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A Review Article On Butterfly Pea (Clitoria Ternatea):

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Abstract:

The review study explores the nutritional, medicinal, and therapeutic benefits of Butterfly Pea (Clitoria ternatea), a plant native to Southeast Asia and other tropical regions and a member of the Fabaceae family. Ayurvedic medicine has long utilized the plant Clitoria ternatea to heal a range of ailments and enhance cognitive function. Its vivid blue, anthocyanin-rich blooms enhance the antioxidant properties of the plant and its potential as a natural food coloring. Numerous phytochemicals present in the plant, including flavonoids, polyacylated compounds, and anthocyanins, are known to have anti-inflammatory, anti-cancer, anti-obesity, and anti-diabetic effects. The plant is also rich in essential vitamins and minerals, has anti-aging and health-promoting qualities, and has a high nutritional content. Clitoria ternatea is a viable candidate for contemporary medical applications due to its diverse array of bioactive compounds. Its numerous pharmacological characteristics are highlighted in this review.

Keywords: Anthocyanins, Phytochemicals, Butterfly Pea, Clitoria ternatea, Ayurvedic Medicine, Anti-inflammatory, Antioxidants, Flavonoids: Anti-diabetic, Anti-cancer

1.Introduction:

The butterfly pea, also known as Clitoria ternatea L., belongs to the Fabaceae family. It is widely grown in Southeast Asia and other tropical regions. The Ayurvedic medical system is the oldest and most well-known medicinal system in India, having been in use for centuries. In this approach, medicinal herbs are used to cure a range of ailments and may even serve as a source of pharmaceuticals. Medhya drugs are a type of herbal medicine used in the Ayurvedic medical system to increase cognitive abilities.

These herbal remedies include extracts of Clitoria ternatea (CT), Celastrus paniculatus, Acorus calamus, Centella asiatica, and Areca catechu. Clitoria ternatea is a well-known Ayurvedic plant and herbal treatment

used to treat a number of diseases. The butterfly pea bloom has a blue tint. This suggests anthocyanins are present. According to the example, it is used to provide color to food and other products. One of the plants is the butterfly pea (Clitoria ternatea L.). Whereas each component benefits our bodies in some way. The flowers contain polyacylated anthocyanins, while ternatins are flavonol glycosides. These include agents that treat diabetes, lower obesity, and antioxidants. Anti-inflammatory, anti-cancer, anti-hyperlipidemic, and asthmatic medications.

It is good for one's health. This is compatible with the fact that anthocyanins' chemical nature renders them very soluble in water. Clitoria ternatea flowers contain a variety of phytochemical compounds, including flavonoids, with anthocyanins accounting for the vast majority of the color components. The flowers of the butterfly pea plant contain anthocyanins. They work as organic antioxidants, preventing premature ageing. helps to prevent the skin from aging. The blue color of Clitoria ternatea flowers is commonly used as a natural coloring agent in a range of dinnerware. Flowers have anti-inflammatory, anti-cancer, anti-diabetic, and antioxidant effects.[2, 3, 13]

2.Taxonomy, Geographic Distribution and Habitat :

Clitoria is found in tropical and subtropical areas all over the world. As with Clitoria, the number of subfamilial taxa is unknown, and Fantz (1977) observes that species descriptions and type specimen citations are either inadequate or incorrect. As a result, determining the genus's species richness is difficult. The Clitoria monograph describes and supports the validity of three subgenera of Clitoria. Fantz considers 58 species genuine within each of the three subgenera, with additional variants and subspecies receiving lower classificationss.

The holotype of the Clitoria subgenus, Clitoria ternatea, is the prototypical Clitoria. Since Linnaeus drew the specific description from specimens found on the Indonesian island of Ternate, it is believed that the specific name originated there. The original extent of Ternate is called into question because it is found in the Molucca Sea and eastern Indonesia, not the Indian Ocean. Only Madagascar, India, Southern and Eastern Africa, and a number of islands in the Western Indian Ocean are home to the other taxa in the subgenus Clitoria. Although the exact geographic origin of C. ternatea is difficult to determine, we can infer from the center of diversity of the subgenus Clitoria that it evolved in or close to the Indian Ocean rather than the Pacific or South China Sea. [10, 11]

Table :1 Butterfly pea taxonomy

Scientific Name	Clitoria ternatea
Kingdom	Plantae
Phylum	Traceophyta
Order	Fabales
Family	fabaceae
Genus	clitoria
Species	Clitoria ternatea L.

3.Morphological Characters:

The pea blossoms are about 4 cm long and 3 cm broad, with five petals. A banner with two wings, two keels, and a brilliant yellow emblem in the middle. The pea plant is one example. Legume climbing plant with incredibly thin leaves that are 1.5–3.5 cm long and 2.5–5 cm long. each and every width. This plant is evergreen and has fibrous roots. Nitrogen can be fixed by its large nodules for use by other plants. Rhizobia are bacteria. The perennial plant Clitoria ternatea reproduces itself by means of black seeds. The colorful pods range in length from 7 to 11 cm. In the culinary industry, the root and leaves are used to manufacture herbal and medicinal drinks. teaching. Butterfly peas are the most popular product in the world. [10, 15]

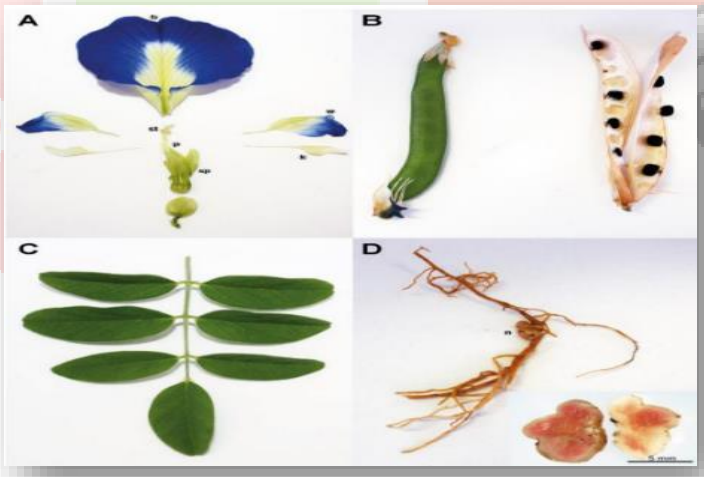
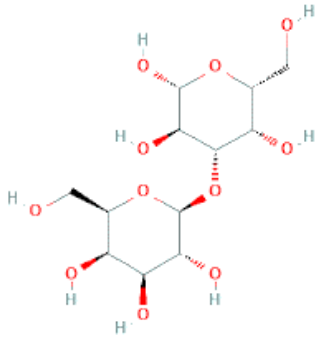
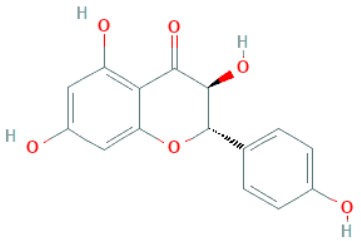
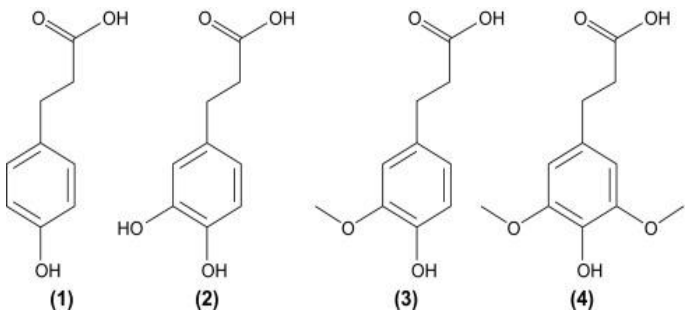
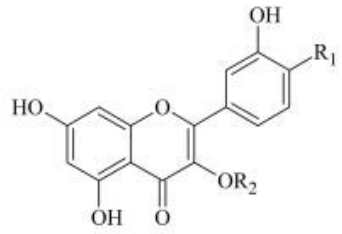
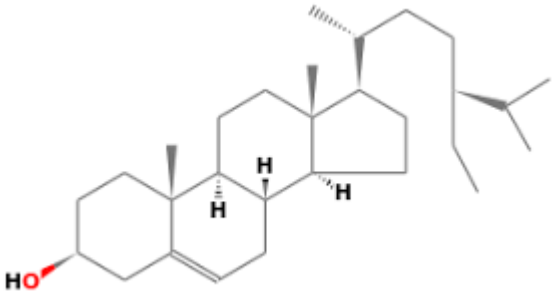
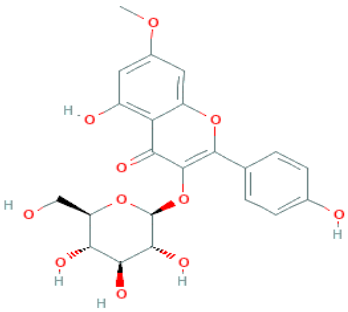
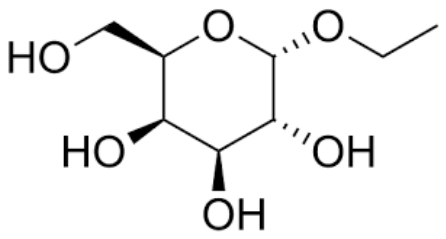
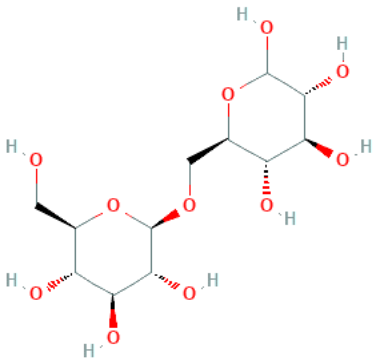


Figure :1 Butterfly Pea Morphology

Figure 1: Clitoria ternatea (A) flower, (B) pods, (C) leaves, and (D) roots with nodules. The C. ternatea flower consists of the stamen (st), pistil (p), sepals (sp), and corollae. The corollae consist of five petals: one banner (b), two wings (w) and two keels (k). C. ternatea has pinnate compound leaves, flat and pointed pods and roots that produce nodules (n).

Table No. 02: Chemical Constituents

Chemical Constituents	Structures
1. (1,3)-O-β-d-galactopyranosyl	
2. 3,5,7,4′- tetrahydroxyflavone	
3. n p-hydroxycinnamic acid	 (1) (2) (3) (4)

4. flavonol-3-glycoside	
5. γ-sitosterol adenosine	
6. 3-rhamno-glucoside	
7. ethyl-α-d-galactopyranoside	
8. (1,6)-O-β-d-glucopyranoside	

4.Nutritional Composition:

This bean plant is rich in copper (6–9 mg/kg), manganese (28–91 mg/kg), zinc (25–44 mg/kg), calcium (1.5–25.9 g/kg), phosphorus (0.3–3.9 g/kg), potassium (7.7–23.0 g/kg), sodium (0.3–1.1 g/kg), magnesium (3.2–6 g/kg), and so on. A range of fatty acids, including linoleic acid, arachidic acid, palmitic acid, and stearic acid, which are known to enhance brain function, are also present in blue pea seeds and petals. Mukherjee et al. (2008). Because CT has a lot of crude protein and fiber, it can be used as pasture. Among other polyphenols, the blue pea plant is rich in flavonoids, phenolic acids, tannins, lignans, alkaloids, terpenoids, and coumarins. Vitamins A, C, and E are also abundant in it.

It mainly gives leaves and flowers their antioxidant and anti-cancer properties due to its substantial role in scavenging free radicals. Numerous methods are used to extract the plant's polyphenolic components, and the quality of the plant is determined by the tools and method used. Roots contain polyphenols such as pentacyclic triterpenoids, taraxerone, and taraxerone. (2012) Sing J. and others. Because it has a number of beneficial components, scientists are currently researching the blue pea (BP) plant in an effort to develop different treatments. Currently available for purchase, blue pea tea has been a popular beverage in Asian countries. In particular, a limited-edition range of chilled beverages with blue pea flowers was launched by "Starbucks" Asia. [8, 20, 13]

5.Medicine:

In Ayurveda, Clitoria ternatea is credited with a number of pharmacological properties, including antidiabetic, nootropic, anaesthetic, antimicrobial, antipyretic, analgesic, anti-inflammatory, antidepressant, antistress, diuretic, anticonvulsant, anxiolytic, and insecticidal properties. Research has shown that CT can be used to treat cancer and diabetes, two diseases that are believed to be among the most recent to appear. Researchers have found through a number of trials that CT lowers blood glucose levels, resulting in a hypoglycemic effect. In one study, mice given an aqueous formulation of CT leaves extract and CT flowers extract (400 mg/kg) in alloxan-induced diabetic-like conditions experienced a significant drop in blood glucose levels (Daisy et al., 2009). When Streptozotocin-induced diabetic rats received a single dose of CT, the same result was observed.

Additionally, the CT seeds contain anti-diabetic properties. In one study, rats with diabetes-like circumstances brought on by streptozotocin were treated with an ethanolic extract from CT seeds; the results showed that the extract had an antidiabetic effect (Kalyan et al., 2011). Similar to diabetes, cancer is a newly discovered disease that has a significant global impact. Because CT has a beneficial effect on particular cancer cell lines, it can be used to treat some tumors. The cytotoxic potential of a crude methanolic extract derived from CT seeds, stem bark, and leaves was investigated in one study. As a result, all extracts showed anti-cancerous activity; however, the leaf extract exhibited much higher cytotoxic activity than the other CT extracts (Rahman et al., 2006). In lung cancer cells resistant to paclitaxel, CT cyclotides were discovered to have chemosensitizing and anticancer properties (Sen et al., 2013) .[16, 19]

CT has been used in Ayurveda to treat severe liver problems because of its promising hepatoprotective qualities. In one study, a methanolic extract of CT leaves (@200 mg/kg) protected mice's liver damage from paracetamol. It has a protective effect since it decreases alanine aminotransferase, bilirubin, and aspartate aminotransferase levels while increasing histopathological levels (Nithiantham et al., 2011). In another study, the CT leaf extract was found to have hepatoprotective activity against rats' hepatotoxicity caused by carbon tetrachloride. According to Jayachitra et al. (2012), extracts from white-flowered CT leaves had a stronger hepatoprotective effect than extracts from blue-flowered CT leaves. [5, 12, 9, 20]

6.Extraction Method:

Extraction of Phytochemicals:

The extraction of phytochemicals from plant sources is a crucial step in the procedure. There are a number of extraction methods available, and selecting the ideal parameters is essential to ensuring the rise in phytochemical output (Azmir et al. 2013). The choice of extraction method should be carefully evaluated in light of the goals to be achieved and the suitability of the samples, as both conventional and non-traditional methods offer advantages over one another.

Before extraction, plant materials are frequently shrunk in size to increase the surface area for combining with the solvent. The samples that are used may be pulverized, powdered, dried, or fresh. Ground/powdered or air/oven-dried fresh flowers were employed in most studies on C. ternatea flowers (Lakshan et al. 2019; López Prado et al. 2019; Mehmood et al. 2019; Pham et al. 2019; Adhikary et al. 2018; Rabeta and An Nabil 2013). Other research has made use of fresh flowers (Kamkaen and Wilkinson 2009; Phrueksanan et al. 2014; Srichaikul 2018).

Fresh flowers were cleaned, split into smaller pieces, and stored in a freezer at or below 25 °C in a number of research. Within a month, the blossoms were either removed (Chong and Gwee 2015) or freeze-dried before being ground into a powder (Shen et al. 2016). Dried flowers have been pulverized or powdered using a variety of conventional and non-traditional extraction methods (Lakshan et al. 2019; López Prado et al. 2019; Mehmood et al. 2019; Pham et al. 2019; Adhikary et al. 2018; Rabeta and An Nabil 2013). Fresh flowers were cleaned, split into smaller pieces, and stored in a freezer at or below 25 °C in a number of research. Within a month, the blossoms were either removed (Chong and Gwee 2015) or freeze-dried before being ground up (Shen et al. 2016). Phytochemicals from C. ternatea flowers have been extracted using a range of standard and non-traditional extraction methods, as will be discussed below.

6.1Conventional Method:

Despite their efficiency, conventional extraction methods including soxhlet extraction, maceration, and hydrodistillation can be costly and require a long extraction time because they frequently include the use of different solvents with heat and/or mixing. The conventional extraction method, a traditional approach, has been widely used to extract C. ternatea flowers since the 1970s. In contrast to prior studies, the structure of a number of phytochemicals, mostly anthocyanins, was identified and extracted from C. ternatea flowers utilizing aqueous solvent combinations in extraction tests. The bulk of studies used extractions using aqueous solvent mixtures of ethanol or methanol rather than water alone with heating to study its potential bioactivities and phytochemical content, however other studies examined the ideal solvent and/or extraction conditions. [4, 25. 27, 28]

6.2Non-Conventional Method:

Compared to conventional extraction methods, non-conventional methods are more recent, highly effective, and environmentally safe. These methods include pressurized liquid extraction, enzyme-assisted extraction, ultrasound-assisted extraction, microwave-assisted extraction, supercritical fluid extraction, and microwave-assisted extraction (Wen et al. 2018; Azmir et al. 2013). As far as the author is aware, the only unconventional methods for obtaining phytochemicals from C. ternatea flowers are microwave-assisted extraction and ultrasonic extraction.

According to Herrera and De Castro (2005), the idea behind ultrasound-assisted extraction is the production of acoustic waves, which shift solvent and sample molecules and make it easier for both organic and inorganic compounds to leach. Srichaikul (2018) investigated the effects of short extraction times with ultrasonic and long extraction times with maceration for one to seven days in order to ascertain the efficacy of phenolic and flavonoid content extraction using aqueous ethanol. Phenolic content might be removed more successfully with the help of ultrasound. On the other hand, maceration in aqueous ethanol on day seven was shown to have a greater flavonoid concentration than ultrasonic extraction (30 min). Day 7 saw a higher flavonoid content in the aqueous ethanol extract without ultrasonic assistance, although this was due to a longer extraction duration (7 days). In one study, the optimal parameters for employing RSM to extract anthocyanins from water were determined by varying the extraction period, temperature, liquid-solid ratio, and ultrasonic frequency. In comparison to 95% methanol without ultrasonic assistance, the extraction under optimal circumstances produced a 246.5% higher extraction yield of anthocyanins (Chong and Gwee, 2015). In order to evaluate the efficacy of using water with and without ultrasonic help to extract the phenolic and flavonoid content from C. ternatea flowers, Mehmood et al. (2019) took a closer look at this ideal scenario as reported by Chong and Gwee (2015). Similarly, ultrasonic extraction showed a greater phenolic yield. [28]

7.Medicinal Activity:

7.1.Antibacterial Activity:

Antibiotic-resistant bacteria drastically diminish the effectiveness of currently available drugs, resulting in infection treatment failure. Both new antibacterial compounds and alternative approaches must be developed to address this issue. The in vitro efficacy of an antimicrobial (antibacterial or antifungal) medication can be examined using a number of methods, such as disc diffusion processes and broth or agar dilution. Several studies investigated the antibacterial properties of C. ternatea flowers. The methanol extract of C was tested using the agar disc diffusion method.

Bacillus cereus, Bacillus subtilis, Bacillus thuringiensis, Staphylococcus aureus, Streptococcus faecalis, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Salmonella typhi, Enterobacter aerogens, Proteus mirabilis, and Herbaspirillum spp. were among the twelve bacterial species that were tested against Ternatea flower. With a minimum inhibitory concentration (MIC) of 12.5 mg/mL, a minimum bactericidal concentration (MBC) of 25 mg/mL, and an inhibition zone of 15.7 mm, the results demonstrated that the methanol extract of C. ternatea flower exhibited the strongest activity against Bacillus thuringiensis. [15]

7.2.Antifungal Activity:

An increase in resistance to the majority of antifungal medicines in a variety of diseases necessitates the discovery of novel therapeutic agents (Perfect 2016). With an inhibitory zone of 19 mm in agar disc diffusion, the methanol extract of C. ternatea flower (100 mg/mL) exhibited the best effectiveness against Candida albicans, Rhizopus, and Penicillium spp. However, it only shown efficacy against Rhizopus and Penicillium spp. in the broth dilution method, with comparable MFC values of 1.6 mg/ml and MIC values of 0.8 mg/mL. With an inhibitory zone of 10 mm on agar disc diffusion technique, the anthocyanin fraction from the ethanol extract of C. ternatea flower teste against Fusarium sp., A. niger, and Trichoderma sp. exhibited the best efficacy against Fusarium sp. [6]
in agar disc diffusion technique.

7.3.Anti-inflammatory Activity:

Aspirin, paracetamol, and other currently available non-steroidal anti-inflammatory drugs (NSAIDs) are known to affect both COX-1 and COX-2, which is why they are associated with negative side effects, particularly in the cardiovascular and gastrointestinal systems. New or alternative strategies must be found to provide sufficient pain relief while reducing the risks related to NSAIDs .
Using the carrageenan paw edema method, the anti-inflammatory properties of the petroleum ether extract of C. ternatea flowers were assessed in healthy albino rats of both sexes. In Eddy's hot plate method, the treatment group (400 mg/kg) exhibited a significantly higher reaction time (measured when animals licked their fore or hind paws or jumped response, whichever appeared first) than the control untreated group, while the extract (200 and 400 mg/kg) significantly inhibited paw edema when compared to the control untreated

group. According to the study, the extracts may be able to prevent the release of prostaglandins, kinnins, and other chemicals in edema caused by carrageenan. [7, 14]

7.4.Anti-diabetic Activity:

Biguanides, meglitinide, thiazolidinedione, sulfonylureas, and dipeptidyl peptidase 4 are among the oral antidiabetic drugs that are known to cause a variety of side effects.Because they are thought to be safer and may have fewer side effects, herbal-based drugs are worth looking into for possible application in the control of diabetes. Numerous research endeavours examined the antidiabetic potential of C. ternatea flower extract both in vitro and in animals. The water extract significantly decreased the fructosamine level (14.47–36.66%) in glycated bovine serum albumin and decreased the generation of fluorescent advanced glycation end products, which had the highest activity at day 28 (49.4% at 1 mg/mL). [13, 16]

Conclusion:

The review paper on the butterfly pea, or Clitoria ternatea, provides a comprehensive analysis of the plant's extensive biological, nutritional, and medicinal benefits, particularly with regard to traditional and modern healthcare systems. Native to tropical and subtropical regions, Clitoria ternatea is a member of the Fabaceae family and is widely recognized in Southeast Asia and Ayurvedic medicine for its therapeutic properties. The plant has long been used as a food coloring and a medication due to the anthocyanins that give its blossoms their blue hue. The origins of this plant are traced in the article.

The richness of the plant's bioactive compounds, including anthocyanins, tannins, alkaloids, and flavonoids, is revealed by a thorough examination of its phytochemical makeup. These constituents are responsible for its numerous health benefits, such as its anti-inflammatory, antioxidant, and anti-diabetic qualities.

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