to grow in a variety of soil types, including calcareous soils, deep alluvial soils, and sandy soils. It grows very well in moderately rich soils but is especially well suited to thick clay alkaline soils. Because Clitoria ternatea prefers rich, wet soil with a 2:1:1 ratio of peat moss to loam and part sand or perlite, the soil must always be consistently moist for healthy development.

Water: It thrives in dry regions such Kordofan in the Sudan and can withstand some drought in Zambia, however it also does well in places that receive irrigation. It needs around 400 mm of rainfall annually. Because of its nature, C. ternetea may withstand brief floods but not protracted inundation or water logging.

Sun light: It is moderately shade-tolerant but can normally grow in full sunlight.

Temperature: Although it is not recommended for areas that experience severe or frequent frosts, it can withstand high summer temperatures and has a poor tolerance to frost. It requires a moderate temperature down to 25ºC.

Fertilizer: *C. ternetea* is normally grown in soil containing phosphorous (P) and sulphur (S) which may be required as fertilizers if sown in the infertile soils.

Propagation: Depending on the seasonal circumstances where it is grown, it includes around 20% hard seed, which develops quickly in warm, humid weather. It is physically picked by hand and reproduced by cuttings from seed. Because Clitoria ternatea seeds have hard seed coats covering them, they cannot ingest water or sprout; nevertheless, after six months in storage, 15-20% of the seeds can germinate. While mechanical scarification boosted the germination of 6-month-old seed from 30% to 71%, other methods that have been shown to improve early plant development and germination include the use of hot water, sulphuric acid (H2SO4), potassium hydroxide, and soaking in a 100 mg/L solution of sodium cyanide (NaCN).

PHYTOCHEMICAL CONSTITUENTS

An essential phase in the process is the extraction of phytonutrients from plant sources. Numerous extraction techniques exist, and choosing the best parameters is

crucial to guaranteeing an increase in phytochemical output. Both conventional and non-traditional extraction techniques have benefits over one another, thus the choice of technique should be carefully considered based on the objectives to be accomplished and the appropriateness of the samples. In order to improve the surface area for mixing with the solvent, plant materials are often reduced in size prior to extraction. The samples utilized might be either fresh, dried, ground, or powdered.

Leaf

The leaves have 21.5% crude fiber and 21.5-29% protein content, respectively. Clitorin and kaempferol have been isolated from leaves. In addition to kaemferol-3-o-rhamnosylo- rhamnosylglucoside, the leaves also contain 3-monoglucoside, 3-rutinoside, 3- neohesperidoside, 3-o-rhamnosyl-glucoside, and 3-o-rhamnosylgalactoside. Aparajitin and β-sitosterol are also present. [33]

Root

The plant roots include taxaxerol and taxaxerone. Root bark comprises flavonol glycosides, starch, tannin, and resin. Glycine, alanine, valine, lecine, α-aminobutyric acid, aspartic acid, glutamic acid, arginine, ornithine, histadine, and γ-aminobutyric acid are all present in the root nodule. [34, 35]

Seed

The seeds of C. ternatea includes a variety of metabolites, including three anonymous trypsin inhibitors, water-soluble mucilage, delphinidin 3,3,5-triglucoside, that may be utilized as a food dye, p-hydroxycinnamic acid, flavonol-3- glycoside, ethyl-α-D-galactopyranoside, adenosine, 3,5,7,4'-tetrahydroxyflavone, 3-rhamnoglucoside, a polypeptide, hexacosanol, β-sitosterol, γ-sitosterol, and anthoxanthin glucoside, as oligosaccharides and anthoxanthin have been identified.Sterols, alkaloids, glycosides, saponins, tannins, carbohydrates, protein, flavonoids, and phenolic substances were also found in the seeds of C. ternatea, according to another research. [36,37]

Flower

It has cyclotides, phenolic acids, flavones, flavonols, anthocyanins, and flavonol glycosides. Kaempferol 3-2G-rhamnosylrutinoside, kaempferol 3-neohesperidoside, quercetin 3-neohesperidoside, myricetin 3-neohesperidoside, kaempferol 3-rutinoside, quercetin 3-rutinoside, myricetin 3-rutinoside, kaempferol 3-glucoside, quercetin 3-glucoside, and myricetin 3-glucoside are all present in the flower. [33]

PHARMACOLOGICAL SIGNIFICANCE

1. **Antimicrobial Activity:**

Clitoria ternatea's antibacterial qualities were examined using the well diffusion and agar plate techniques. Clitoria ternatea leaf extracts in organic solvents (petroleum ether, ethyl acetate, and methanol) were evaluated against Salmonella typhi, Bacillus cereus, Staphylococcus aureus, Proteus vulgaris, and Klebsiella pneumonia. Promising antibacterial efficacy against the studied microbiological pathogens was demonstrated by the findings. It was discovered that the methanol extract outperformed the petroleum ether and ethyl acetate extracts in terms of inhibitory power.Rats were used to test the ethanolic extract's antidiabetic properties. Because galactosidase and glycosidase activity were inhibited, rats given ethanol extracts of flowers for three weeks dramatically lowered their blood sugar levels in experimentally caused diabetes; fructosidase activity was not inhibited.[38, 39]

2. **Antihistamine Activity:**

Numerous investigations on Clitoria ternatea's anthelmintic activity have been published. When compared to the standard reference piperazine citrate, the crude alcoholic extract of Clitoria ternatea and its ethyl acetate and methanol fractions have been demonstrated to significantly paralyze and kill worms, particularly at higher dosages of 50 mg/ml.[40] The ethanolic extract of Clitoria ternatea roots' antiasthmatic properties was assessed in Wister rats by inducing bronchospasm by the use of histamine aerosol. Rats treated with 400 mg/kg po of Clitoria ternatea ethanol extract demonstrated 47.45% protection against histamine-induced bronchoconstriction. The findings demonstrated that C. ternatea aqueous extract not only has a bronchodilator effect but also lowers bronchial hyperreactivity by decreasing the infiltration of inflammatory cells into the airways and blocking the mast cell's release of mediators like histamine, stabilizing the airway.[41]

3. **Wound healing effect**

Using rat models for excision, incision, and dead space, the ability of Clitoria ternatea seed and root extracts to promote wound healing was examined. Applying Clitoria ternatea root and seed extracts topically as an ointment and orally as gavages dramatically enhanced wound healing in excision, incision, and dead-space models. These outcomes were similar to those of the ointment cotrimoxazole. The study's

conclusions also shown that Clitoria ternatea had an impact on the wound healing process during its three phases: the inflammatory, proliferative, and remodeling phases. [42]

4. **Gastrointestinal effect**

Rats were used to test the antiulcer properties of aqueous & ethanolic extracts of Clitoria ternatea using several experimentally produced ulcer models. Rats with pylorus ligation and indomethacin-induced stomach ulcers were treated with ethanolic extract (200 and 400 mg/kg) and aqueous extract (200 and 400 mg/kg) of the whole plant. Following ulcer induction, a number of parameters were measured and compared between the extracts, standard, and vehicle control group, including the volume of stomach acid secretion, pH, total acidity, ulcer index, and antioxidant parameters. A high dosage of the alcoholic extract demonstrated notable antiulcer action in indomethacin-induced ulceration and pylorus ligation . [43]

5. **Hypoglycemic Effect :-**

The effects of aqueous extracts of C. ternatea leaves and flowers given orally (400 mg/kg body weight) on insulin, glycosylated hemoglobin, and blood glucose were investigated in rats in the test and control groups. The glycolytic enzyme, glucokinase, liver and skeletal muscle glycogen, and serum insulin activity were all significantly ($P>0.05$) elevated by the aqueous extracts of C. ternatea leaves and flowers; however, serum glucose, glycosylated hemoglobin, and the activities of the gluconeogenic enzyme, glucose-6-phosphatase, were all decreased. Following every biochemical test, the rats given with leaf extract showed nearly the same profile as the rats treated with floral extract. [44]

6. **Hypolipidemic effect :-**

Rats with artificially generated hyperlipidemia were used to study Clitoria ternatea L.'s anti-hyperlipidemic impact. This study employed the models of acute hyperlipidemia generated by poloxamer 407 and diet-induced hyperlipidemia. When Clitoria ternatea roots and seeds were administered orally, the levels of blood total cholesterol, triglycerides, very low-density lipoprotein cholesterol, and low-density lipoprotein cholesterol were all significantly ($p<0.05$) decreased. In diet-induced hyperlipidemic rats, the atherogenic index and the HDL/LDL ratio likewise returned to normal following therapy. A comparison was made between the effects of gemfibrozil (50 mg/kg, po) and atorvastatin (50 mg/kg, po)[45]

7. **Antihelmintic Activities:**

Numerous investigations on Clitoria ternatea's antihelmintic activity have been published. In comparison to the conventional reference piperazine citrate, it was shown that the crude alcoholic extract of CT, together with its ethyl acetate and methanol fractions, considerably displayed paralysis and also caused death of worms, especially at higher concentrations of 50 mg/ml. Using both aqueous and methanol extract, the inhibitory impact of CT leaves on free-living nematodes was assessed.In a different investigation, the antihelmintic activity of CT's flowers, leaves, stems, and roots was assessed against adult Pheretima posthuma Indian earthworms. Compared to other extracts, the methanol extract of the root is the most effective and causes the paralysis and death of worms in a much shorter amount of time. From blossoms to leaves to stems to roots, the potency grows.[46]

8. **Anti-inflammatory Antipyretic and Analgesic Effects**

By preventing mice from developing catalepsy due to clonidine, the ethanol extract of Clitoria ternatea root (ECTR) demonstrated antihistaminic action. However, this effect was not observed when catalepsy caused by haloperidol. The Clitoria ternatea root with blue flowers (MECTR) methanol extract, on the other hand, showed anti-pyretic properties. Similar to the actions of paracetamol, it successfully lowered both normal body temperature and yeast-induced pyrexia in mice.[47, 48]

9. **Antiparasitic and Insecticidal Effects**

The ethanolic extract of Clitoria ternatea (100 mg/ml) paralyzed Indian earthworms (Pheretima posthuma) in 15-20 minutes and killed them in another 28–30 minutes. The Clitoria ternatea root methanol extract showed the strongest anthelmintic activity among the other extracts. Clitoria ternatea leaves were extracted aqueously and ethanolically, and both showed considerable anthelmintic activity against Eisenia foetida; however, the ethanolic extract was more effective. Additionally, potential mosquito larvicidal efficacy against Aedes aegypti, Culex quinquefasciatus, and Anopheles stephensi was demonstrated by the seed extract of Clitoria ternatea. [49–51]

10. **Local Anaesthetic effect**

An alcoholic extract of the aerial portion of Clitoria ternatea was used to study the local anesthetic impact on rabbits' corneas and frogs' plexuses. Frogs' foot withdrawal reflex was eliminated by a 10% solution of an alcoholic extract of Clitoria ternatea

(CT) aerial portion, although rabbit corneas did not experience any surface anesthetic effects. Inducing local anesthesia, an alcoholic extract of the CT aerial portion was nearly as successful as xylocaine. [52]

11. Anticonvulsant and anti-stress activity

Mice administered 100 mg/kg of a methanol extract from the aerial portions of C. ternatea were used to test the extract's anticonvulsant properties against seizures produced by PTZ and maximal electroshock (MES). In convulsions caused by PTZ, C. ternatea greatly postponed the beginning of convulsions, and in convulsions induced by MES, it also postponed the length of tonic hind limb extension. These findings imply that CT might be helpful in the management of seizures. [53]

CONCLUSION

For centuries, people have used the traditional herb C. ternatea as an anxiolytic and cognitive enhancer. For many years, extracts from the flowers, seeds, roots, and leaves of C. ternatea have been utilized in traditional medicine. Numerous secondary metabolites, including as flavonoids, anthocyanin glycosides, pentacyclic triterpenoids, and phytosterols, have been identified from this plant. This might serve as a memory enhancer and a model for the creation of cutting-edge phytopharmaceuticals intended to treat disorders of the central nervous system. Although the floral portion includes a lot of secondary metabolites, a comprehensive clinical study hasn't been done on it yet. Therefore, it is strongly advised that future studies examine the floral portion of C. ternatea in a therapeutic setting.

CONFLICT OF INTEREST

The authors declare that the review was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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