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A review on pharmacological studies of *Clitoria ternatea*

Pratik Deepak Salve *, Khedkar Sir, Pansare Vikram J and Sujata Veer

Department of Pharmaceutical Science, Saikrupa Institute of Pharmacy, Ghargaon, Ahmednagar, Maharashtra, India-413728.

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Abstract

The butterfly pea, a plant belonging to the Fabaceae family, is found extensively globally, particularly in tropical and subtropical regions. Locals often utilize butterfly pea (*Clitoria ternatea*) as a medicinal resource due to its flavonoid compounds, predominantly present in its roots, leaves, and flowers. Flavonoids, which are phenolic compounds, possess antioxidant properties that safeguard against cell damage caused by free radicals. This review of the literature aims to explore the various health benefits associated with the butterfly pea. The approach conducted in writing this article involves sourcing information from diverse journal articles available online, including Google Scholar, PubMed, and ScienceDirect. Based on the review, butterfly pea flowers are recognized for their advantageous qualities, including antioxidants, anti-inflammatory, antidiabetic, antihyperlipidemic, hypoallergenic, antitussive, anti-aging, and antidepressant properties.

Keywords: Fabaceae; Flavonoids; Antioxidant properties; Free radicals; Anti-inflammatory; Antihyperlipidemic; Hypoallergenic

1. Introduction

Figure 1 *Clitoria ternatea*

* Corresponding author: Pratik Deepak Salve

2. Classifications and characteristics

Table 1 Characteristics of *Clitorea ternatea*

Plant Division	**Angiosperms (Flowering seed Plants) (Dicotyledon)**
Plant Growth Form	Climber
Lifespan (in Singapore)	Perennial
Mode of Nutrition	Autotrophic
Plant Shape	Irregular

Clitoria ternatea, commonly called butterfly pea, is an evergreen climber that typically grows on slender stems to 10' (less frequently to 15') tall. It will trail through a shrub to 6'. The native range of this species is not fully agreed upon, but has escaped cultivation and can be found in tropical regions around the world today. This climber features compound odd-pinnate leaves (to 5" long), each with 5-9 elliptic to ovate rich green leaflets. Pea-like, clear blue flowers (2" diameter) with yellowish centers bloom singly or in pairs from summer to fall. Fruits are flattened pods.

Genus name comes from the Latin word clitoris meaning clitoris for a characteristic of the flower.

The specific epithet is in reference to the island of Ternate in Indonesia which was considered by Linnaeus as the native territory of this species.

Inflammation is your body's response to an illness, injury or something that doesn't belong in your body (like germs or toxic chemicals). Inflammation is a normal and important process that allows your body to heal. Fever, for example, is how you know your body's inflammatory system is working correctly when you're ill. But inflammation can harm you if it occurs in healthy tissues or goes on for too long.

When an invader (like a virus) tries to enter your body, or you get injured, your immune system sends out its first responders. These are inflammatory cells and cytokines (substances that stimulate more inflammatory cells). These cells begin an inflammatory response to trap germs or toxins and start healing injured tissue. Inflammation can cause pain, swelling or discoloration. These are signs your body is healing itself. Normal inflammation should be mild, and pain shouldn't be extreme.

But inflammation can also affect parts of your body you can't see. Inflammatory responses that occur behind the scenes can help you heal, but other times, they can harm your health.

Table 2 Traditional uses of *Clitoria ternatea*

Useable part of *Clitoria ternatea*	Function	References
Flower	Color food	Jain et al., 2003
Root	Nootropic, anxiolytic, antidepressant, anticonvulsant and antistress activity	Jain et al., 2003
Whole plant	Treat sexual ailments such as: infertility and gonorrhea	Fantz, 1991
Clitoria ternatea extract	Heat stable function	Nguyen et al., 2011

3. Pharmacological activies of *Clitoria ternatea*

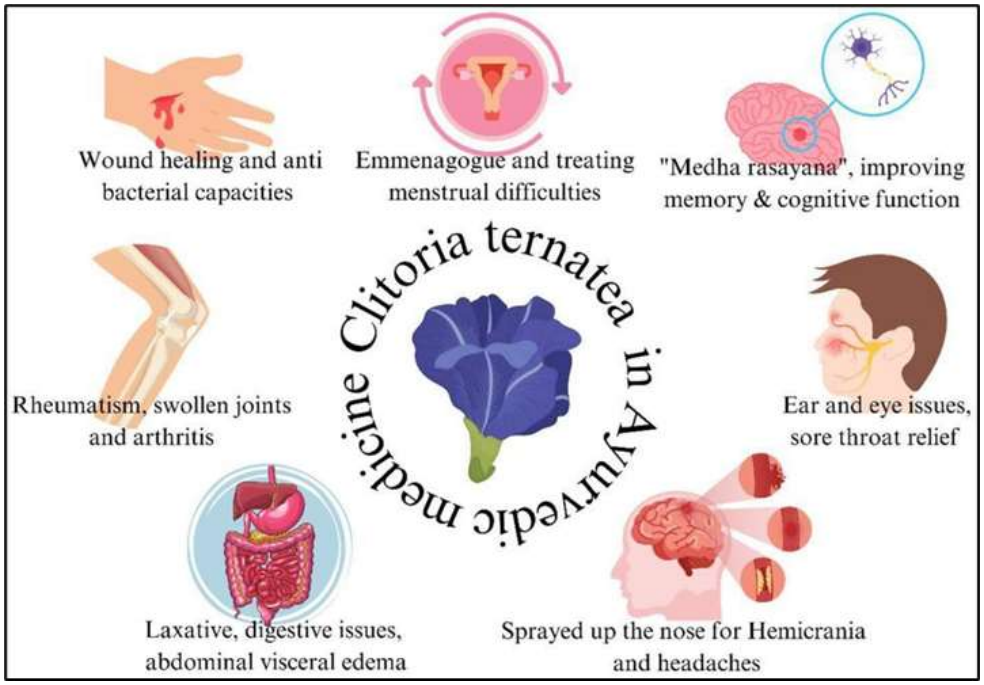

Figure 2 *Clitoria ternatea* in Ayurvedic Medicine

The methanolic extracts of the leaves and root of *Clitoria ternatea* were tested for their antibacterial activity against different pathogenic drug resistant Gram-positive and Gram- negative clinical isolates (Chauhan et al., 2012). The leaf was found to possess powerful antibacterial activity against Escherichia coli and Vibrio cholera, known for causing dysentery, and Staphylococcus aureus, causative agent of fever. The leaf extract showed stronger antibacterial activity than root extract.

Both extracts were shown to be bactericidal in their mode of action. Quercetin may contribute to the activity of leaf extract. In another study, it was reported that crude extract from seeds of *Clitoria ternatea* showed maximum zone of inhibition (22±0.5 mm) against Escherichia coli at 0.75 mg concentration and minimum (14±1.0 mm) with Micrococcus flavus. The callus extract showed maximum zones of inhibition (16±2mm) against Salmonella typhi while the lowest with Escherichia coli and Staphylococcus aureus (12±1 mm and 12±0.9mm respectively) (Mhaskar et al., 2010). Alcoholic and aqueous extracts

from in vitro raised calli were tested for antibacterial activity by agar well diffusion method against Gram-negative bacteria. Antibacterial activity was shown against Salmonella spp. and Shigella dysenteriae; organisms causing enteric fever (Shahid et al., 2009). In addition, the methanol crude extracts showed anti-bacterial activity against Klebsiella pneumoniae and Pseudomonas aeruginosa (Shekawat and Vijayvergia, 2010). The crude extract from seeds of *Clitoria ternatea* showed strong antimicrobial activity. This plant's root is specially used for leucoderma (Pendbhaje, 2011).

3.1. Anti carcinogenic activity

Recent reports have cited that plants and its components could act as tumor suppressor, apoptotic inducer in cancer cells and the most commonly used herbal medicine have tumor suppressing activity, interfere with cell cycle progression, enhance immune activity and suppress tumor angiogenesis (Devita, 1983). *Clitoria ternatea* extracts is well correlated with other reports from different plant extracts on cancer suppressing activity or anti carcinogenic activity (Ramaswamy et al., 2011). The purified lectin was found to be potential tool for cancer studies (Naeem et al., 2007).

3.2. Anti-stress activities

The anti-stress activity of aerial parts was assessed using cold restraint stress (CRS) induced ulcers, lithium-induced head twitches, clonidine-induced hypothermia, sodium nitrite- induced respiratory arrest and haloperidol-induced catalepsy in rat and mice (Chauhan et al., 2012).

3.3. Effect on general behavior

Ethanol extract of the root of *Clitoria ternatea* shows significant neuropharmacological activity (Gupta, 2010).

3.4. Antioxidant

Extracts of *Clitoria ternatea* (butterfly pea) flowers are used in Thailand as a component of cosmetics and the chemical composition of the flowers suggest that they may have antioxidant activity. The aqueous extracts of *Clitoria ternatea* were shown to have stronger antioxidant activity than ethanol extracts (Kamkaen and Wilkinson, 2009).

3.5. Effect on digestive system

It is an antiemetic, antidypsetic mild-laxative and cholagogue .Therefore it is used in emesis, dyspepsia, constipation jaundice and piles. It is used in healing ulcers of pylorus duodenum etc (Pendbhaje, 2011).

3.5.1. Anti-Tumor Activity

As a part of very limited research, Shivprakash et al. [25] examined cell apoptosis activation with a methanolic extract of the flower, in which the cytotoxic activity was checked with the MTT Cell Viability Assay, light microscopy, DNA fragmentation, and activation of the caspase-3 enzyme, which were used to assess the onset of cell death/apoptosis. The results were that the methanolic extract from the C. ternatea was found to be cytotoxic against several cancer cell lines, in which the most effective action was against MCF-7 breast cancer cells, with an IC50 of 27.2 2.6 g/mL. The apoptotic morphology was verified under the light microscope which showed that MCF-7 cells, treated with various methanolic extracts of C. ternatea doses, inhibited proliferation and induced apoptosis as evidenced by DNA fragmentation and caspase-3 enzyme activation. While the exact bioactive component for this effect was not recognized, the authors mainly attributed it to polyphenols, including flavonoids, which also exhibit strong antioxidant activity

3.5.2. Anti-Pyretic Effect

In one early study by Devi et al. [20], it was found that all doses of C. ternatea methanolic root extract effectively decreased the body temperature of rats. The rats were subjected to yeast-induced pyrexia and were orally given the extract. The result was that the extract, at doses of 200, 300, and 400 mg/kg body weight, produced a significant reduction in normal body temperature and yeast-provoked elevated temperature in a dose-dependent manner. The effect remained for up to 5 h after the drug had been administered. It was attributed to the flavonoids present in the plant and the antipyretic activity was compared to that of paracetamol, a common antipyretic drug [18].

In another significant study, the antipyretic activities of ethanol and acetone extracts of the leaves were studied using albino rats. In this model, it was found that the antipyretic activity for both types of extracts was higher than the standard drug paracetamol

3.5.3. Wound Healing and Blood Platelet Aggregation Inhibition

Clitoria ternatea's seed and root extracts significantly enhanced wound healing in all mice, whether given orally via gavage or applied topically as an ointment (in an experiment by Solanki and Jain in 2012). These results are similar to those of "cotrimoxazole" ointment. The flavonol glycoside in the seed extract and the phenolic chemicals in plants were summarized as responsible for changing the inflammatory and immunological components of healing [18]. Blood platelet aggregation inhibition is one of the key benefits of this flower, in that the Ternatin D1 present in C. ternatea petals showed blood platelet aggregation inhibition (in which collagen and adenosine diphosphate induced platelet aggregation were both inhibited significantly for in vitro rabbit platelets

4. Inflammation

Inflammation is your body's response to an illness, injury or something that doesn't belong in your body (like germs or toxic chemicals). Inflammation is a normal and important process that allows your body to heal. Fever, for example, is how you know your body's inflammatory system is working correctly when you're ill. But inflammation can harm you if it occurs in healthy tissues or goes on for too long.

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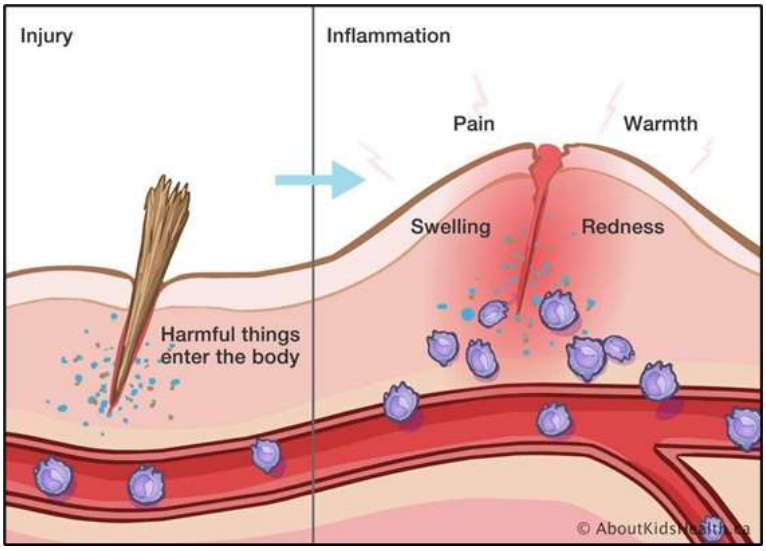

Figure 3 Inflammation

But inflammation can also affect parts of your body you can't see. Inflammatory responses that occur behind the scenes can help you heal, but other times, they can harm your health.

5. The mechanism of inflammation

Inflammation is a complex biological process that is essential for the body's defense against injury or infection. It involves a coordinated response by immune cells, blood vessels, and molecular mediators.

Here's a simplified overview of the key steps involved:

- Injury or Infection: When tissues are damaged (e.g., due to a cut, burn, or infection), cells release signaling molecules called cytokines and chemokines.
- Vascular Changes: These signaling molecules cause blood vessels to dilate and become more permeable, allowing for increased blood flow and the movement of immune cells into the injured area.
- Immune Cell Recruitment: Neutrophils, a type of white blood cell, are among the first responders. They migrate to the site of injury to engulf and destroy foreign pathogens or damaged cells.
- Tissue Repair: As the inflammation subsides, the body begins to repair the damaged tissue. This involves the growth of new cells and the remodeling of extracellular matrix.

Key players in the inflammatory process include:

- Immune cells: Neutrophils, macrophages, dendritic cells, T cells, and B cells.
- Blood vessels: Endothelial cells.
- Molecular mediators: Cytokines, chemokines, prostaglandins, and leukotrienes.

It's important to note that while inflammation is a necessary protective response, chronic inflammation can contribute to a variety of health problems. When the inflammatory response becomes excessive or prolonged, it can damage healthy tissues and lead to conditions such as arthritis, heart disease, and autoimmune disorders.

6. Stages of inflammation

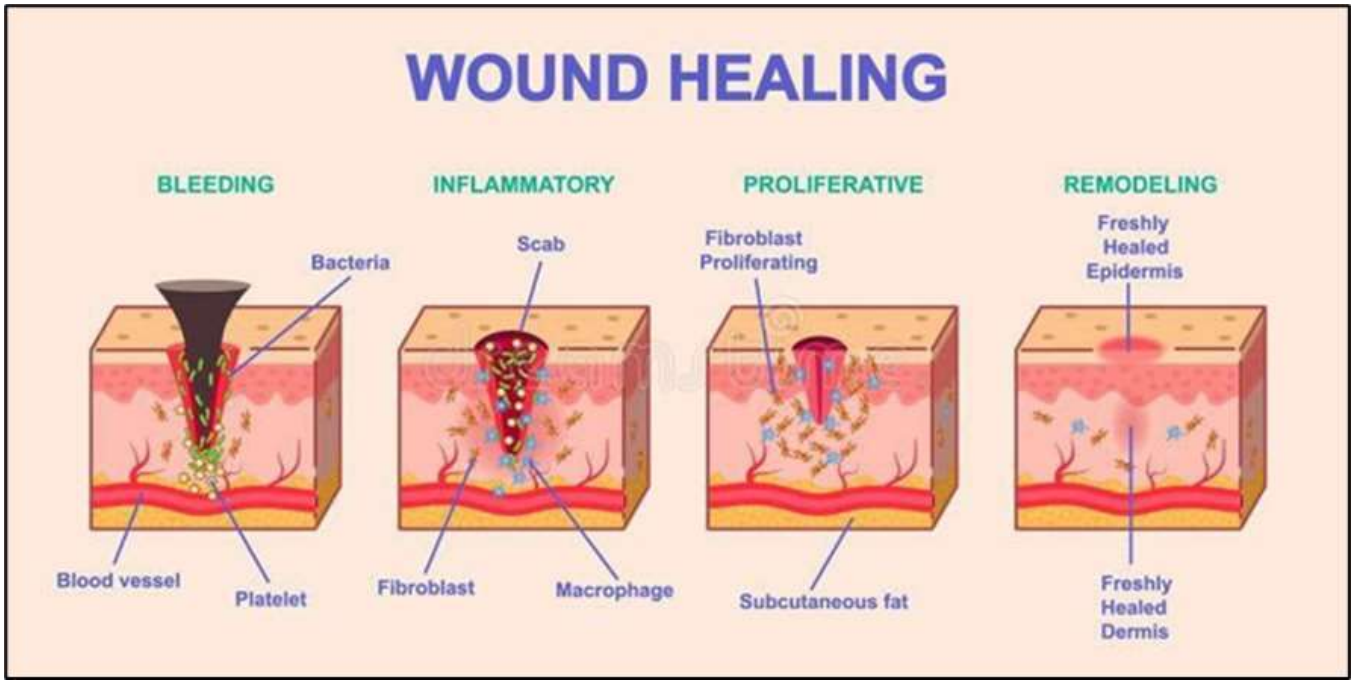

Figure 4 Stages of Healing

Inflammation is a result of damage to body tissues and can be caused by a number of factors including trauma, repetitive use and those conditions affected by age such as Osteoarthritis.

The are three main stages of inflammation which can each vary in intensity and duration:

- Acute -swelling stage
- Sub-acute – regenerative stage
- Chronic – scar tissue maturation and remodelling stage

During the acute inflammatory stage, there is evident redness (erythema) and swelling due to vascular changes. Exudation of cells and chemicals cause swelling and pain. A haematoma may form if there is bleeding within the tissues. Secondarily, chemical irritants are neutralized and the area is sealed off from surrounding tissues and circulation is impaired. There is early fibroblastic cell activity. Pain is normally present at rest over a diffuse area and can be aggravated by activity. Secondary muscle spasm and guarding normally restrict passive movement. During range of movement testing, pain is felt before the tissue resistance is reached. Injuries to deep structures or poorly vascularised areas can lead to surface swelling and oedema but may not be noticeable.

The sub-acute stage is the commencement of healing and repair. Noxious chemicals are further neutralized and new capillary beds growing into the damaged areas are supported by connective tissue growth (collagen fibres) and together form granulation buds. Visible signs of inflammation start to subside and range of movement increases with pain felt at the point of tissue resistance.

The chronic inflammatory stage is the period when tissue remodelling takes place. Signs of inflammation are absent and scar tissue is maturing. Pain is felt further into the range of movement after the tissue resistance has been reached. Maturation refers to the growth of the fibroblasts to fibrocytes and remodelling refers to the organization of and shrinking of collagen fibres along the lines of stress.

The skill of the physiotherapist is to identify the exact stage of the inflammation and then intervene to enhance the healing process with the most appropriate form of treatment.

7. Uses

7.1. Food and Beverages

- Natural food coloring: The vibrant blue pigment derived from *Clitoria ternatea* is used to color food and beverages such as rice, desserts, and cocktails.
- Tea: The flowers can be brewed into a blue tea with a mild, earthy flavor. This tea is often consumed for its potential health benefits.
- Flavoring agent: The plant's extracts can be used as a flavoring agent in various food products.

7.2. Traditional Medicine

- Anti-inflammatory properties: *Clitoria ternatea* has been traditionally used to treat inflammatory conditions such as arthritis and skin ailments.
- Nootropic effects: Some believe that the plant's compounds may enhance cognitive function and memory.
- Antioxidant properties: The plant contains antioxidants that can help protect cells from damage.
- Aphrodisiac: In some cultures, *Clitoria ternatea* is believed to have aphrodisiac properties.

7.3. Other Potential Uses

- Dyeing fabric: The plant's pigment can be used to dye fabric.
- Ornamental plant: *Clitoria ternatea* is a beautiful flowering plant that can be grown in gardens.

It's important to note that while *Clitoria ternatea* has been used traditionally for various purposes, more scientific research is needed to fully understand its potential benefits and risks. If you're considering using *Clitoria ternatea* for medicinal purposes, it's recommended to consult with a healthcare professional.

7.4. Can Help Protect Your Vision

Antioxidants found within *Clitoria ternatea* can protect the eyes from free radical damage, including from the sun, irritants and effects of a poor diet. It might also help boost blood flow to the eyes.

Extracts and eye gels made from *Clitoria ternatea* are used in some cases to manage vision- related issues, such as glaucoma, damaged retinas, blurred vision, poor night vision and tired/dry/strained eyes.

7.5. Promotes Skin and Hair Health

Butterfly pea flower may be able to prevent signs of premature aging on the skin when used topically, such as loss of skin elasticity, fine lines, and uneven tone and texture.

There’s evidence that it can boost skin hydration and defend against sun damage due to antioxidants, such as polyphenols. Because it has anti-inflammatory properties, it may also help treat rashes, swelling, itching and dermatitis or allergies that affect the skin.

Yet another benefit is butterfly pea’s ability to help maintain a healthy scalp and hair health. It’s thought to help bring extra blood to the hair follicles and reduce inflammation, which might impair hair growth.

For this season, you’ll find it in some hair shampoos, conditioners and other hair products intended to reduce graying and hair thinning

8. Conclusion

Clitoria ternatea is not only a wild herb but also a medicinal plant. It has so many traditional usages as well a number of medicinal usages. Even, it is useful in treatment of some incurable diseases such as cancer, neurological disorder, nephorological disorder, hyperglycemia, urinary disorder, goiter, respiratory disorders etc. The exploring the active component of this plant responsible for the pharmacological activities along with their mode of action will be guided by the accumulative information presented in this article.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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