



COMPREHENSIVE REVIEW STUDY ON APRAJITA *CLITORIA TERNATEA L.*

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ABSTRACT

Clitoria ternatea, commonly known as Aprajita or Butterfly Pea, is a perennial medicinal herb belonging to the Fabaceae family and is widely distributed throughout tropical and subtropical regions. The plant has been extensively utilized in traditional systems of medicine such as Ayurveda, Siddha, and Unani for the management of various diseases and health disorders. Owing to its remarkable therapeutic value and diverse pharmacological properties, Aprajita has gained increasing scientific attention in recent years. Different parts of the plant including flowers, roots, leaves, stems, and seeds are reported to possess medicinal importance and are traditionally used in the treatment of neurological disorders, skin infections, inflammation, respiratory diseases, urinary disorders, fever, and digestive problems. The present review provides a comprehensive overview of the botanical profile, phytochemical constituents, traditional uses, pharmacological activities, and therapeutic potential of *Clitoria ternatea*. Phytochemical investigations have revealed the presence of several biologically active compounds such as flavonoids, anthocyanins, alkaloids, tannins, glycosides, saponins, triterpenoids, phenolic compounds, and steroids. Among these constituents, anthocyanins known as ternatins are primarily responsible for the characteristic blue coloration of the flowers and contribute significantly to the antioxidant potential of the plant. Experimental and pharmacological studies have demonstrated that Aprajita exhibits a wide range of biological activities including antioxidant, antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, neuroprotective, analgesic, antipyretic, anticancer, immunomodulatory, and wound-healing properties. The antioxidant activity of the plant helps in neutralizing free radicals and reducing oxidative stress associated with chronic diseases and aging. Antimicrobial studies have reported inhibitory effects against several pathogenic bacteria and fungi, supporting its traditional use in skin infections and wound management. Anti-inflammatory and analgesic activities of the plant contribute to its usefulness in relieving pain, swelling, and inflammatory conditions. Aprajita is also widely recognized as a brain tonic in traditional medicine due to its memory-enhancing and neuroprotective effects. Several studies suggest that the plant may improve learning ability, cognitive performance, and mental health by protecting neuronal cells from oxidative damage. In addition, antidiabetic investigations indicate that plant extracts may assist in lowering blood glucose levels and improving glucose metabolism. Hepatoprotective studies further demonstrate its ability to protect liver tissues against toxin-induced damage. Apart from medicinal applications, the natural blue pigment obtained from the flowers has gained importance in food, cosmetic, and nutraceutical industries as a natural coloring agent. Herbal teas and functional beverages prepared from the flowers are increasingly popular because of their health-promoting properties and antioxidant content. Although numerous preclinical studies support the therapeutic potential of *Clitoria ternatea*, further clinical investigations, toxicity evaluations, and standardization studies are necessary to confirm its safety, efficacy, and therapeutic applications in modern healthcare systems. Overall, the plant represents a promising source of bioactive compounds with significant pharmaceutical and industrial potential, highlighting its importance in herbal medicine and future drug development research.

KEYWORDS: *Clitoria ternatea L.*, antimicrobial activity, Fabaceae, extraction, traditional use, phytochemistry herbal.

INTRODUCTION

History of Aprajita in Ayurveda

Aprajita, commonly known as butterfly pea, is an important medicinal plant described in traditional Ayurvedic literature for its wide therapeutic value. The name —Aprajita means —the one who cannot be defeated, which reflects the high medicinal importance given to this herb in ancient Indian medicine. In Ayurveda, the plant has been used for centuries as a natural remedy for improving memory, treating skin disorders, reducing inflammation, and managing various infectious conditions.

Ancient Ayurvedic texts mention Aprajita as a sacred and healing herb possessing multiple pharmacological properties. The plant was traditionally included in several herbal formulations because of its ability to balance the three doshas—Vata, Pitta, and Kapha. Ayurvedic practitioners believed that regular use of Aprajita helped in maintaining physical strength, mental clarity, and overall body wellness. Due to its rejuvenating and detoxifying nature, it was commonly utilized in Rasayana therapy, which aims to improve longevity and immunity.

Historically, different parts of the plant such as roots, flowers, leaves, and seeds were used for medicinal purposes. The roots were especially valued for their nervine and laxative actions, while the flowers were widely used for enhancing brain function and relieving stress-related conditions. Traditional healers also employed Aprajita in the treatment of respiratory disorders like asthma and cough because of its expectorant activity. In addition, the herb was used externally for wound healing, skin infections, and inflammatory diseases.

In Ayurvedic practice, Aprajita was also considered beneficial for improving intellect and memory. Therefore, it was often prescribed in formulations intended for neurological health and mental development. The herb was traditionally administered in the form of powders, decoctions, juices, and medicated pastes depending on the disease condition and therapeutic requirement.

Apart from its medicinal significance, Aprajita also holds cultural and spiritual importance in India. The flowers are frequently used in religious rituals and worship ceremonies because the plant is regarded as sacred in many regions. This traditional association further increased its popularity in folk medicine and household remedies.

With the advancement of modern scientific research, many traditional claims related to Aprajita have gained experimental support. Studies have reported that the plant possesses antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and neuroprotective activities. These findings have strengthened the

historical importance of Aprajita in Ayurveda and encouraged its use in herbal pharmaceutical preparations.

Naturopathy

Aprajita, commonly known as butterfly pea, is a well-known medicinal herb that has been used for centuries in traditional systems of medicine such as Ayurveda, Siddha, and folk healing practices. The plant belongs to the Fabaceae family and is widely distributed throughout tropical regions of India and Southeast Asia. In Ayurveda, it is popularly called —Aprajita, meaning —invincible or —unconquered, symbolizing its powerful healing potential. Ancient healers considered the plant highly valuable because of its ability to support both physical and mental health naturally.

Historically, Aprajita was used as a rejuvenating herb in Ayurvedic medicine. Traditional practitioners utilized different parts of the plant including roots, flowers, leaves, and seeds for treating a variety of disorders. The herb was especially recognized as a brain tonic and memory enhancer. Classical Ayurvedic literature described Aprajita as a —Medhya Rasayana, a category of herbs believed to improve intellect, concentration, and nervous system function. It was commonly prescribed for mental fatigue, anxiety, insomnia, epilepsy, and stress-related disorders.

In naturopathy, Aprajita gained importance because of its natural healing properties and minimal side effects. Naturopathy focuses on supporting the body's self-healing mechanism through natural remedies, diet, herbal preparations, and lifestyle management. Due to its antioxidant, anti-inflammatory, and detoxifying nature, Aprajita became an important herbal component in natural therapies. The plant has traditionally been used to purify the blood, improve digestion, enhance immunity, and maintain overall body balance.

One of the major naturopathic uses of Aprajita is in promoting brain health. Traditional healers believed that the herb nourishes brain tissues and improves cognitive performance. Herbal preparations prepared from the roots and flowers were administered to improve memory, learning capacity, concentration, and mental clarity. Modern scientific studies also support these traditional claims and indicate that the plant possesses neuroprotective and nootropic activities.

Aprajita has also been widely used in natural treatment approaches for stress and anxiety management. The calming effect of the plant on the nervous system made it useful in relieving mental tension and emotional disturbances. In folk medicine, herbal tea prepared from blue flowers of Aprajita was consumed to promote relaxation and improve sleep quality. This practice continues today in many wellness and naturopathy centers where butterfly pea tea is used as a refreshing herbal beverage.

Another important area of naturopathy involving Aprajita is skin and wound care. Traditional medicine systems used flower and leaf paste externally for treating skin infections, inflammation, boils, and wounds. The antimicrobial and anti-inflammatory properties of the plant helped in faster healing and protection against microbial growth. Recent pharmacological studies have shown that extracts of the plant exhibit antibacterial, antifungal, and antioxidant activities, supporting its traditional use in skin therapies.

In digestive health management, Aprajita has traditionally been used as a mild laxative and detoxifying herb. Naturopathic practitioners utilized root preparations for relieving constipation, indigestion, and intestinal discomfort. The plant was also believed to help in removing toxins from the body and improving metabolic activity. In Ayurveda, it was additionally used in liver-related disorders because of its protective effects on hepatic tissues.

Aprajita also holds importance in respiratory care. Traditional healers used the herb in conditions such as cough, asthma, bronchitis, and throat irritation. Decoctions prepared from roots and leaves were believed to help clear mucus and support healthy breathing. Some ethnomedicinal reports from tribal communities in India mention the use of Aprajita in treating respiratory infections and fever-related conditions.

In natural healthcare systems, Aprajita is additionally recognized for its antioxidant potential. The flowers contain anthocyanins and flavonoids that help neutralize harmful free radicals in the body. Because of this property, the plant is considered beneficial in reducing oxidative stress and delaying cellular damage. Modern herbal industries now incorporate butterfly pea extracts into herbal teas, nutraceuticals, skincare products, and wellness supplements.^[1]

From a cultural and spiritual perspective, Aprajita has been associated with purity and positive energy in Indian traditions. The flowers are frequently used in religious rituals and worship ceremonies. In many rural regions, the plant continues to be cultivated around homes not only for ornamental beauty but also for household medicinal use.^[2] This strong traditional association contributed significantly to its survival as an important medicinal herb across generations.

Comprehensive scientific research performed in recent years has further validated many traditional and naturopathic claims associated with Aprajita. Studies indicate that the plant possesses antimicrobial, antidiabetic, anti-inflammatory, hepatoprotective, analgesic, antioxidant, and anticancer activities. Researchers have identified several bioactive constituents such as flavonoids, tannins, alkaloids, anthocyanins, and triterpenoids responsible for these pharmacological effects.

Overall, Aprajita represents an important medicinal herb in both Ayurveda and naturopathy because of its broad therapeutic applications and natural healing abilities. Its long historical use, combined with modern scientific evidence, highlights its significance in herbal medicine and natural healthcare systems.^[3] The increasing interest in plant-based therapies and herbal formulations has further enhanced the value of Aprajita in pharmaceutical, cosmetic, and nutraceutical research. Since ancient times, plant-based medicines have played a vital role in the prevention and treatment of diseases. However, many bioactive constituents derived from these natural sources remain unexplored. This has motivated researchers to identify and isolate new compounds from medicinal plants for the treatment of various infectious diseases. Studies indicate that many medicinal plants exhibit antimicrobial, antioxidant, and anti-inflammatory activities, contributing significantly to the prevention and management of infectious conditions and offering substantial benefits to society.^[4] In the current global health landscape, infectious diseases continue to be a major concern, particularly due to the growing problem of antibiotic resistance in clinical settings.^[5] Therefore, there is an urgent need to develop effective natural formulations capable of combating microorganisms responsible for skin infection.

Clitoria ternatea L., a perennial climbing herb in the Fabaceae family, is sometimes referred to as butterfly pea or Aprajita. India, Southeast Asia, and parts of Africa are among the tropical and subtropical locations where it is widely dispersed.^[6,7,8] Due to its alleged benefits for brain health, the plant is highly valued in traditional medical systems like Ayurveda and is sometimes referred to as "Shankhapushpi" in local contexts.^[9] Aprajita has long been used to treat a wide range of illnesses, such as anxiety, fever, inflammation, skin issues, respiratory disorders, and cognitive difficulties.^[10]

Clitoria ternatea is known to contain a wide variety of bioactive substances, including as flavonoids, anthocyanins (particularly ternatins), alkaloids, triterpenoids, saponins, glycosides, and phenolic compounds, according to phytochemical studies.^[11,13] Its many pharmacological characteristics, including antioxidant, anti-inflammatory, antibacterial, antidiabetic, neuroprotective, hepatoprotective, and anticancer capabilities, are caused by these phytochemicals.^[14,15] Notably, its blossoms' vibrant blue anthocyanin pigments have drawn a lot of interest as natural colorants for foods, drinks, cosmetics, and nutraceutical formulations.^[16,17] In an effort to verify its traditional claims and investigate novel uses, scientific research on Aprajita has been sparked in recent years by the increased interest in plant-based medicines and natural goods.^[18] Information about its phytochemistry, pharmacology, and therapeutic potential is still dispersed throughout many sources despite a large number of experimental investigations. As a result, a thorough

assessment is necessary to compile the body of knowledge, assess the available data, pinpoint research gaps, and emphasize potential future directions for the creation of pharmaceutical, nutraceutical, and cosmetic products based on aprajita.^[19,20]

Antimicrobial Activity of Aprajita

Aprajita (*Clitoria ternatea* Linn.) is an important medicinal plant extensively used in traditional systems of medicine because of its wide range of therapeutic properties. Among its various pharmacological activities, antimicrobial activity has attracted considerable attention in recent years due to the increasing incidence of microbial resistance against synthetic antibiotics.

Different parts of the plant, including flowers, leaves, roots, stems, and seeds, possess significant antimicrobial potential against several pathogenic microorganisms. The antimicrobial efficacy of the plant is mainly associated with the presence of biologically active phytoconstituents such as flavonoids, tannins, alkaloids, phenolic compounds, anthocyanins, glycosides, and saponins.

Various extracts of *Clitoria ternatea*, particularly ethanolic and methanolic extracts, have demonstrated inhibitory effects against a broad spectrum of microorganisms. These extracts are reported to be effective against both Gram-positive and Gram-negative bacteria. Several studies have shown that the plant exhibits antibacterial activity against pathogens such as *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, and *Klebsiella pneumoniae*. The antimicrobial effect is generally assessed using agar well diffusion, disc diffusion, and minimum inhibitory concentration methods. Among different solvent extracts, ethanolic extracts often exhibit greater antimicrobial activity because ethanol efficiently extracts polar phytoconstituents responsible for microbial inhibition.

The antibacterial activity of Aprajita is mainly attributed to flavonoids and phenolic compounds, which interfere with microbial cell wall integrity and membrane permeability. These phytochemicals may cause leakage of intracellular constituents, resulting in microbial cell death. Tannins present in the plant are capable of precipitating microbial proteins and inhibiting essential enzymes required for microbial metabolism. Similarly, saponins possess membrane-disrupting properties that further contribute to antimicrobial action. Anthocyanins, especially abundant in the blue flowers of the plant, also play an important role due to their antioxidant and antimicrobial characteristics.

In addition to antibacterial effects, *Clitoria ternatea* also possesses notable antifungal activity. Extracts of the plant have shown inhibitory effects against fungal organisms such as *Candida albicans*, *Aspergillus niger*, and *Aspergillus flavus*. The antifungal activity is

believed to occur through alteration of fungal cell membrane structure and suppression of fungal growth and spore formation. This property supports the traditional use of the plant in the treatment of skin infections and wound-related disorders.

Scientific investigations suggest that the antimicrobial activity of Aprajita involves multiple mechanisms of action. These include disruption of microbial cell membranes, inhibition of nucleic acid and protein synthesis, interference with enzymatic activity, and induction of oxidative damage within microbial cells. Due to the presence of multiple active compounds acting through different pathways, the plant may help minimize the development of microbial resistance.

The increasing demand for herbal antimicrobial agents has encouraged the use of *Clitoria ternatea* in the formulation of herbal gels, creams, ointments, and wound-healing preparations. Herbal formulations containing Aprajita extract may provide effective protection against microbial infections while producing fewer adverse effects compared to synthetic antimicrobial agents. Furthermore, the antioxidant activity of the plant may enhance tissue repair and accelerate wound healing.

Overall, available scientific evidence supports the significant antimicrobial potential of *Clitoria ternatea*. The plant exhibits broad-spectrum antibacterial and antifungal activity due to the synergistic action of various phytochemicals. Therefore, Aprajita can be considered a promising natural source for the development of safe and effective herbal antimicrobial formulations and pharmaceutical preparations.



Figure 1: *Clitoria ternatea* L.

Vernacular name

Language	Name
Arabic	Mazerion Hidi, Baslat el-Zuhoor
Bengali	Aparajita
Chinese	Die dou
English	Blue-pea, butterfly-pea, Darwin-pea
French	Honte
German	Blaue klitorie
Hindi	Aprajita
Sanskrit	Conchitas papito, azulejio, zapatillo
Tamil	Kakkanam

Plant type: Perennial herbaceous plant.

Origin: Latin America or Asia.

Habit: Climbing or trailing vine becoming woody with age to 10m in length, sparsely pubescent throughout.

Taxonomical classification

Kingdom - Plantae Order - Fabales Family - Fabaceae
Tribe - Phaseoleae Subtribe - Clitoriinae Genus - Clitoria.

Plant Description

Perennial climbing or trailing herb, growing from a woody rootstock. Leaves imparipinnate with 2-4 pairs of leaflets and a terminal leaflet. Leaflet ovate to elliptic-oblong, up to 6.5×4cm, mostly hairless above, pubescent below. Flower axillary, solitary or 2 together, resupinate, large and showy, bright blue. Pod linear, oblong 6-13 cm long, flattened, mucronate at the apex, hairless or finely pubescent. It is growing wild and also in gardens, bearing conspicuous blue or white flower resembling a conch-shell. While presumably of American origin, today it is cultivated and naturalized throughout the humid tropics of the old and new world below 1600m elevation. It is distributed in India, the Philippines, other tropical Asia countries, South and Central America, the Caribbean and Madagascar.

Phytochemical review

Seed

Three unknown trypsin inhibitors, water-soluble mucilage, delphinidin-3,3,5-triglucoside (a substance that can be used as a natural food colorant), p-hydroxycinnamic acid, flavonol-3-glycoside, ethyl- α -D-galactopyranoside, adenosine, 3,5,7,4'-tetrahydroxyflavone, 3-rhamnoglucoside, a polypeptide, hexacosanol, β -sitosterol, and anthoxanthin glucoside are just a variety of metabolites.^[21,23] There have also been reports of anthoxanthins and oligosaccharides in the seeds. Sterols, alkaloids, glycosides, saponins, tannins, proteins, carbohydrates, flavonoids, and other phenolic chemicals have also been found in *C. ternatea* seeds by other studies.^[22,24]

Root

Numerous phytochemicals, including as ternatins, alkaloids, flavonoids, saponins, tannins, carbohydrates, proteins, resins, starch, taraxerol, and taraxerone, are abundant in *C. ternatea* roots.^[25] Resin, tannins, starch, and flavonol glycosides are found in root bark, and several amino acids, including glycine, alanine, valine, and glutamic acid, have been found in root nodules.^[26] Alkaloids, terpenoids, steroids, phenolics, glycosides, coumarins, triterpenoids, and reducing sugars have all been found using various extraction techniques (aqueous,

methanolic, ethanolic, and hydroalcoholic).^[27] Compounds including campesterol, taraxasterol, n-hexadecanoic acid, vitamin E, and 12-oleanen-3-yl acetate were also found by GC-MS analysis, demonstrating the extensive chemical diversity of the plant's root.^[28]

Leaves

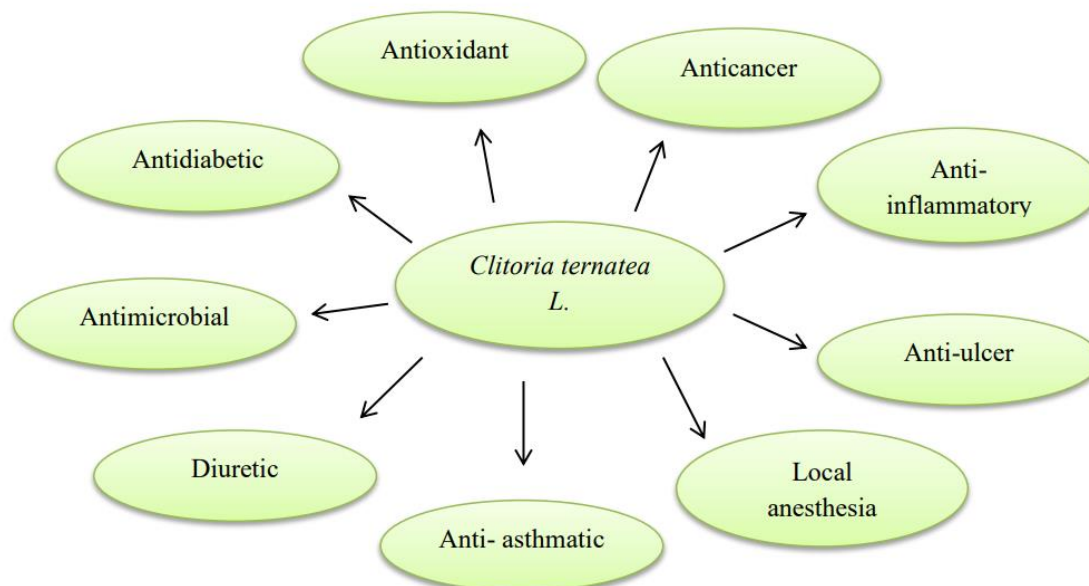
Alkaloids, flavonoids, phenols, terpenoids, glycosides, coumarins, catechol, quinones, gum, mucilage, proteins, carbohydrates, tannins, saponins, steroids, sterols, and volatile oils are just a few of the many secondary metabolites found in *C. ternatea* leaves.^[29] In general, aqueous extracts produce more constituents than organic solvents, and the phytochemical profiles of blue-and white-flowered cultivars are comparable, while the compounds present in blue-flowered leaves are more varied.^[30] Antioxidant flavonoids, including various kaempferol glycosides, as well as β -sitosterol and other bioactive chemicals has been found using a variety of extraction techniques (methanolic, hydromethanolic, and hydroalcoholic), confirming the leaves' rich phytochemical diversity.^[31]

Flower

C. ternatea flowers are abundant in bioactive phytochemicals with cytoprotective, larvicidal, hepatoprotective, antipyretic, antibacterial, antidiabetic, and antioxidant properties. The main components of the petals include flavonol glycosides of kaempferol, quercetin, and myricetin, phenolic acids, and other flavonoids, as well as anthocyanins (particularly ternatins, which are derivatives of delphinidin).^[32] Polyacylated delphinidin glucosides, or ternatins, are responsible for the blue coloring, but anthocyanin structure and acylation patterns vary to produce distinct petal hues.^[33] Furthermore, it has been possible to identify lipophilic components such tocopherols, phytosterols, and fatty acids.^[34] High anthocyanin yields have been shown by a variety of extraction procedures (such as ethanolic and ultrasonication-assisted extraction), and sophisticated technologies like LC-MS/MS have proven the presence of many phenolics and flavonoids. The flower's high concentration of blue anthocyanins makes it a popular natural culinary coloring.^[35]

Biological Activity

Clitoria ternatea contains many types of phytochemicals. Because of these compounds, the plant shows several biological activities such as antioxidant, anticancer, anti-inflammatory, antidiabetic, antimicrobial, diuretic, and anthelmintic effects.



Antioxidant

Clitoria ternatea (commonly known as Aprajita or Butterfly pea) contains a wide variety of important phytochemicals that contribute to its medicinal properties.^[36] These phytochemicals mainly include phenolic acids, flavonoids, anthocyanins, and polyphenols. These compounds are well known for their strong antioxidant activity.^[37,38]

Antioxidants are substances that help protect the body from damage caused by reactive oxygen species (ROS) or free radicals.^[39] Free radicals are unstable molecules that are produced naturally during normal metabolic processes in the body. However, excessive production of these molecules can lead to oxidative stress, which can damage cells, proteins, and DNA.^[40]

The antioxidant compounds present in *Clitoria ternatea* help neutralize these harmful free radicals and reduce oxidative stress. By doing so, they help maintain cellular health and protect biological systems from oxidative damage.^[41]

Oxidative stress is considered a major factor in the development of many chronic and degenerative diseases. These diseases include cancer, autoimmune disorders, cardiovascular diseases, and neurological disorders. Continuous oxidative damage may also contribute to aging and the progression of several metabolic conditions.^[42]

Because of its rich antioxidant content, *Clitoria ternatea* has attracted significant attention in pharmaceutical and herbal medicine research. The natural antioxidants present in this plant may play an important role in preventing or reducing the risk of various diseases by protecting cells and tissues from oxidative damage.

Therefore, the antioxidant activity of *Clitoria ternatea*

makes it a valuable medicinal plant with potential applications in health promotion, disease prevention, and therapeutic formulations.

Anti-cancer Activity

Cancer is one of the most serious health problems worldwide and is responsible for a large number of deaths every year. Conventional cancer treatments such as chemotherapy, radiotherapy, and surgery are widely used to control and treat different types of cancer. Among these, chemotherapy is commonly used to destroy or stop the growth of cancer cells. However, these treatments often cause severe side effects, including toxicity to normal cells, nausea, hair loss, immune suppression, and damage to various organs. Moreover, in many cases these treatments do not provide a permanent cure, and cancer cells may develop resistance to drugs.^[43]

Because of these limitations, researchers are continuously searching for new, safer, and more effective anticancer agents, especially those derived from natural sources such as medicinal plants. Natural products are considered promising because they often show biological activity with lower toxicity and fewer side effects compared to synthetic drugs.^[44]

Clitoria ternatea (commonly known as Aprajita or Butterfly Pea) is an important medicinal plant that has attracted attention for its potential anticancer properties. The plant contains several bioactive phytochemicals such as flavonoids, anthocyanins, tannins, phenolic compounds, and triterpenoids.^[45] These compounds are known to possess strong antioxidant, anti-inflammatory, and cytotoxic activities, which may contribute to the inhibition of cancer cell growth.^[46]

Studies suggest that the anticancer activity of *Clitoria ternatea* may occur through several biological

mechanisms. Generally, four important mechanisms are involved in the anticancer action of plant-derived compounds:

- ❖ **Induction of apoptosis (programmed cell death):** Certain phytochemicals in *Clitoria ternatea* may trigger apoptosis in cancer cells, which helps eliminate abnormal or damaged cells without affecting normal tissues.
- ❖ **Inhibition of cell proliferation:** The plant extract may slow down or stop the uncontrolled division and growth of cancer cells.
- ❖ **Antioxidant protection:** The antioxidant compounds present in the plant help neutralize free radicals and reduce oxidative stress, which is one of the major factors involved in the initiation and progression of cancer.
- ❖ **Anti-inflammatory and immune-modulating effects:** Chronic inflammation can promote tumor development. Bioactive compounds of *Clitoria ternatea* may reduce inflammation and improve the immune response against cancer cells. Due to these multiple mechanisms of action, *Clitoria ternatea* is considered a potential source of natural anticancer agents. Researchers are currently investigating its extracts and isolated compounds to better understand their pharmacological effects and possible applications in cancer therapy.

In conclusion, the presence of diverse phytochemicals and biological activities suggests that *Clitoria ternatea* may play a significant role in the development of novel anticancer drugs. However, further experimental studies, clinical trials, and pharmacological investigations are required to fully confirm its safety, effectiveness, and therapeutic potential in cancer treatment.

Anti-inflammatory

Non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used to treat inflammation. However, they are associated with several side effects. For example, drugs like acetaminophen and aspirin affect both COX-1 and COX-2 enzymes and may cause gastrointestinal and cardiovascular problems.^[47] Because of these side effects, researchers are now focusing on plant-based therapies to treat inflammatory diseases safely while still providing effective pain relief.

In a recent study, Swathi et al. evaluated the anti-inflammatory activity of the ethanolic extract of *Clitoria ternatea* roots using two experimental models: carrageenan-induced paw edema and histamine-induced paw edema.^[48] In the histamine-induced model, two doses of the extract (200 mg/kg and 400 mg/kg) significantly reduced inflammation.

Anti-diabetic Activity

Herbal-based drugs are worth exploring for prospective usage in diabetes control because they are thought to be safer and have fewer adverse effects.^[50] Biguanides, meglitinide, thiazolidinedione, sulfonylureas, and

dipeptidyl peptidase oral antidiabetic drugs have been linked to a variety of side effects. In recent days, many anti-diabetic activities have been carried out to evaluate the potency of extracts of *C. ternatea*. According to a study, a short-term intake of *C. ternatea* flower extract or beverage, when consumed with sugar, was found to lower postprandial plasma glucose and insulin levels in healthy individuals.^[51] The model postulates that flavonoid principles (flavonol glycosides and anthocyanins) and alkaloids, which may potentiate insulin production from the beta-cell or enhance blood glucose transfer from plasma to peripheral tissues, are responsible for the extract's hypoglycemic activity.^[52] An anti-diabetic effect can also be achieved by inhibiting the production of Advanced Glycation End products (AGEs). At dosages of 0.25–1.00 mg/mL, *C. ternatea* flower extract significantly inhibited AGE formation as well as decreased fructosamine levels and protein oxidation. This was accomplished by lowering protein carbonyl content and preventing free thiol depletion. According to Chu et al., *C. ternatea* flower water extract can suppress the function of the alpha-amylase enzyme in vitro. Another study showed that *C. ternatea* flower extract, at concentrations of 1% and 2% (w/v), reduced the activity of the pancreatic amylase enzyme when starch from potato, cassava, rice, corn, wheat, and glutinous rice flour was used as a substrate. A study found that treatment with an ethanolic extract of *C. ternatea* significantly reduced the serum sugar level in experimentally induced diabetes by inhibiting the galactosidase and glucosidase activities. In another investigation, the 200 mg/kg dose of methanolic leaf extract was found to be most effective at lowering blood glucose levels when compared to the 400 mg/kg dose. Studies also revealed that the 200 mg/kg dose of extract is far more effective in controlling blood glucose levels over the long term than the 400 mg/kg dose in alloxan-induced diabetic rats. It showed a significant reduction in blood glucose levels twelve hours after administration. Serum glucose, glycosylated hemoglobin, and activities of the gluconeogenic enzyme, glucose-6-phosphatase, were significantly decreased by a 400 mg/kg body weight dose of *C. ternatea* aqueous extract of leaves and flowers, while serum insulin, liver and skeletal muscle glycogen, and activities of the glycolytic enzyme, glucokinase, were significantly increased.^[53] The effects of a *C. ternatea* aerial ethanolic extract and its fractions on streptozotocin-induced diabetic rats were investigated in a separate investigation. Doses of 100–200 mg/kg were used to test the extract and its components for acute and sub-chronic antidiabetic activities. The results demonstrated that a dose of 200 mg/kg of either the ethanol extract or the butanol-soluble fractions was efficacious. Rajamanickam et al. reported that chloroform extract of *C. ternatea* flower had more effective hypoglycemic activity than ethyl acetate and methanol extract due to non-polar bioactive components contributing to the hypoglycemic activity. This was shown by the mechanism of elevated insulin secretion. A study also revealed that methanol leaf extract of *C.*

ternatea had the best diuretic activity at a maximal dose of 450 mg/kg, followed by aqueous extract and then chloroform extract in a dose-dependent manner.^[54]

Anti-microbial Activity

Antimicrobial activity refers to the ability of a substance to inhibit the growth of or destroy harmful microorganisms such as bacteria and fungi. Many medicinal plants possess natural antimicrobial properties due to the presence of bioactive compounds. One such plant is *Clitoria ternatea*, commonly known as butterfly pea. This plant has been widely studied for its medicinal potential, especially for its antimicrobial effects.^[55]

Research has shown that the antimicrobial activity of *Clitoria ternatea* mainly depends on the type of solvent used to extract its bioactive compounds. Solvents such as methanol and ethanol are considered the most effective for extracting these compounds from the flowers of the plant. These solvents help dissolve important phytochemicals that are responsible for antimicrobial effects. Studies have demonstrated that ethanolic extracts of *Clitoria ternatea* can inhibit the growth of several bacteria and fungi. In contrast, aqueous extracts (water-based extracts) often show little or no antimicrobial activity because some active compounds are not easily soluble in water.^[56]

One of the main compounds responsible for the antimicrobial activity of *Clitoria ternatea* is anthocyanin. Anthocyanins are natural pigments that give the flowers their bright blue color. Apart from their role in providing color, these compounds also possess strong antibacterial properties. Scientific studies have shown that anthocyanin-rich extracts obtained from the blue flowers can effectively inhibit the growth of certain bacteria. For example, research has reported that ethanolic extracts of the flowers showed strong antibacterial activity against *Bacillus subtilis*. Laboratory tests revealed clear inhibition zones, indicating that the extract was able to stop the growth of this bacterium. These results suggest that the plant contains powerful natural compounds that can act against harmful microorganisms.

In addition to antibacterial activity, *Clitoria ternatea* also shows antifungal properties. Fungal infections can affect humans, animals, and plants, making the search for natural antifungal agents very important. Studies have demonstrated that ethanolic extracts of the plant can inhibit the growth of different fungal species. For instance, the callus extract prepared using ethanol showed antifungal activity against *Trichoderma* species. Similarly, ethanolic extracts have been reported to show inhibitory effects against *Fusarium* species, which are known to cause diseases in plants and sometimes infections in humans. These findings highlight the broad antimicrobial potential of the plant.^[57]

Further studies have also explored the antimicrobial activity of *Clitoria ternatea* against disease-causing

bacteria. In one study conducted in 2019, researchers investigated the antimicrobial effects of crude extracts of the plant against *Proteus mirabilis*, a bacterium responsible for urinary tract infections in humans. The results revealed that extracts prepared using different solvents showed different levels of antibacterial activity. Among them, the acetone extract showed the strongest antibacterial effect against *Proteus mirabilis*. On the other hand, extracts prepared using isopropyl alcohol and petroleum ether showed relatively weaker antibacterial activity. This clearly indicates that the choice of solvent plays a crucial role in determining the effectiveness of plant extracts.

Scientists have also isolated specific compounds from different parts of the plant, including its roots. One such compound is an antibacterial flavanol glycoside obtained from the ethyl acetate-soluble fraction of the roots of *Clitoria ternatea*. However, some studies suggest that certain bacteria and fungi may show resistance to this compound. This highlights the need for further research to better understand how these natural compounds work and how they can be used effectively.

The antimicrobial properties of *Clitoria ternatea* are mainly due to the presence of several phytochemicals such as flavonoids, phenolic compounds, tannins, and anthocyanins. These compounds work by damaging microbial cell walls, disrupting metabolic processes, or preventing microorganisms from multiplying. Because of these mechanisms, the plant extract can effectively reduce or stop the growth of harmful microbes.

The antimicrobial activity of *Clitoria ternatea* has important applications in medicine and healthcare. Traditionally, this plant has been used in herbal medicine to treat infections, wounds, and inflammation. Modern scientific research supports many of these traditional uses by demonstrating the plant's ability to fight against bacteria and fungi. Natural antimicrobial agents derived from plants are becoming increasingly important because they are generally safer and produce fewer side effects compared to synthetic drugs.

In conclusion, *Clitoria ternatea* shows significant antimicrobial activity due to the presence of various bioactive compounds. Ethanolic and methanolic extracts of the flowers are particularly effective in inhibiting the growth of several bacteria and fungi. The plant's anthocyanins and other phytochemicals play a key role in its antimicrobial effects. Although more research is needed to fully explore its potential, *Clitoria ternatea* remains a promising natural source of antimicrobial agents that may contribute to future medical and pharmaceutical developments.

Anthelmintic Activity

Anthelmintic are medications that work locally to expel worms from the gastrointestinal tract while also

eradicating adult worms and diseases that can harm organs and tissues on a systemic level. *C. ternatea* was tested for its anthelmintic properties using ethanol and aqueous leaf extracts at 100 mg/mL.⁷⁹ The anthelmintic activity of the ethanolic extract of *C. ternatea* was more effective than that of the aqueous extract, which was comparable to levamisole. In the case of the aqueous extract, the time of paralysis and death was 18 ± 1.57 min and 53.33 ± 0.33 min, respectively, and in the case of the ethanolic extract, 12.33 ± 0.80 min and 32.33 ± 0.71 min. According to Nirmal et al.⁸⁰ the roots of *C. ternatea* showed the highest anthelmintic content due to the short time it takes to kill the earthworm *Pheretima posthuma*.^[58] According to Kanthal et al.⁸¹ the crude chloroform extract of *C. ternatea* showed significant anthelmintic activity against *Pheretima posthuma* at concentrations of 25, 50, and 150 mg/mL, demonstrating that the chloroform extract of *C. ternatea* had a death time of 97.02.0 min, 75.02.0 min, and 65.51.5 min (slowest), respectively.^[59,60]

THERAPEUTIC AND TRADITIONAL USES

Clitoria ternatea, commonly known as Aprajita, butterfly pea, or Asian pigeonwings, is a well-known medicinal herb used in traditional systems of medicine such as Ayurveda, Siddha, and folk medicine. The plant is valued for its beautiful blue flowers as well as its wide range of healing properties. Different parts of the plant including the roots, leaves, flowers, and seeds are traditionally utilized for the management of various diseases and health conditions. In recent years, scientific studies have also supported many of its traditional therapeutic claims because of the presence of phytoconstituents such as flavonoids, anthocyanins, alkaloids, glycosides, tannins, and triterpenoids.

Traditional Uses of Aprajita:-

In Ayurveda, Aprajita is regarded as a —Medhya Rasayana, meaning a herb that promotes intellect, memory, and mental wellness. Ancient Ayurvedic texts describe the plant as useful in balancing bodily doshas, especially Kapha and Pitta. The roots of the plant have traditionally been used as a brain tonic to improve concentration, memory retention, and mental clarity. It has also been administered in conditions like anxiety, insomnia, and nervous disorders.

Traditionally, the flowers of Aprajita are used in religious rituals and herbal preparations. In many Indian households, the blue flowers are prepared as herbal tea for maintaining general health and vitality. Folk healers have used the flower extract for reducing body heat, relieving stress, and improving skin complexion.

The root paste of the plant has been applied externally to treat swelling, inflammation, and skin infections. In rural medicinal practices, crushed leaves are often placed over wounds and cuts to promote faster healing and prevent microbial infection. The seeds of Aprajita have also been employed as mild purgatives and are sometimes used in

traditional detoxification therapies.

In Siddha medicine, Aprajita is believed to possess rejuvenating and cleansing properties. It is used for treating respiratory ailments such as cough, bronchitis, asthma, and throat irritation. Decoctions prepared from the roots and leaves are traditionally consumed to relieve fever and support the immune system.

Therapeutic Uses of Aprajita

- 1. Antioxidant Activity:** Aprajita is rich in natural antioxidants, especially anthocyanins and flavonoids present in the flowers. These compounds help neutralize harmful free radicals generated within the body. Oxidative stress is associated with aging and several chronic diseases, and the antioxidant potential of the plant may help protect cells from damage. Regular use of Aprajita preparations may contribute to better skin health, delayed aging, and improved overall wellness.
- 2. Antimicrobial Activity:** Extracts of Aprajita have demonstrated antimicrobial effects against various bacteria and fungi. The plant contains bioactive compounds capable of inhibiting the growth of pathogenic microorganisms. Because of this property, Aprajita has gained importance in the development of herbal antimicrobial formulations such as gels, creams, and ointments. Traditionally, the leaves and roots were also applied on wounds and skin infections to prevent microbial contamination.
- 3. Anti-inflammatory Property:** Inflammation is a common response associated with pain, swelling, and tissue injury. Aprajita possesses anti-inflammatory constituents that may help reduce inflammation and discomfort. Herbal preparations made from the plant have been used traditionally for joint pain, swelling, and inflammatory skin conditions. Scientific investigations suggest that the phytochemicals present in the plant may inhibit inflammatory mediators.
- 4. Neuroprotective and Memory Enhancing Effect:** One of the most recognized medicinal uses of Aprajita is its effect on the nervous system. Ayurvedic medicine considers the plant beneficial for enhancing intelligence and memory. Experimental studies indicate that the herb may improve cognitive functions and protect brain cells from oxidative damage. It is also believed to help reduce stress, anxiety, and mental fatigue. Due to these properties, the plant is often considered a natural brain tonic.
- 5. Antidiabetic Activity:** Aprajita has shown potential in regulating blood glucose levels. Certain phytochemicals present in the plant may improve insulin sensitivity and reduce elevated blood sugar levels. Traditional healers have used decoctions of the plant in the management of diabetes and metabolic disorders. The antioxidant activity of the herb may further help prevent diabetic

complications.

6. **Hepatoprotective Activity:** The liver plays a major role in detoxification and metabolism, and Aprajita has demonstrated protective effects on liver tissues. Herbal extracts of the plant may help reduce liver damage caused by toxins and oxidative stress. Traditional medicine systems have used the plant to support liver health and improve digestion.
7. **Analgesic and Antipyretic Activity:** Aprajita has been traditionally used for relieving pain and reducing fever. Root and leaf extracts are commonly prepared as decoctions to manage body aches, headaches, and fever-related discomfort. The analgesic and antipyretic effects may be linked to its anti-inflammatory phytochemicals.
8. **Anticancer Potential:** Recent scientific studies have explored the anticancer activity of Aprajita. Bioactive compounds isolated from the plant may help suppress the growth of certain cancer cells by inducing apoptosis and inhibiting oxidative stress. Although more clinical studies are required, the plant has shown promising results in preliminary investigations.
9. **Wound Healing Property:** Aprajita is traditionally applied on wounds, cuts, and ulcers because of its healing and antimicrobial properties. The plant may accelerate tissue repair and reduce the risk of infection. Herbal pastes prepared from the leaves and roots are commonly used in folk medicine for external application.
10. **Respiratory Benefits:** Traditional practitioners have used Aprajita for respiratory disorders including asthma, cough, bronchitis, and sore throat. The expectorant and soothing properties of the herb may help clear mucus from the respiratory tract and ease breathing difficulties.

CONCLUSION

Clitoria ternatea (Aprajita) is recognized as an important medicinal plant with considerable therapeutic, nutritional, and pharmacological significance. This review emphasizes that the plant contains a wide range of bioactive compounds, including flavonoids, anthocyanins, alkaloids, phenolics, and triterpenoids, which are responsible for its diverse biological activities. These constituents contribute to its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, anticancer, and neuroprotective effects, supporting its traditional use in systems like Ayurveda as well as its increasing importance in modern healthcare.

Additionally, the plant shows great potential for applications in pharmaceuticals, nutraceuticals, cosmetics, and functional food industries due to its natural origin and favorable safety profile. Its use as a natural coloring agent along with therapeutic benefits further enhances its commercial value. However, much of the current evidence is based on laboratory and preclinical studies, highlighting the necessity for more well-structured clinical trials to confirm its effectiveness

and safety in humans.

Overall, *Clitoria ternatea* can be considered a promising natural resource with wide-ranging benefits. Further research focusing on standardization, detailed mechanisms of action, and clinical validation is essential to fully utilize its potential and support its inclusion in evidence-based medical practices.

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