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Medicinal usage of *Clitoria ternatea* flower petal: A narrative review

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Abstract

The plant *Clitoria ternatea* (butterfly pea), possesses a rich heritage of traditional applications, with various plant parts historically employed to address diverse health concerns. Beyond its established medicinal uses, the vibrant flowers of *C. ternatea* have been widely utilized as a natural food colorant. This review article aims to comprehensively examine recent advancements in the understanding of the medicinal properties and phytochemical composition of *C. ternatea* flowers, with a particular emphasis on their diverse biological activities. By consolidating these developments, this paper endeavors to offer valuable insights into the therapeutic promise and broad applications of *C. ternatea* flowers, thereby stimulating further research in this promising domain. While the plant's traditional uses are extensive, clinical investigations specifically focusing on the flower petals of *C. ternatea* remain limited, with only three notable studies exploring their potential for antidiabetic, cholesterol-lowering, and antidandruff effects. This review article specifically highlights these clinical applications, while also providing a concise overview of the current phytochemical profiles and pharmacological research associated with *Clitoria ternatea*, particularly its flower petals.

Keywords

Medicine, *Clitoria ternatea*, Butterfly pea

Introduction

Butterfly pea (Clitoria ternatea), a prominent member of the Fabaceae family, is extensively cultivated across the Asian region, where it is commonly referred to as "telang flower" in Indonesia and Malaysia. This robust perennial herb typically reaches heights between 90.00 and 162.00 cm and exhibits an erect growth habit [1]. Historically, this plant has been recognized for its medicinal properties, attributed to its rich content of diverse natural compounds, notably phenolic compounds. The striking solitary flowers of C. ternatea display vibrant hues of deep blue and white. Its pods yield 6 to 8 brown or black seeds, which are typically smooth in texture [2].

The genus name "Clitoria" is derived from the flower's morphology, which strikingly resembles the female clitoris, while the species name "ternatea" originates from

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Ternate, an island located in Eastern Indonesia. Floral coloration in C. ternatea exhibits considerable variation, encompassing dark blue, violet, white, light blue, and mauve [3].

The vivid, deep-blue and white coloration of the flowers makes them a popular natural colorant in various food preparations. Beyond their aesthetic appeal, different parts of the plant, including its leaves, flowers, and roots, are widely believed to possess significant medicinal value [3]. Individual pea flowers are approximately 4 cm long and 3 cm wide, characterized by five distinct petals. As a perennial species, C. ternatea propagates through its black seeds, producing colorful pods that measure approximately 7-11 cm in length. The plant is notably rich in anthocyanin compounds, making it a valuable resource for the food coloring industry [4].

Phytochemical analyses of Clitoria ternatea have revealed a diverse array of bioactive compounds, including anthraquinone, anthocyanins, phenols, flavonoids, tannins, volatile oils, phlorotannin, carbohydrates, saponin, triterpenoids, flavanol glycosides, proteins, alkaloids, cardiac glycosides, stagnant-4-ene-3, 6-dione, and steroids [5]. Research indicates that ultrasound-assisted extraction (UAE) is a superior method for obtaining higher yields of total phenolic compounds (TPC), flavonoid content (FVC), and anthocyanins (TAC), as well as enhancing their bioactivity, compared to conventional extraction techniques such as maceration and reflux [6].

A remarkable characteristic of the aqueous extract (which is typically dark blue) is its pH-dependent color transformation, allowing it to shift to green, pink, or red depending on the solution's pH. This property highlights the significant technological potential of the blue aqueous extract, offering a promising and natural alternative to synthetic coloring agents in the food and beverage industries [7].

Method

Literature search

In this narrative review, an exhaustive literature search was conducted to identify research publications investigating Clitoria ternatea in human subjects. The search strategy involved employing the keywords "clinical studies" OR "pharmacological studies" AND "Clitoria ternatea." This comprehensive search was performed across prominent academic databases, namely PubMed/Medline, Scopus, Science Direct, and Google Scholar, and encompassed all studies published up to September 2024. A critical distinction of this review is its exclusive focus on studies examining the flower petals of Clitoria ternatea, consciously excluding research on other parts of the plant. Research articles retrieved through the databases and keyword combinations were meticulously analyzed through an in-depth interpretation of either their abstracts or full texts to determine their relevance and extract pertinent information.

Eligibility criteria

The inclusion criteria used for this narrative review, were:

1. English language article, original articles and full text
2. Published in the last 10 years (since 2014-2024)
3. Studies report clinical trial (human respondent)

The exclusion criteria were all studies that did not satisfy the requirement mentioned above, such as a preclinical study (in animal), research in vivo, in vitro and in silico.

Selection of study

The two independent reviewer (MCNS and SM) evaluated all of the article according to the inclusion and exclusion criteria. We read all the abstract from all the selected paper.

Results and Discussion

The electronic literature search yielded 3 selected articles. This review revealed clinical practice evidence, but it is very difficult to find high-quality literature about clinical trials of *Clitoria ternatea* flower petals. Only 3 articles fulfil the criteria.

Antidiabetic and antioxidant

A randomized, crossover study investigated the impact of Clitoria ternatea extract (CTE) on postprandial glucose, insulin, and antioxidant markers in 15 healthy male participants. The study design involved participants consuming five distinct beverages: a control sucrose solution, 1g CTE in water, 2g CTE in water, a combination of sucrose and 1g CTE, and a combination of sucrose and 2g CTE. Over three hours, researchers measured incremental postprandial plasma glucose, insulin, uric acid, various antioxidant capacities, and lipid peroxidation indicators.

The findings indicated that co-ingestion of sucrose with either 1g or 2g CTE significantly reduced postprandial plasma glucose and insulin levels within 30 minutes. Notably, CTE alone did not affect fasting glucose or insulin. Both CTE doses substantially elevated plasma antioxidant capacity, evidenced by increases in FRAP, ORAC, TEAC, and protein thiol levels, alongside a decrease in malondialdehyde (MDA), a marker of lipid peroxidation. Furthermore, CTE mitigated sucrose-induced reductions in ORAC and TEAC while attenuating the rise in plasma MDA. These results suggest that acute CTE consumption enhances plasma antioxidant capacity without causing hypoglycemia in fasted individuals. When consumed with sucrose, CTE positively influences postprandial glucose, insulin, and overall antioxidant status [8].

Complementing these human findings, various preclinical studies support C. ternatea's antidiabetic potential. For example, a study showed that 14 days of C. ternatea flower extract treatment (150 mg/kg body weight) significantly lowered glucose levels in diabetic rats. Proposed mechanisms for its hypoglycemic effects include flavanol glycosides, anthocyanins, and alkaloids, which may stimulate insulin secretion or improve glucose uptake [9]. Recent research also highlights the antidiabetic promise of C. ternatea leaf extracts [9], with malonylated flavanol glycosides from petals identified as active compounds [10].

Regarding antioxidant activity, aqueous extracts of C. ternatea flowers exhibit significantly higher free radical scavenging activity compared to methanol-based extracts, with efficacy improving as extract concentrations increase [2]. Similarly, aqueous extracts demonstrated superior antioxidant activity over ethanol extracts [11]. A beverage formulated with blue pea flower extract exhibited shelf stability for 28 days without preservatives, positioning it as a potentially healthier alternative to artificial beverages due to its inherent antioxidant properties and ability to mitigate oxidative stress linked to chronic diseases [12].

A key advantage of anthocyanins derived from butterfly pea flowers is their remarkable stability, particularly under low temperatures and neutral to mildly acidic pH conditions. They maintain decent antioxidant activity within the pH range of 4–7, which is typical for many daily food items [13]. This stability, coupled with their vibrant blue coloration, makes C. ternatea flowers excellent candidates for natural food colorants [13].

Hypolipidemic activity

Research has explored the hypolipidemic activity of Clitoria ternatea extract (CTE). A randomized human study involving sixteen participants (mean age: 23.5 ± 0.6 years; BMI: 25.7 ± 0.7 kg/m^2) investigated the effects of CTE on lipid profiles. Participants were assigned to one of three groups: a high-fat (HF) meal, or an HF meal supplemented with either 1 gram or 2 grams of CTE. Blood samples were collected at various intervals post-meal (fasting, 30, 60, 90, 120, 180, 240, 300, and 360 minutes). Notably, the 2-gram CTE dose significantly reduced the incremental area under the curve (iAUC) for serum triglyceride levels and lowered postprandial serum free fatty acids at 360 minutes following the HF meal [14].

Further preclinical investigations have elucidated the broader metabolic impacts of C. ternatea. Oral administration of an aqueous flower extract (400 mg/kg body weight) over 84 days demonstrated a substantial reduction in the activity of gluconeogenic enzymes, such as glucose-6-phosphatase. This intervention also resulted in a significant decrease in total cholesterol, triglycerides, urea, serum glucose, glycosylated hemoglobin, and creatinine. Concurrently, there was a notable increase in HDL-cholesterol, serum insulin, protein, and glycogen content in both liver and skeletal muscle [15], [16].

Beyond these metabolic benefits, another preclinical study highlighted the rich mineral composition of C. ternatea flowers. These flowers contain significant concentrations of essential minerals, including calcium (3.09 mg/g) and magnesium (2.23 mg/g). Furthermore, elevated levels of potassium (1.25 mg/g), zinc (0.59 mg/g), sodium (0.14 mg/g), and iron (0.14 mg/g) were observed, surpassing most other analyzed parameters ($p<0.05$) [17]. The flowers are also a rich source of various ternatins (A1-3, B1-4, C1-5, D1-3) and kaempferol derivatives, such as kaempferol 3-2G-rhamnosyl rutinoside, kaempferol, kaempferol 3-neohesperidoside, and kaempferol 3-rutinoside [5].

Anti dandruff

A study investigated the efficacy of Clitoria ternatea flower extract as a potential treatment for dandruff, comparing it against a standard 2% ketoconazole shampoo. Seventy female patients aged 18 to 25 years, all diagnosed with dandruff, were randomized into two groups: an experimental group receiving 20% C. ternatea shampoo and a control group using 2% ketoconazole shampoo. The findings indicated that the 2% ketoconazole shampoo significantly reduced Malassezia spp. DNA expression more effectively than the 20% C. ternatea shampoo, with a statistically significant difference ($p=0.008$). Conversely, no significant differences were observed between the two shampoos in their effects on plakoglobin levels or IL-8 levels. Interestingly, the 20% C. ternatea shampoo demonstrated a significantly greater reduction in sebum levels compared to ketoconazole. Both shampoos yielded comparable results in terms of dandruff scores and patient satisfaction. Notably, the 2% ketoconazole shampoo group reported a higher incidence of adverse effects, affecting 21.2% of patients [18].

The flowers of C. ternatea also contain various kaempferol derivatives [19], and are rich in anthocyanin compounds called ternatins, similar to those found in berries, cherries, and red wine. Additionally, the plant contains other antioxidants, including kaempferol [20]. Antioxidants like polyphenols are known to enhance skin hydration and provide protection against sun damage. Due to its anti-inflammatory properties, C. ternatea can help alleviate rashes, swelling, itching, dermatitis, or skin allergies. Another recognized benefit is its ability to promote a healthy scalp and hair by increasing blood flow to hair follicles and reducing inflammation that can impede hair growth [4].

Further preclinical investigations have revealed that aqueous extracts of C. ternatea exhibit superior antioxidant capacity (demonstrating an IC50 of 1 mg/mL for DPPH scavenging) when compared to ethanol extracts (which had an IC50 of 4 mg/mL). When these aqueous extracts were integrated into an eye gel formulation, they largely maintained their antioxidant properties, albeit to a lesser extent than a commercially available anti-wrinkle cream used as a benchmark. The total phenolic content of these extracts was quantified at 1.9 mg/g, expressed as gallic acid equivalents. These results highlight the promising utility of C. ternatea extracts as antioxidant components in cosmetic formulations [21].

The petals of C. ternatea are rich in diverse bioactive compounds, including α- and γ-tocopherols, ternatins, flavone glycosides, and delphinidin derivatives, in addition to four distinct phytosterols. While β-sitosterol and γ-tocopherol concentrations were found to be higher in the seeds than in the petals, linoleic acid was the predominant fatty acid identified in the petals, with phytanic acid also being present [22]. Moreover, studies assessing both lipophilic (LBP) and hydrophilic (HBP) extracts from butterfly pea petals have indicated their potential to influence the viability of HEp-2 human carcinoma cells, suggesting their applicability in the development of functional foods [22]. Significantly, the presence of quercetin glycosides and ternatin anthocyanins within the blue flower petals of C. ternatea may hold considerable value for the creation of

pharmaceuticals or nutraceuticals. These compounds show promise in their ability to alleviate chronic inflammatory conditions by suppressing the overproduction of pro-inflammatory mediators by macrophage cells [23]. Further supporting data are presented in Table 1.

Table 1. Summary

Author- year	Test for	design/doses/ concentration	Result
Chusak, et al - 2018 - Bangkok, Thailand/ 18 person	Plasma glucose, insulin and uric acid concentration and also plasma antioxidant	five groups beverages: (1) 50 g sucrose in 400 mL water; (2) 1 g CTE in 400 mL of water; (3) 2 g CTE in 400 mL of water; (4) 50 g sucrose and 1 g CTE in 400m Lofwater; and (5) 50g sucrose and 2g CTEin 400 mL of water.	CTE effectively decreases postprandial plasma glucose and insulin, while simultaneously boosting antioxidant status.
Thilavech, et al - 2021- Bangkok, Thailand/ 16 men	Serum Triglyceride and Free Fatty Acid (FFA) Concentration	3 groups participants: consumed a high-fat (HF) meal, an HF meal plus 1 g of CTE, or an HF meal plus 2 g of CTE	CTE decreases postprandial serum triglycerides and FFA concentration in overweight and obese men.
Assegaf et al - 2024 - Pekanbaru, Indonesia/70 women	Malassezia spp. DNA expression, dandruff severity score, and sebum level	20% C ternatea shampoo compare with 2% ketoconazole shampoo	showed effective in decreasing Malassezia spp. DNA, ameliorating dandruff severity, effective in sebum control and were well-tolerated by patients

Conclusion

The flower petal of *Clitoria ternatea* has been widely screened for its wide range of phytochemical and pharmacological properties, but not in clinical trial, because it is very difficult to find the respondent. *Clitoria ternatea* extract effective as hypoglycaemic agent, as antioxidant, as lipophilic agent and as antidandruff. In the future, Studies in human being (clinical trial) are needed, to explore the medicinal usage of *Clitoria ternatea* flower petal.

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