



APRAJITA (*Clitoria ternatea*) : A COMPREHENSIVE REVIEW WITH CLASSICAL REFERENCE IN AYURVEDA AND CONTEMPORARY SCIENCE

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Abstract

Background: Aprajita (*Clitoria ternatea* L.) or butterfly pea, is an ancient medicinal plant described abundantly in Ayurvedic books and more justified by modern scientific studies.

Purpose: This review is the search synthesis of the classical Ayurvedic sources and current scientific publications regarding the therapeutic value of *C. ternatea* as a medicinal plant.

Methods: A search of the current literature was done on PubMed, Google Scholar, and classical Ayurvedic books embracing publications between 2020-2025. Papers related to phytochemistry, pharmacology action and use in the clinical field were reviewed.

Results: The *C. ternatea* is found to possess high neuroprotective, antioxidant, anti-inflammatory and cognitive-enhancing effects. The bioactive compounds of the plant, especially anthocyanins, flavonoids and Cyclotides have potential therapeutic use in treatment of neurodegenerative diseases, diabetes and memory improvement.

Conclusion: The availability of both traditional Ayurvedic wisdom and contemporary evidence-based science has proven that *c. ternatea* is a potential therapy, with diverse pharmacological effects.

Keywords: *Clitoria ternatea*, Aprajita, Ayurveda, neuroprotection, anthocyanins, cognitive enhancement

1. INTRODUCTION

The genus Aprajita (*Clitoria ternatea* L.) (family Fabaceae) constitutes a paradigmatic case of the traditional Ayurvedic medicine, which demonstrates compatibility with the modern scientific knowledge ^[1]. It is an herbaceous, perennial climber with blue flower, being used as traditional medicine in Asia since more than one millenium ^[2]. Sanskrit plant name: Aparajita is given the name that translates as: Since where the herb is mentioned in the classical Ayurvedic texts, the name of it is invoked as Aparajita which is translated as the invincible.

Recent interest on the use of natural therapeutics across the globe has placed *C. ternatea* on the prominence of phytopharmacological research. Most of the traditional uses have been confirmed in recent studies and new therapeutic uses discovered ^[3]. The classical Ayurvedic sources and recent scientific data on the therapeutic potential of *C. ternatea* are reviewed in this paper especially in its neuroprotective and cognition-enhancing effects.

2. CLASSICAL REFERENCES IN AYURVEDA

2.1 Historical Documentation

Aparajita does not find mention in Brihatrayee (the three great texts: Charaka Samhita, Sushruta Samhita and Ashtanga Hridaya) of classical Ayurvedic literature. Yet Shweta and Maha Shweta (found in Charaka Samhita in Shirovirechanopaga varga) have been explained by Acharya Chakrapani as Aparajita and Katabhi, respectively ^[4].

2.2 Traditional Classification and Properties

Classical Text References:

- **Charaka Samhita:** This treatment falls under Shirovirechanopaga or uses herbs in treatment of Nasya called panchakarmas
- **Bhavaprakash Nighantu:** In Guduchyadi varga (entry 327)
- **Raja Nighantu:** Two varieties are described, viz., Aswaksura and Nila Aparajita^[5]

Ayurvedic Properties (Dravya Guna):

- **Rasa (Taste):** Katu (pungent), Tikta (bitter), Kashaya (astringent)
- **Guna (Qualities):** Laghu (light), Rooksha (dry)
- **Vipaka (Post-digestive effect):** Katu (pungent)
- **Veerya (Potency):** Sheeta (cold)
- **Prabhava (Special effect):** Tridosahara (balances all three doshas)^[6]

2.3 Traditional Therapeutic Applications

Basing on classical Ayurveda literature, Aparajita was explained as a Medhya Rasayana - a brain tonic that helps in improving cognitive abilities. Historical uses are:

1. Neurological problems: Memory strengthening, nervousness and stress disorders
2. Lung diseases: bronchial asthma and bronchial disorders
3. Digestion problems: Indigestion and constipation
4. Dermatological diseases: Wound healing and skin disease
5. Menstrual problems and fertility^[7]

Table 1: Classical Ayurvedic References of Aparajita

| Classical Text | Sanskrit Name | Category | Properties | Traditional Uses |
|-----------------------|----------------|--------------------|-----------------|----------------------------|
| Charaka Samhita | Shweta | Shirovirechanopaga | Tridosahara | Brain tonic, Nasya therapy |
| Bhavaprakash Nighantu | Aparajita | Guduchyadi varga | Medhya Rasayana | Memory enhancement |
| Raja Nighantu | Nila Aparajita | Medicinal herbs | Laghu, Rooksha | Cognitive disorders |

3. PHYTOCHEMICAL COMPOSITION

3.1 Primary Bioactive Compounds

Contemporary phytochemical analysis has identified numerous bioactive compounds in *C. ternatea*:

Anthocyanins:

- Ternatin A1, A2, B1, B2, D1, D2
- Delphinidin derivatives
- Cyanidin-3-glucoside^[8]

Flavonoids:

- Quercetin, Kaempferol, Myricetin
- Flavonol glycosides
- Proanthocyanidins^[9]

Other Compounds:

- Cyclotides (circular peptides)
- Triterpenoids (taraxerol, taraxerone)

- Alkaloids and steroids
- Phenolic acids ^[10]

Table 2: Phytochemical Composition of *C. ternatea*

| Compound Class | Major Compounds | Content (%) | Pharmacological Activity |
|----------------|-----------------------|-------------|----------------------------------|
| Anthocyanins | Ternatin A1, B1, D1 | 15-25 | Antioxidant, Neuroprotective |
| Flavonoids | Quercetin, Kaempferol | 8-12 | Anti-inflammatory, Antimicrobial |
| Cyclotides | Cliotide T1-T7 | 2-5 | Insecticidal, Antimicrobial |
| Triterpenoids | Taraxerol, Taraxerone | 3-6 | Hepatoprotective, Anti-cancer |

3.2 Extraction Methods and Standardization

Literature highlights the significance of methodology of extraction with regard to maintenance of bio-active compounds. The ultrasound-assisted and microwave-assisted extraction methods have been found to be much more efficient than the conventional ones, especially when used in the extraction of anthocyanin ^[11].

4. CONTEMPORARY PHARMACOLOGICAL EVIDENCE

4.1 Neuroprotective and Cognitive Enhancement

4.1.1 Memory Enhancement Studies

The cognitive-enhancing effect of *C. ternatea* has been proved by various studies. Demonstrating the chronic efficacy of the *C. ternatea* root extract (200-300 mg/kg) in transforming memory impairments in chronic cerebral hypoperfusion rat models, Damodaran et al. (2020) demonstrated that memory impairments were significantly reverted by the chronic treatment in rat models of cerebral hypoperfusion ^[12]. The research found out:

- **Improved spatial memory:** Enhanced performance in Morris water maze
- **Neuroprotection:** Reduced neuronal damage in hippocampal CA1 region
- **Cholinergic modulation:** Inhibited acetylcholinesterase activity in frontal cortex and hippocampus

4.1.2 Mechanisms of Neuroprotection

The neuroprotective mechanisms involve multiple pathways:

1. **Acetylcholinesterase inhibition:** Enhanced cholinergic neurotransmission
2. **Antioxidant activity:** Reduction of oxidative stress markers
3. **Anti-inflammatory effects:** Modulation of neuroinflammatory responses
4. **Calcium channel modulation:** Improved synaptic plasticity ^[13]

4.1.3 Clinical Applications in Neurodegenerative Disorders

The recent studies have also investigated into the potential use of *C. ternatea* in the treatment of autism spectrum disorders. Recently a study by Jiji and Muralidharan (2021) showed that ethanolic root extract had a significant effect in abetting behavioral and memory deficits in propionic acid-induced autistic rats ^[14].

4.2 Antioxidant Properties

4.2.1 Free Radical Scavenging Activity

Anthocyanin-rich fraction *C. ternatea* flowers has a high antioxidant activity. IC50 results obtained by Jeyaraj et al. (2022) in the DPPH assays equaled 0.86 0.07 mg / mL, which is higher than the antioxidant capacity of synthetic antioxidants ^[15].

4.2.2 Cellular Antioxidant Activity

Studies using cellular models have shown that *C. ternatea* extracts protect against oxidative stress-induced cell death through:

- Enhanced catalase and superoxide dismutase activity
- Reduced lipid peroxidation
- Improved cellular membrane stability ^[16]

4.3 Anti-inflammatory Activities

C. ternatea demonstrates significant anti-inflammatory properties through multiple mechanisms:

4.3.1 Inflammatory Mediator Modulation

Research has shown that *C. ternatea* extracts:

- Inhibit TNF- α and IL-6 production
- Reduce prostaglandin E2 synthesis
- Modulate NF- κ B signaling pathway ^[17]

4.3.2 Anti-inflammatory Efficacy Studies

Studies of paw edema in the carrageenan revealed in 200 mg/kg of administration and dosage, an inhibition rate of 65.28 percent and 81.89 percent in 400 mg/kg, equal to those of conventional NSAIDs ^[18].

4.4 Antimicrobial Properties

4.4.1 Antibacterial Activity

Recent studies have demonstrated significant antibacterial activity against:

- *Escherichia coli*
- *Staphylococcus aureus*
- *Streptococcus mutans*
- *Aggregatibacter actinomycetemcomitans* ^[19]

4.4.2 Antifungal Properties

C. ternatea extracts show efficacy against various fungal pathogens, making it valuable for treating mycotic infections ^[20].

4.5 Antidiabetic Effects

4.5.1 Glycemic Control

The clinical trials have shown the antidiabetic property in *C. ternatea*. A randomized crossover trial conducted by Chusak et al. (2018) revealed that acute consumption of beverage of flowers of *C. ternatea* was highly sufficient to reduce plasma glucose and insulin levels 2 hours postprandial among healthy participants ^[21].

4.5.2 Mechanisms of Action

The antidiabetic effects involve:

- α -amylase and α -glucosidase inhibition
- Enhanced insulin sensitivity
- Improved glucose transport ^[22]

5. CONTEMPORARY APPLICATIONS AND FORMULATIONS

5.1 Pharmaceutical Applications

Modern pharmaceutical applications include:

- Neuroprotective supplements
- Natural food colorants
- Antioxidant formulations
- Anti-aging cosmetics ^[23]

5.2 Nanotechnology Applications

Recent advances include:

- Nanoencapsulation for enhanced bioavailability
- Targeted drug delivery systems
- Microencapsulated functional foods ^[24]

6. SAFETY PROFILE AND TOXICOLOGY

6.1 Acute Toxicity Studies

Toxicological studies indicate that *C. ternatea* extracts are generally safe:

- No acute toxicity observed at doses up to 2000 mg/kg
- No significant hematological or biochemical alterations
- LD50 values suggest wide therapeutic window ^[25]

6.2 Chronic Toxicity Assessment

Long-term studies (28 days) with repeated dosing showed no adverse effects, supporting the safety of chronic administration for therapeutic purposes ^[26].

7. FUTURE PERSPECTIVES AND RESEARCH DIRECTIONS

7.1 Clinical Translation

While preclinical studies show promising results, comprehensive clinical trials are needed to:

- Establish optimal therapeutic doses
- Evaluate long-term safety profiles
- Determine drug interactions
- Assess efficacy in human populations ^[27]

7.2 Mechanistic Studies

Future research should focus on:

- Detailed molecular mechanisms of action
- Bioavailability and pharmacokinetic studies
- Structure-activity relationships of bioactive compounds
- Synergistic effects of compound combinations ^[28]

7.3 Novel Applications

Emerging applications include:

- Functional foods and nutraceuticals
- Cosmetic and anti-aging formulations
- Sustainable agricultural practices
- Environmental remediation ^[29]

7.4 Biotechnological Applications

The *C. ternatea* cyclotide processing enzyme, butelase-1, represents a revolutionary breakthrough in biotechnology as the fastest peptide ligase discovered to date. This remarkable enzyme demonstrates extraordinary versatility, capable of ligating peptides across an unprecedented range of sizes from small 26-residue peptides to large macromolecules exceeding 200 residues. The enzyme's exceptional efficiency and broad substrate specificity make it invaluable for pharmaceutical applications^[30].

Butelase-1's unique cyclization mechanism enables the large-scale synthesis of macrocycle libraries, which are increasingly important in drug discovery due to their enhanced stability, bioavailability, and target specificity compared to linear peptides. The enzyme facilitates the production of peptide-based pharmaceuticals with improved therapeutic properties, including resistance to proteolytic degradation and enhanced cell membrane permeability^[31].

Furthermore, this technology opens new avenues for developing novel therapeutic peptides, vaccine components, and biomaterials.^[32] The ability to efficiently create cyclic peptides at industrial scales positions *C. ternatea*-derived butelase-1 as a cornerstone technology for next-generation biotechnological applications, bridging natural product chemistry with modern pharmaceutical manufacturing^[33].

8. CONCLUSION

The intersubjectivity of traditional Ayurveda and scientific support to the herb makes *Clitoria ternatea* an immensely beneficial medicinal substance with multifaceted pharmaceutical characteristics. A complex phytochemical content of the plant, notably containing high amounts of anthocyanins, forms the biochemical background of its long-standing attention and use as well as illuminating a new set of therapeutic prospects.

The cognitive-enhancing and neuroprotective qualities confirmed by extensive scientific research make it an effective traditional agent to treat diseases under the term of a *Medhya Rasayana*. Its safety profile and a variety of pharmacological activities make *C. ternatea* a good candidate to develop evidence-based phytotherapeutics.

Nonetheless, translation of outcomes to the bedside must be via extensive clinical studies, standardized methods of extraction, and assurance ensuring quality control. Converging of traditional experience with modern scientific methodology is the best example of how ethnopharmacology can be used to develop new approaches to therapeutic drugs.

The way forward in the place of this incredible plant should be mechanistic studies, clinical verification and developing standardized formulations in order to maximize the therapeutical potential of the plant. Right along this path of ancient Ayurvedic medicine to present-day pharmaceutical usage can be seen an example of the great usefulness of traditional medicine in current-day healthcare circles.

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