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Review Paper

Exploring the Bioactive Compounds & Potential Health Benefits of *Clitoria ternatea* Linn. in the Treatment of OCD: A Systematic Review

H. A. Bankar*, N. Gupta, Y. Charde, R. Rangari, S. Shrivastav

Shree Sainath College of Pharmacy, Dawalameti, Nagpur-440023, Maharashtra, India.

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ABSTRACT

Clitoria ternatea L. is a member of the Fabaceae family. This annual herbaceous plant is endemic to Africa, Australia, America, Southeast and South Asia, and Equatorial Asia. Its activity includes the enhancement of memory, nootropic, antistress, anxiolytic, antidepressant, anticonvulsant, tranquillizer, and sedative effects. The plant's morphology looks like the female reproductive organ, so it was traditionally associated with female sex desire in Chinese medicine. The extract of the plant was found to decrease the effect severity of serotonin and acetylcholine in mice. Some of the chemical compounds that were found are steroids, flavanol glycosides, anthocyanins, and triterpenoids. The bioactive flavonoids found in C. ternatea exhibit neuroprotective, anxiolytic, and potentially, antidepressant effects, possibly related to obsessive-compulsive disorder. It was demonstrated to reduce OCD-like behaviors and neuroinflammation. It provides symptomatic relief in the management of OCD and comorbid conditions such as anxiety, depression, and cognitive impairment. Ayurvedic medicine, with this herb, being applied to the management of numerous diseases in the ancient system of medicine.

INTRODUCTION

Known by various names, particularly butterfly pea and blue pea, Clitoria ternatea L. is a herbaceous perennial that is native to tropical equatorial Asia (1). The plant, which is a member of the Fabaceae family, gained notoriety first for its unusual deep-blue blossoms, which are now common ornamental plants in many gardens across the world (2). Apart from the ornamental value of this plant, C. ternatea is really prized in all lands of its area for medicinal, culinary, and cultural reasons. One of the notable features of the plant is that it displays a climbing habit, with stems that may reach three meters long. The common name is derived from the flowers, which are usually 4-5 cm in diameter with typical

***Corresponding Author:** H. A. Bankar
Address: *Shree Sainath College of Pharmacy, Dawalameti, Nagpur-440023, Maharashtra, India.*
Email : himanshuabankar11@gmail.com

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morphology featuring a strong central keel with bright blue petals. Horticultural attractiveness is expanded with varieties bearing white and purplish flowers (Fig 1). There are decades of traditional application in both Ayurvedic and conventional medicine; Clitoria ternatea. As a result of the scientific value that its diverse pharmacological properties have elicited, there is enormous research into its bioactive compounds and their applications in therapy. The abundance of antioxidants in the plant can be accredited to anthocyanins such as cyanidin and delphinidin which are some of the flavonoids. This allows flowers to acquire bright colours besides sustaining their medicinal potential. It is a natural pigment present in plants that give flowers, fruits, and leaves different colours, such as blue, red, and purple. Prior research has applied C. ternatea herbal extract from florals, which contains a natural colouring agent, as a meal colouring agent and to improve the products' functionality (3,4,5). Current research on C. ternatea's pharmacological actions have shown its potential in managing infectious diseases, metabolic disorders, and neural disorders. These findings suggest a decrease in oxidative stress, enhanced cognitive function, and antimicrobial and anti-inflammatory properties. However, the scientific ability of C. ternatea hadn't been widely explored and validated. This study explores the implicit uses and operations of C. ternatea in nutrition and drugs by examining its botanical traits, remedial parcels, and current exploration trends. Being an Ayurvedic treatment, Clitoria ternatea is used to cure a variety of illnesses, including OCD, because of its unique pharmacological and phytochemical properties. It contains bioactive compounds with neuroprotective properties, such as flavonoids and anthocyanins, which modulate neurotransmitters. Clitoria ternatea has no major side effects, reduced neuroinflammation, and improved memory and learning ability. Its traditional use in Ayurvedic medicine provides a significant cultural context for further scientific validation.

Characteristics For Morphology And Cultivation

Clitoria ternatea's tubular calyx with pea-shaped pentamerous zygomorphic blooms, which comprise over two-thirds of the flower's length, has five fused sepals, Five free flower petals, two creased wings, and twin white keels (6) (7). This plant, native to the US, grows in gardens or wild, producing large blue or white flowers resembling conch shells. It likes full sun, however, it may additionally tolerate little shade (2). C. ternatea, cultivated using fine twinning, can grow up to 3 meters in length and has seven pinnate leaves with a roughly ovate or orbicular form, measuring 3 cm in width and 5 cm in length(8). For the germination and establishment of C. ternatea, the optimal temperature range is between 24 and 32°C. Plant the sprouts within wettish soil, 20 to 30 cm piecemeal, and 2.5 to 5 cm deep (9,10). C. ternatea thrives in regions with elevated levels of wetness, precipitation between 650 and 1250 mm, with temperatures at least 27°C, while it may tolerate dry circumstances. The ideal growing conditions for the plant are warm temperatures (27°C or above), lots of downpour (650–1250 mm) and humidity (6). Frost-related harm is a risk for C. ternatea, just like other tropical legumes. Nonetheless, it can hold onto leaves over a maximum of a week, and its wooded portions usually grow back (11). C. ternatea cultivation in vitro can be beneficial to address its poor rate of development of seeds and preserve superior lines. A 1968 study found that adding 5-10 ppm ascochitine to culture media caused callus formation in 60% of embryos (12). Since 1990, a great deal of research has been completed to find the best explants, basal media, and proportions of plant hormones for the in vitro development of C. ternatea.

Agriculture

For a very long time, Clitoria ternatea has been grown as a fodder crop (6), yielding 17–29 tons tasty cow hay per hectare (13,14). This yield can replace established feed crops like alfalfa (Medicago sativa) in warm climates with little rainfall, since it is similar to its yield (13). Because it can withstand harsh conditions and persist on heavily textured farmlands, they have cultivated C. ternatea primarily throughout Queensland, Australia (15). The optimal moment to harvest C. ternatea straw is 45 days, as it optimizes bioavailability and dehydrated matter percentage. Animal diets composed of C. ternatea contain less acid-detergent fibre, increasing energy density while maintaining large amount of nitrogen (16). Clitoria ternatea represents an ideal plant for a crop rotation scheme because its roots form huge, circular nodules that are known to contain nitrogen-fixing bacteria. Assessments of C. ternatea's capacity to fix nitrogen date back to the 1970s (17,18) Crop rotation depends on the nitrogen-fixing Rhizobium species' capacity for cross-nodulation. According to studies, Rhizobium species from soybean, cowpea, and C. ternatea get along better with one another. However, when C. ternatea's Rhizobium sp. was cross-inoculated with three legume species—Pisum sativum, Phaseolus vulgaris, and M. sativa—no nodules were produced (18). These investigations help determine the species of legumes that will benefit the most on the soil upon planting C. ternatea. In Thailand, 11 isolates of rhizobia of C. ternatea were isolated and identified, with ten being different strains of Bradyrhizobium elkanii and the last being Bradyrhizobium japonicum type. The strains mentioned improved the growth of plants and induced increased ability to fix nitrogen (19).

Bioactive Components

From the very start of time, C. ternatea's health advantages have been acknowledged. In addition, it is a natural dietary ingredient and an all-natural cure for a number of ailments. The nutritional composition of C. ternatea flowers and the phytochemicals they contain are displayed in the following table [Table 1] (20). These effects are ascribed to several different phenolic chemicals found in the plant, particularly in flowers. Active ingredients like steroids, alkaloids, glycosides, tannins, resins, flavonoids, phenols, and saponins are especially abundant in the ternatea (21). It has been demonstrated that flower petals can yield flavonol glycosides that are malonylated (22). The main phenolic compounds found in C. ternatea flowers comprised ternatin anthocyanins and many flavanol glycosides of myricetin, rutin, kaempferol, and quercetin that were separated in a hydrophilic extract (1,23). Moreover, an extract that is lipophilic includes a broad spectrum of phytosterols (including sitostanol, campesterol, and β-sitosterol), tocopherols, and fatty acids (such as linoleic acid, behenic acid, arachidic acid, stearic acid, petroselinic acid, palmitic acid, and phytanic acid) (24) [Figure 3].

• **Polyphenols**

The diet of humans is thought to contain a significant amount of polyphenols, a family of physiologically beneficial compounds found in plants. The phenolic ring is the main monomer of the polyphenol, and this is further subdivided into phenolic acids and phenolic alcohols. It is acknowledged that C. ternatea is one of the most important sources of potent antioxidant polyphenols. Following that, a C. ternatea blossom was screened for its secondary metabolites. C. ternatea's secondary metabolites include polyphenols, kaempferol, flavonols, myricetin, glycosides, quercetin, anthocyanins and phenolic acids (2,25,26). The antioxidant property of flowers of C. ternatea, which have pharmacological activities and are advantageous to human well-being, antidiabetic, anticancer, antibacterial, and anti-inflammatory, and have become closely associated with their phenolic content [Table 2] (25, 26, 27).

•Flavonols

In 1967, cinnamic acid, flavonol glycosides, and phenolic aglycones were formed inside the seeds of C. ternatea (28). Posterior studies reacted in the birth of flower-derived flavonol glycosides (22,23) and leaves(29). Five flavonols, kempferol 3-quercetin, videlicet kempferol, robinobioside-7-rhamnoside, and quercetin 3- glucoside, were uprooted out of C. ternatea, a many times latterly (30). However, even though the C. ternatea flower cultivars were blue, mauve, or white, they matured with flavonol glycosides [Table 3] (22).

•Anthocyanins

The flavonoid molecules obtained from plants, known as anthocyanins, are what give colours like deep blue, crimson-purple, and pastel pink to their hues. The name anthocyanin comes from the Greek words anthos, also known flowering and kyanos (vibrant blue) (31). Anthocyanins are the main phytochemical substance found in C. ternatea flowers, which are distinguishable by the rich blue hue of the petals. Ternatins are compounds that were isolated from C. ternatea, ternatin A1-A3, B1-B4, C1-C4, and D1-D3 are among the blue anthocyanins in the petals that are acylated utilising delphinidin (22–24,32–35). In 1985, 6 acylated anthocyanins were discovered in C. ternatea blooms, all of which were delphinidin 3,3′,5′-tri glucoside derivatives(30). C. ternatea's acylated chemical characteristics delphinidins, also known as ternatins, were investigated in more detail in later research. In 1989, the structure of the biggest separated blue anthocyanin, ternatin A1, was identified. Furthermore, the study found that the largest and most durable ternatin in neutral solution was A1 [Table 4] (36,37,38)

•Proteinaceous Components

C. ternatea is not an exception to the rule that studies of phytochemistry have traditionally concentrated more on plant components that don't have proteins. However, due to advancements in mass spectrometry, methods for characterising proteins and peptides, and sequencing of nucleic acids, there has been a notable surge in interest in proteinaceous substances in the last several years, especially in the detection of protein and peptides linked to plant defence. Among the phytochemical components of C. ternatea that have been found as being associated with defence, cyclotides, a type of peptide, are especially significant (8,39,40). Enzymatic transpeptidation of the structural framework of the peptide converts linear precursors into roughly thirty amino acid cyclic molecules. Three disulfide connections that create a knot make up cyclotides, resembling the patterns found in knots that are linear found in many different species(41). In circumstances that would otherwise encourage peptide degradation, cyclotides are extremely stabilized as a result of their cyclic and twisted structure (42). Cyclotides are exclusively found in a few species of the Viridiplantae, or the angiosperm dicotyledon, in contrast to the omnipresent straight knottins in many territories of life (43). Cyclotides and linear chains that don't resemble cyclotides are limited to a few plant families, according to research conducted using the popular program tblastn to search every cyclotide sequence in the Viridiplantae (44).

Pharmacological Activities

Anti-Cholesterol activity

The C. ternatea blossom perhaps have anti-cholesterol oxidation qualities (45,46). The study aimed to determine if 50 microliters of partly purified extract (PPE) and crude lyophilized extract (CLE) from C. ternatea flowers might stop Human copper-induced low-density lipoprotein oxidation (LDL) cholesterol. Following a few hours of incubation, PPE revealed more inhibition than CLE. Both provided proof that the phenolic substance protected oxidation of human LDL cholesterol (46). To prevent the oxidation of cholesterol, extraction of flower extract of C. ternatea was done using methanol, pure water, and a combination of the two. The results showed that this combination of solvents after six hours of soaking prevented 89.8% of the production of 7-ketocholesterol in the emulsion, and the extract's anthocyanin content was 63.9 µg/mL. It has been demonstrated that the phenolic compounds, primarily anthocyanins, within C. ternatea flower extracts offer further health advantages, such as anti-lipidemic and anti-cholesterol qualities (45).

Antioxidant and cytotoxic activity

The antioxidant properties of extracts from butterfly peas and eye gel was examined using spectrophotometry. The C. ternatea liquid extract showed higher levels of antioxidants compared to the ethanol extract, according to the DPPH reduction test. The water extract's strong antioxidant activity was the crucial component for the assessment of the gel's and extract's overall phenolic content (47). The antioxidant assay in vitro was utilized to assess the antioxidative rates of the C. ternatea splint methanolic extract. Using the entire content of 358.99 ± 6.21 mg/g gallic acid equivalent and 123.75 ± 2.84 mg/g catechin equivalent, the extract demonstrated 67.85% antioxidant activity with 1 mg/mL dose and an IC50 value of 420µg/mL (48). Clitoria ternatea's ethanolic extract shown characteristics that are both antioxidant and cytotoxic. Having an EC50 of 305 µg/ml, the extract demonstrated a substantial cytotoxic effect on DLA lines of cells in an experiment including the exclusion of trypan blue pigment. The free radical DPPH method was employed to evaluate the antioxidant capacity, with the results showed considerable activity with an EC50 of 36.5µg/ml (49).

Anti-Diabetic activity

Rats were used to test the ethanolic extract's anti-diabetic properties. When rats with experimentally induced diabetes were given flower ethanol extracts for three weeks, their serum sugar levels significantly decreased due to the inhibition of the glucosidase and galactosidase enzymes; however, the fructosidase activity was not affected (50). The research assessed the hypoglycemic potential of four leaf extracts from Clitoria ternatea among the rats with streptozotocin-induced diabetes. The extract (400 and 200 mg/kg) dramatically lowered blood glucose levels in streptozotocin-induced diabetic mice, based on the results. The 200 mg/kg dose reduced glucose levels somewhat less than the 400 mg/kg dose, which had a considerable effect. Blood glucose levels were marginally lower at 30 minutes, but the methanolic extract had the same impact at both doses. It was discovered that the extract was more beneficial when used over an extended period of time at a dosage of 200 mg/kg (51). According to a study, specific components of the Clitoria ternatea L. aerial parts' ethanol extract have the capacity to regenerate pancreatic tissue. Streptozotocin-induced diabetic rats were used to look into the drug's anti-diabetic and anti-hyperlipidemic qualities; these effects were connected to both in vivo and in vitro antioxidant activity.

Local Anaesthetic effect

An alcohol-based Clitoria ternatea's aerial section extract was utilized to investigate the local anaesthetic effects of plexus anaesthesia in frogs and corneal anaesthesia in rabbits. Frogs' foot withdrawal response was eliminated by a 10% alcoholic extract solution of Clitoria ternatea's aerial section, but the rabbit cornea did not experience any surface anaesthetic effects. Alcoholic extract from Clitoria ternatea aerial sections was nearly as effective as xylocaine at producing local anesthesia (52).

Gastrointestinal effect

A variety of experimentally created rat ulcer models were used to analyze Clitoria ternatea ethanolic and aqueous extracts' anti-ulcer characteristics. The consequences of ethanolic and aqueous extracts of the entire plant, including 200 and 400 mg/kg on rats suffering from pylorus ligation and indomethacin-induced stomach ulcers were investigated. Numerous parameters were analyzed and contrasted between the extract-receiving, standard, and vehicle control groups following the development of ulceration. Measurements were made of the total acidity, antioxidant qualities, ulcer secretion volume, pH, and ulcer index. The high dosage of alcoholic extract had a noteworthy antiulcer effect in the ulceration and the pylorus ligation caused by indomethacin (53)

Therapeutic Actions Against Fever, Inflammation and Pain

In rats, the Clitoria ternatea roots' methanolic extract showed potent anti-inflammatory, antipyretic and analgesic properties. Compared to diclofenac, it caused less peritoneal inflammation, less paw oedema from carrageenin, and less Evan blue dye leakage from acetic acid. Additionally, albino rats' body temperature and yeast-induced pyrexia were demonstrated as being decreased by the methanolic extract of the Clitoria ternatea root. The extract effectively reduced body temperature after a 19-hour subcutaneous injection, removing both elevated and normal body temperature (54).

Anticonvulsant and antistress activity

A methanol extract from the upper sections of C. ternatea was shown in mouse research to considerably delay the beginning of seizures induced by PTZ and maximal electroshock. Additionally, it prolonged the tonic hindlimb broadening period, suggesting that CT could be helpful in treating seizures (55). Pentylenetetrazol and maximal electroshock seizure tests were used to check the anticonvulsant potential of an ethanolic extract of ternatea's aerial parts in rats. Doses of 230 and 460 mg/kg did not prove to have any discernible effects. Additionally, the extract demonstrated anti-stress qualities in head twitches and ulcers caused by cold-restraint stress (52).

Antihistamine activity

The study tested Clitoria ternatea roots' antihistaminic properties on mice stimulated with clonidine and a model of catalepsy caused by haloperidol. Clitoria ternatea extract specifically from the roots (ECTR) and chlorpheniramine maleate were identified to significantly reduce clonidine-induced catalphagenesis, but not haloperidol-induced catalphagenesis. This indicates that ECTR possesses antihistaminic properties, potentially aiding in asthmatic symptoms (56).

Anti-Asthmatic activity

Rat models of egg albumin-induced degranulation of mast cell, mouse models of milk-induced eosinophilia, leucocytosis and rat models of passive cutaneous anaphylaxis were used to determine the antiasthmatic effectiveness of the ethanol extract (ECTR) from Clitoria ternatea roots. The findings showed that ECTR's LD50 exceeds 1300 mg/kg. Along with significantly lowering milk-induced leucocytosis and eosinophilia in rats and blocking the region where blue dye escapes during passive cutaneous allergy, ECTR protects mice from egg albumin-induced degranulation of mast cell. Glycosides, flavonoids, steroids, and saponins were recognized by phytochemistry studies (56).

Antidepressant and Relaxation-Enhancing Properties

An investigation into the behavioral influence of a 1-2 g/kg alcoholic extract of the herb found that it has potent tranquillizing impacts on the CNS, suppressing alertness, decreasing spontaneous motor activity, and increasing sedation. Some mice developed a lack of the righting reflex and preferred tactile, auditory, and nociceptive stimuli after consuming these extracts (52). A methanol extract of ternatea's aerial part was tested for its antidepressant effects using tail suspension tests. Results showed that oral C. ternatea reduced immobility duration, improved cognitive performance, and did not cause drowsiness or behavioural toxicity. The conditioned avoidance response test was accustomed to investigate its sedative properties in rats (55).

Nootropic activity

An observation of C. ternatea suggested that it have nootropic qualities, which were shown to improve experimental animals' cognitive performance (55,57). For about 60 days, rats were given a 1:1 mixture of crushed jaggery and C. ternatea plant, which decreased the degree of autophagy in their brains. Rats administered ethanolic extracts from the aerial tissues or roots of C. ternatea (300 mg/kg) orally were demonstrated as more successful than controls at reducing the activities of amnesia caused by electric shock in a different study (58). In another investigation, rats given 100 mg/kg of aqueous C. ternatea extract of root orally for 48 hours and 1 month shown improved spatial learning and memory retention abilities (57). According to Rai (2001), nootropic action is more noticeable in the root than in the bloom (59).

Hepatoprotective activity

Apart from histological analysis, the hepatoprotective impact of C. ternatea leaf methanolic extract (ME) was assessed by measuring the action of the enzymes bilirubin, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) on mice's liver damage brought on by paracetamol. The methanolic extract of leaf of C. ternatea (200 mg/kg) significantly reduced AST, bilirubin, and ALT levels in mice compared to the group taking paracetamol ($p < 0.01$) according to a study on paracetamol-induced liver injury. Additionally, therapy with C. ternatea extract (leaf) protects against histological changes (48).

Wound healing effect

Similar to cotrimoxazole, the study examined the effective ability of Clitoria ternatea seedlings and root concentrates in accelerating wound healing in rhodents and discovered that they greatly improved healing in a range of wound types (60). The study investigated the efficiency of standard leaf extract from Clitoria ternatea in wound healing, focusing on its ability to inhibit enzymes like MMP-1, hyaluronidase, and elastase (61).

Anthelmintic effect

C. ternatea anthelmintic products have been thoroughly examined, showing different levels of resistance to parasitic root-knot nematodes and preventing fruit ripening (62). 93% of uncertain fruits were stopped from ripening by the C. ternatea's methanolic concentrate (63). Studies with Caenorhabditis elegans showed extract of CT was effective, the root extract is more poisonous than the leaf extract, and it kills tapeworm larvae (64,65,66). Two studies have shown antineurothelial ability of C. ternatea, with a 50 mg/mL extract causing more worm death and paralysis than piperazine citrate (65). 100 mg/mL of C. ternatea extract in aqueous and ethanolic forms caused worm death and paralysis, with extracts showing a slower rate of death and paralysis compared to levamisole (66).

In treatment of OCD

What's OCD?

Prepossessions — willful, distressing, recreating studies, impulses, or images and forces repetitious behaviours or internal acts performed with the intention of reducing torture — are emblems of compulsive- obsessive complaint (OCD), an enervating and disturbing internal health condition (67). The etiology of OCD includes hereditary factors and anomalies of the CNS, including those involving the dopaminergic, glutamatergic, and serotonin pathways (68). The high burden of complaints and negative socioeconomic impacts of OCD make there few remedial options. Exposure and response forestallment (ERF) combined with Integrative behavioral treatment is a proven treatment, but some individuals don't fully benefit (69). Camfield et al. discovered chemical compounds and pharmacological sauces that alter glutamatergic and serotonergic pathways (70).

Role of Clitoria ternatea (herbal drug) in the management of OCD

Clitoria ternatea, an Ayurvedic remedy, is being used to treat various ailments, including sadness and anxiety. Its seedlings and roots are utilized to make Sankhapushpi, a neurotonic (1). The neuropsychiatric characteristics of Clitoria ternatea might affect 5-HT reuptake and are associated with its serotonergic exertion (26,55). It has antidepressant and anxiolytic properties as well (71). Research has indicated that the plant's ethanol extract can reduce compulsive obsessive gestures, similar to fluoxetine's ability to moderate compulsive obsessive gestures (72). Ternatins and flavonoids are the main phytoconstituents of Clitoria ternatea that is currently investigated for its potential use to cure compulsive-obsessive complaints (OCD). These substances have a range of antidepressant, anxiolytic and neuroprotective rates.

Other Herbal Medicines used for the treatment of OCD

1) Benincasa hispida

The native Asian fruit Benincas hispida, sometimes known as furry melons, cold melon, wax gourds, ash pumpkin, or white pumpkin, is prized for its medicinal and nutritional qualities. It is used to treat nerve disorders and is a necessary component of Ayurvedic treatments. Strong antidepressant qualities are found in hairy melon fruit extract and juice (73), which also increase serotonin activity (74,75). Its anti-OCD properties has been suggested, however the precise mechanism is still unknown. Without impairing motor function, mice's compulsive marble-burying behaviour was decreased by a methanol-based solution of B. hispida fruit (76).

2) Colocasia esculenta

Elephant ear, belonging to the Araceae family, is a traditional "nerve tonic" used to treat various ailments. In a marble-burying test, it showed anti-compulsive plots and a dose-dependent reduction in marbles, similar to fluoxetine. It also produced antidepressant and anxiolytic effects, supporting conventional claims (77).

3) Curcumin and Curcuma species

The Zingiberaceae genus Curcuma is indigenous to regions that are tropical or subtropical, is utilised in traditional medicines for treating various illnesses (78). Curcuminoids, the main components, modulate serotonin, dopamine, and norepinephrine within the brain and suppress biogenic amines (79). Curcumin may be used as mental illnesses remedy, as it raises serotonin level (80). A studied data on curcumin's effects on OCD found it significantly affected brain monoamine levels and had a shielding impact.

4) Lagenaria siceraria

Bottle gourd, or Lagenaria siceraria, is a herbal remedy used in India, used for treating cardiovascular and hepatic disorders. It has been demonstrated that its ethanolic extract possesses adaptogenic and anti-stress qualities, and has been discovered to contain antidepressant properties, with some studies showing similar effects to fluoxetine (81,82,83).

5) Withania somnifera

Indian ginseng, W. somnifera, being used for a long period in Ayurvedic treatment. According to research, it has neuroprotective, adaptogenic, anxiolytic, depressive, and cognitive-enhancing qualities (84). Alkaline substances, withanolides, and sitoindosides are among its active ingredients (85). When taken by those who are under a lot of stress, 300 mg of W. somnifera root extract was observed to considerably reduce depression, anxiety, cortisol, and social dysfunction (86,87).

Why Clitoria ternatea is better than other herbs

OCD is being treated with Clitoria ternatea because of its unique phytochemical and pharmacological characteristics.

1) Phytochemicals having Neuroprotective Abilities:

Bioactive substances having antioxidant and neuroprotective characteristics like flavonoids, anthocyanins (ternatins), alkaloids and triterpenoids are present in Clitoria ternatea. These phytochemicals can modulate the neurotransmitters like glutamate, dopamine and serotonin which are necessary for mood and anxiety control. Serotonin: OCD is serotonergic mediated and Clitoria ternatea increases serotonin levels. Hence OCD symptoms will be reduced.

2) Depression and Anxiety Relief:

OCD often coexists with depression as well as anxiety behaviour and Clitoria ternatea has shown anxiolytic and antidepressant properties in preclinical studies. Its capability to act on multiple pathways (serotonergic, GABAergic, dopaminergic) is helpful in addressing the emotional components of OCD.

3) No Major Side Effects:

Compared to conventional OCD medications like SSRIs and antipsychotics, Clitoria ternatea contain a low side effect profile. Many herbal remedies can have side effects or toxicity when used long-term but Clitoria ternatea is regarded as safe in traditional use. Additionally, there are no documented sedative effects from long-term use.

4) Neuro Inflammation:

It is believed that neuroinflammation plays a part in the pathogenesis process of OCD. Beyond neurotransmitter regulation, Clitoria ternatea's anti-inflammatory qualities can also lessen neuroinflammation, which is another way to treat OCD.

5) Brain enhancer:

It has been investigated for nootropic or cognitive-enhancing effects. It enhances learning and memory. This is crucial for those who suffer from OCD that consistently show reduced cognitive flexibility, executive function, as well as memory, due to intrusive thoughts and compulsive behaviours. The herb could offer twofold benefits- It might improve cognitive function and lessen OCD symptoms.

6) Ayurvedic and Traditional Usage:

The traditional use of the herb Clitoria ternatea to calm the mind and improve mental clarity has been valued for ages in the Ayurvedic medicine system. It therefore presents a very important cultural and historical context within which deeper exploration regarding potential use might make it a very potential prospect for further scientific validation in the cure of OCD.

7) Targeted serotonergic modulation:

One of the primary causes of this condition is a serotonin imbalance. The brain's serotonin concentrations are directly impacted by Clitoria ternatea. Serotonin is more effective at controlling impulsive behaviour and mood. Perhaps Clitoria ternatea is a better option for treating OCD because it directly modulates the serotonergic system.

8) Potential for Faster Relief of Symptoms:

Clitoria ternatea because of its direct action on neurotransmitters such as dopamine and serotonin, Clitoria ternatea may thus show relatively quicker symptomatic relief of OCD behaviours, such as compulsions and intrusive thoughts. Its rapid onset of anxiolytic and anti-compulsive activity could be quite beneficial in managing acute episodes of OCD.

Future Aspects and Next-Generation Applications

The growing desire for natural and healthful products in today's market is both an opportunity and a difficulty for the dietary industry. The aerial sections of C. ternatea are among the most prevalent and practical sources for organic pigment. Nevertheless, because they are unstable and their tendency to degrade in response to changes in temperature, light and pH natural plant colourants are not frequently utilised (88). Given that natural colourants' pigments are often unstable and easily deteriorate, microencapsulation is the best method for protecting them.

Insect Prevention Applications of Clitoria ternatea Peptide Extract

Recent preparation of organic ethanol extract from vegetative tissue of C. ternatea has demonstrated excellent insecticidal action against a variety of crop-related pests (89). There are currently outstanding applications for the extract, known as Sero-X®, within Australia and other countries. It is approved for usage in macadamia and cotton. It is unknown exactly how this ethanolic extract works, even if the high concentration of ternatea cyclic chemicals in it is most likely partially to blame (39,40,64).

Consumer Products

Butterfly pea flowers, a type of flower, can be white, bright blue, or any shade. They are highly prized in Asia for their vibrant blue pigment in teas, desserts, and clothing. As a substitute for artificial blue food colouring because of health concerns, C. ternatea's floral extracts have recently been employed to produce vivid blue alcohol-dependent gins (90,91).

CONCLUSION

Clitoria ternatea is a plant with many uses and with numerous medicinal properties, making it an essential addition to modern drug search. Its flower petals contain bioactive compounds like polyphenols, which prevent various diseases. These petals have additional advantages for pharmaceutical treatments and useful meals because of their diuretic, nootropic, antiseptic, anti-asthmatic, pain-relieving, antipyretic, hypoglycemic, antilipidemic, anti-arthritic, natural antioxidant, and wound-healing properties. Being a different origin of treatment for OCD, Clitoria ternatea is a whole approach, which includes achieving its goal at the stages of serotonin, pathways related to serotoninergic, dopaminergic, and GABAergic pathways that regulate mood and anxiety, and optimizing cognitive health through deficiencies such as reduced memory and executive function. According to most research studies, the flowering part of C. ternatea is acceptable and non-toxic for consumption. Flower extracts in liquid form are utilized in food items but microencapsulated extracts remain relatively less studied

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50. We the undersigned herewith submit a manuscript entitled 'Exploring the Bioactive Compounds & Potential Health Benefits of Clitoria ternatea Linn. in the Treatment of OCD: A Systematic Review' author by Himanshu Ashok Bankar in the Indian J. Pharmaceutical Sciences.
51. We hereby declare that the manuscript is not submitted or being considered to another Journal in part of full for publication.
52. The manuscript is not submitted to or being considered by another journal in part or full for publication
53. The authors listed above are involved in the carrying out research work presented in the manuscript and that the research work was carried out at the address(es) listed in the title page of manuscript.
54. No part of the manuscript contains plagiarized portion from any other published material.
55. We also acknowledge that if any of the above declarations are found to be incorrect, then the manuscript will get rejected L. International Journal of Drug Discovery. 2011 Jul 30;3(1):74–7.

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Fig 1: Image of *Clitoria ternatea* Linn.

Table 1: General nutritive components in *Clitoria ternatea*

Components	Concentration
Moisture Content	92.40%
Fat	2.50%
Carbohydrates	2.20%
Fibres	2.10%
Proteins	0.32%

Components	Concentration
Potassium	1.25 mg/g
Zinc	0.59 mg/g
Sodium	0.14 mg/g
Calcium	3.09 mg/g
Magnesium	2.23 mg/g
Iron	0.14 mg/g

Table 2: Examples of polyphenols present in *Clitora ternatea*

Phytoconstituent	Examples	Therapeutic Uses
Polyphenols	Flavonols	Anticancer effect
	Glycosides	Antidiabetic effect
	Myricetin	Anti-bacterial effect
	Quercetin	Anti-inflammatory effect
	Phenolic acids	Cardiovascular health
	Kaempferol	Anti-aging and skincare

Table 3: Examples of flavonols in *Clitoria ternate*

Phytoconstituent	Examples	Therapeutic Uses
Flavonols	Quercetin 3-glucoside	Anticancer effect
	Kaempferol 3-robinobioside-7-rhamnoside	Neuroprotective effect
	Myricetin 3-rutinoside	Cardiovascular health
	Myricetin 3-glucoside	Anti-inflammatory effect

Table 4: Examples of anthocyanins in *Clitoria ternatea*

Phytoconstituent	Examples	Therapeutic Uses
Anthocyanins	Delphinidin	Antioxidant properties
	Delphinidin-3,5-diglucoside	Neuroprotective
	Delphinidin-3-glucoside	Gastroprotective
	Petunidin	Eye health
	Malvidin	Anticancer

	Peonidin	Immune system support

Undertaking to be signed by all authors while submitting manuscript

We the undersigned herewith submit a manuscript entitled 'Exploring the Bioactive Compounds & Potential Health Benefits of Clitoria ternatea Linn. in the Treatment of OCD: A Systematic Review' author by Himanshu Ashok Bankar in the Indian J. Pharmaceutical Sciences. We hereby declare that the manuscript is not submitted or being considered to another Journal in part of full for publication.

- The manuscript is not submitted to or being considered by another journal in part or full for publication
- The authors listed above are involved in the carrying out research work presented in the manuscript and that the research work was carried out at the address(es) listed in the title page of manuscript.
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