ETHNOPHARMACOLOGY AND POTENTIAL OF BIOACTIVE COMPOUNDS IN BUTTERFLY PEA (*Clitoria ternatea Linn.*) AS ANTIBACTERIAL – A REVIEW

ETNOFARMAKOLOGI DAN POTENSI SENYAWA BIOAKTIF PADA BUNGA TELANG (Clitoria ternatea Linn.*) SEBAGAI ANTIBAKTERI - REVIEW*

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ABSTRACT

Clitoria ternatea, also called the butterfly pea, has an extended tradition of usage in medicine. Worldwide, Clitoria ternatea is a popular ornamental flower and has long been used as a culinary colouring. In order to treat conditions including digestive issues, constipation, joint inflammation, skin ailments, and liver and intestinal problems, among others, the plant's many sections are used. This plant shows many antimicrobials, gastrointestinal antiparasitic, and insecticidal effects on its flower parts. Therefore, Clitoria ternatea must be cultivated, preserved, and studied for its potential further because of its many benefits. This paper reviews the potential of Clitoria ternatea flowers in antibacterial activity and its bioactive compounds based on recent research reviews, chemical compounds such as tannins, phlobatannins, carbohydrates, saponins, triterpenoids, phenols, flavonoids, flavonol glycosides, proteins, alkaloids, anthraquinones, anthocyanins, glycosides, stigmast-4-ene-3,6-dione, essential oils, steroid

kaempferol, quercetin, myricetin glycosides, and anthocyanins have been isolated from Clitoria ternatea flowers. These compounds are found to have an antimicrobial activity that benefits human health. Thus, Clitoria ternatea is a promising candidate for functional food applications due to its various pharmacotherapeutic properties, safety, and effectiveness.

***Keywords*:** *antibacterial, Clitoria ternatea, bioactive compound*

ABSTRAK

Clitoria ternatea atau dikenal dengan nama bunga telang atau 'Butterfly Pea' telah digunakan secara tradisional dalam pengobatan di berbagai negara, termasuk Indonesia. Bunga Clitoria ternatea digunakan di seluruh dunia sebagai bunga hias dan secara tradisional digunakan sebagai pewarna makanan. Beberapa bagian tanaman digunakan untuk mengobati masalah kesehatan seperti gangguan pencernaan, sembelit, radang sendi, penyakit kulit, masalah hati dan usus. Tumbuhan ini menunjukkan banyak efek antimikroba, antiparasit gastro-intestinal, dan insektisida pada bagian bunganya. Oleh karena itu, tanaman Clitoria ternatea perlu dibudidayakan, dilestarikan dan dikaji potensinya lebih lanjut karena banyak manfaatnya. Tulisan ini meninjau potensi bunga Clitoria ternatea dalam aktivitas antibakteri dan senyawa bioaktifnya berdasarkan ulasan penelitian-penelitian terbaru. Senyawa kimia seperti tanin, phlobatannins, karbohidrat, saponin, triterpenoid, fenol, flavanoid, glikosida flavonol, protein, alkaloid, antharaquinone, anthocyanin, glikosida, stigmast-4-ene-3,6-dione, minyak atsiri, steroid kaempferol, quercetin, myricetin glycoside, dan anthocyanin telah diisolasi dari bunga Clitoria ternatea. Senyawa-senyawa ini ditemukan memiliki aktivitas antimikroba yang bermanfaat bagi kesehatan manusia. Manfaat kandungan senyawa tersebut menjadikan Clitoria ternatea sebagai kandidat yang menjanjikan untuk aplikasi makanan fungsional karena berbagai sifat farmakoterapi serta keamanan dan efektivitasnya.

***Kata Kunci*:** *antibakteri, Clitoria ternatea, senyawa bioaktif*

INTRODUCTION

The butterfly pea, also known as *Clitoria ternatea*, belongs to the Fabaceae family and is commonly used as an ornamental plant and for reforestation. The Balinese community, Bali Aga, utilizes the *Clitoria ternatea* flower in religious ceremonies as an offering (canang) and a symbol of femininity (Miyaura et al., 2015; Wijana et al., 2019). In most Southeast Asian countries, the blue pigment of the flower is used as a food colouring agent and in traditional medicine (Havananda & Luengwilai, 2019; Oguis et al., 2019). *Clitoria ternatea* is known to possess healing properties for various diseases and symptoms such as chronic bronchitis, goitre, leprosy, visual impairments, skin diseases, sore throat, and tumours (Suveena et al., 2022; Lijon et al., 2017).

This plant's Phytochemical constituents indicate various secondary metabolites such as flavonoids, anthocyanin glycosides, pentacyclic triterpenoids, and phytosterols (Mukherjee et al., 2008). A protein called 'finotin' has been isolated from *Clitoria ternatea* and reported to possess antifungal, antibacterial, and insecticidal properties (Kelemu et al., 2004). It is likely that this compound is primarily responsible for the antimicrobial effects (Manjula et al., 2013). Numerous studies have been conducted on the roots, seeds, flowers, and leaves of *Clitoria ternatea*. The flower of *Clitoria ternatea* is known to have potential health benefits, with several studies showing its extract to exhibit antimicrobial activity (Leong et al., 2017). Compounds such as ternatin anthocyanin and various flavanol glycosides of kaempferol, quercetin, and myricetin have been identified in flowers (Kazuma et al., 2003; Mukherjee et al., 2008).

The bioactive compounds in the *Clitoria ternatea* flower have received less attention as a source of antibacterial agents or medicinal applications than other plants. Cumulative information on this plant's ethnopharmacology and chemical compounds would greatly assist in discovering new drugs from natural sources. With these benefits, this plant contributes to developing science

and technology trends for sustainable living. This trend focuses on solving problems in the field of food and human health that need further research development. This article focuses on the potential of the compounds found in the *Clitoria ternatea* flower that exhibit antibacterial activity in their traditional and pharmacological utilization.

DISCUSSION

1. Traditional Use

In Indonesia, Butterfly Pea flowers are used by the Betawi tribe to brighten infants' eyes (Marpaung, 2020). They are also used for treating eye infections by local communities in Lombok and Bali (Rezaldi et al., 2022; Silalahi, 2021). In West Lombok, butterfly pea flowers are used for treating boils in the Sesaot forest (Rahayu & Andini, 2019). The Togean tribe in Central Sulawesi utilizes the flowers for treating fever and abscesses (Purba, 2020). In Malaysia, the Siamese Kelantan community uses them to treat infections, burns, urinary tract disorders, edema, antidotes, tumors, snake bites, digestive disorders, cough, headaches, eye diseases, and joint inflammation. In Myanmar, they neutralize snake venom, and the flower extract treats eye ailments in infants (Kyaw et al., 2021; Luu-Dam et al., 2016). The K'Ho-Cil tribe in Lam Dong province, Vietnam, uses this plant to relieve constipation and treat diarrhea and snakebites (Pham et al., 2020).

Clitoria ternatea is widely used in Ayurvedic medicine in India for some medical issues in countries apart from Southeast Asia. Its seeds function as a laxative and are used to cure colic and joint swelling, digestive issues, constipation, fever, joint inflammation, sore throat, and skin and eye ailments. Its roots are used to treat these kinds of illnesses. The plant is widely used in traditional Indian medicine to enhance intelligence and improve memory function. It treats chronic bronchitis, goiter, leprosy, mucus disorders, visual weakness, skin diseases, sore throat, and tumors (Muniroh et al., 2023). In traditional Cuban culture, the boiled root alone or combined with the flower regulates menstruation, induces uterine

contractions, and treats liver and intestinal issues. In traditional Chinese medicine, the flower is believed to affect female libido (Mukherjee et al., 2008).

Table 1. Traditional Uses of Butterfly Pea Flower in Various Countries

No.	Country	Use	Preparation	References
1	Indonesia	- Brightening and treating infant eyes - Treating fever - Treating boils - Treating abscesses	Applied topically Crushed or boiled	(Rezaldi et al., 2022; Silalahi, 2021)
2	Malaysia	- Treating infections, burns, urinary tract disorders, edema, antidotes, tumors, snake bites, digestive disorders, cough, headaches, eye diseases, joint inflammation	Applied topically Crushed or boiled	(Ganesan et al., 2019)
3	Myanmar	- Neutralizing snake venom - Treating infant eye ailments	Applied topically Crushed or boiled	(Kyaw et al., 2021)
4	Vietnam	- Relieving constipation - Treating diarrhea - Acting as a snakebite antidote	Juiced, crushed, boiled	(LUONG et al., 2023; Pham et al., 2020)
5	Philippines	Food (boosting immunity)	Consumed directly, boiled	(Maghirang et al., 2018)
6	Thailand	Food and beverages	Processed, boiled	(Luu-Dam et al., 2016)

No.	Country	Use	Preparation	References
7	Burma	Food and beverages	Processed, boiled	(Luu-Dam et al., 2016)
8	India	Enhancing intelligence and improving memory function	Boiled, crushed	(Muniroh et al., 2023)
9	Cuba	Regulating menstruation, inducing uterine contractions, treating liver and intestinal issues	Boiled	(Mukherjee et al., 2008)
10	China	Increasing female libido	Boiled	(Mukherjee et al., 2008)

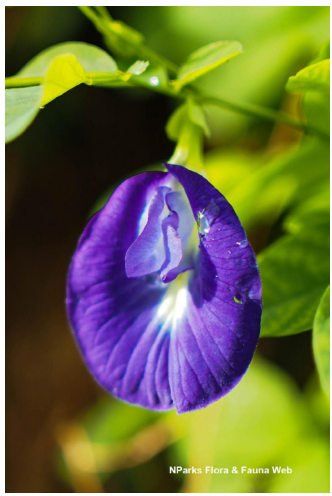
2. Local Food Usage

The flower has been utilized as a food colourant and nutraceutical in the Indonesian town of Sidoarjo in the East Java Province (Imayanti et al., 2019). Numerous Malaysian communities consume the flower as a natural food colouring agent when creating regional or traditional foods like "nasi kerabu" and "kueh tekan" (Muhammad Ezzudin & Rabeta, 2018; Rosli et al., 2015.). The flower is utilized by natives in Palawan, Philippines, for the creation of the traditional dish "dinengdeng," while its petals are utilized for the dessert "rujak" (Maghirang et al., 2018). Locals in northern Vietnam use the flower to colour sticky rice meals. In Burmese and Thai cuisine, the flowers are dipped in batter and fried. Dried flowers are used for making tea. In Thailand and Vietnam, this flower tea is typically mixed with honey and lemon to enhance acidity and transform the drink into a pink-purple colour, commonly served as a post-dinner beverage or refreshment in hotels and spas (Luu-Dam et al., 2016).

3. Distribution and Habitat

Clitoria ternatea originates from Southeast Asia and is found in tropical regions of Asia, including India, the Philippines, and Madagascar. It has since spread to South Asian countries, Central

America, South America, and the Caribbean (Arya et al., 2018). *Clitoria ternatea* is a perennial herb that grows as a climbing or trailing plant, particularly in compact and neutral soils. It is cultivated as an ornamental plant and for reforestation purposes (e.g., in coal mines in Australia) and requires minimal care when planted. As a legume, its roots form a symbiotic relationship with bacteria of the Rhizobium genus, which convert atmospheric N2 into a usable form for plants. Therefore, this plant also improves soil quality by decomposing nitrogen-rich plant materials. As a result, it is known to be suitable as a fertilizer plant capable of suppressing annual weeds and enriching the soil through nitrogen fixation. *Clitoria ternatea* thrives in full sunlight or partial shade, with seed germination taking approximately 1-2 weeks and flowering occurring within four weeks (Jamil & Pa'ee, 2018; Suarna & Wijaya, 2021).



Source: *NParks Flora & Fauna Web, 2023*

Figure 1. *Clitoria ternatea* Flower

4. Taxonomic Characteristics

Clitoria ternatea is classified as part of the family Fabaceae, class Magnoliopsida, phylum Tracheophyta, and kingdom Plantae (Jamil & Pa'ee, 2018). This plant, also known as butterfly pea flower, blue pea flower, or bluebell vine, is a plant that grows to a height of two to three meters (Mukherjee et al., 2008). This flower is known as 'bunga biru' or 'kembang telang' in Bahasa Indonesia, 'bunga telang' in Malaysia, 'dangchan' in Thai, 'chi dau bieˆc' in Vietnamese, 'lan hu die' in China, 'aparajita' in Bengali, 'kajroti' in India, 'clitoria azul' in Spanish, 'cunhã' and 'fula criqua' in Portuguese, 'cunha' in Brazil, and 'mavi kelebek sarmas ¸g ı' in Turkish (Dhanraj et al., 2019; Mukherjee et al., 2008; Vidana Gamage et al., 2021).

Clitoria ternatea is a climbing plant with bright blue and striking white flowers, measuring 1 to 2 inches long, with wavy-framed standards and a white center (Neal, 1965). It is a woody vine, winding and reaching a length of 1-3 m. The stem is slender and cylindrical, with small trichome lines. The leaves are pinnate, consisting of 5-7 leaflets, elliptical or, ovate or lanceolate in shape, with a length and width ranging from 2.5 - 5.0 cm and 2.0 - 3.2 cm, respectively. The flowers are solitary, with short stalks; the stalk length is 1 cm. *Clitoria ternatea* appears in various flower hues, including white, light purple, light blue, and dark blue, and measures 4.5 - 5 cm in length. The flowers appear in the rainy season, and the fruits develop in winter. The flower stalk is 1.5-2.2 cm long, green, lanceolate-ovate in shape, and purplish-blue with pale yellow at the base and center. The seeds are elongated, flattened, measuring 5-6 mm, and dark brown (Acevedo-Rodríguez 2005). The seeds are elongated and either dark brown or yellowish, with a length ranging from 4.5-7.0 mm and a width of 3-4 mm. The plant has a taproot system with numerous slender lateral roots (Mukherjee et al., 2008; Vidana Gamage et al., 2021).

5. Antibacterial Activity

Clitoria ternatea flowers have been studied for their antibacterial properties. *Clitoria ternatea* flower methanol extract was evaluated against 12 bacterial species including *Proteus*

mirabilis, Bacillus thuringiensis, B. subtilis, B. cereus, Streptococcus faecalis, Staphylococcus aureus, Escherichia coli, Salmonella typhi, Enterobacter aerogens, Herbaspirillum spp*, Klebsiella pneumoniae, and Pseudomonas aeruginosa*. Using the agar disc diffusion technique, the flower demonstrated the most significant antibacterial activity against *B. thuringiensis* with a minimum inhibitory concentration (MIC) of 12.5 mg/mL and a minimum bactericidal concentration (MBC) of 25 mg/mL, with a zone of inhibition of 15.7 mm (Kamilla et al., 2009). *Clitoria ternatea* flower extract (4 mg) has been shown to inhibit the growth of *P. aeruginosa*, *E. coli*, and *K. pneumoniae* but showed no activity against *S. typhi* and *S. enteritidis*. *P. aeruginosa* and *K. pneumoniae* had the maximum zone of inhibition of 26 mm (Dhanasekaran et al., 2019).

Anthocyanin extracts from *Clitoria ternatea* flowers have been found to exhibit potent antibacterial activity against *K. pneumoniae* with a Minimum Inhibitory Concentration (MIC) of 1.6 mg/mL and a Minimum Lethal Concentration (MLC) of 25 mg/mL. With a disc diffusion zone of inhibition of 10 mm, the anthocyanin fraction derived from the ethanol extract of *Clitoria ternatea* flowers had the best impact against *B. subtilis*. The results indicate that anthocyanins are antimicrobial (Mahmad et al., 2018).

The methanol extract of *Clitoria ternatea* flowers was found to have more robust inhibitory activity compared to other extracts against *Bacillus cereus, Staphylococcus aureus, Klebsiella pneumoniae, Proteus vulgaris,* and *Salmonella typhi* (Chakraborty et al., 2017). The efficiency of different solvent extractions against the examined bacteria varied. These variations could be ascribed to the type and concentration of antimicrobial compounds contained in the extract and their mechanism of action on various test bacteria (Balouiri et al., 2016). The maximum inhibitory zone against *P. aeruginosa* was demonstrated by ethyl acetate extract of *Clitoria ternatea* (21 mm). In comparison, the maximum inhibitory zone against *A. formicans* was demonstrated by ethanol extract of *Clitoria ternatea* (18 mm) and the maximum inhibitory zone against *S. agalactiae* was demonstrated by acetone extract (19 mm) (Al-Snafi, 2016).

Table 2. Antimicrobial Activity of *Clitoria ternatea* Flower

No	Sample	Tested microorganism	MIC	Reference
1	methanolic extract of *Clitoria ternatea*	*Bacillus thuringiensis*	12,5 mg/mL	(Kamilla et al. 2009)
2	chloroform extract of *Clitoria ternatea*	*K. pneumoniae, P. aeruginosa*	4 mg	(Dhanasekaran et al., 2019)
3	methanolic extract of *Clitoria ternatea*	*K. pneumonia* *P. aeruginosa*	0,8 mg/mL 1,6 mg/mL	(Dhanasekaran et al., 2019)
4	ethanolic extract of *Clitoria ternatea*	*K. pneumonia*	1,6 mg/mL	(Leong et al., 2017)
5	methanolic extract of *Clitoria ternatea*	*S. aureus*	300 g/mL	(Jamil & Pa'ee, 2018)
6	ethanolic extract of *Clitoria ternatea*	*S. aureus*	10 mg/mL	(Mahmad et al., 2018)
7	anthocyanin-rich fraction.	*B. subtilis*	10 mg/mL	(Jeyaraj et al., 2021)

6. Phytochemistry

The flower of *Clitoria ternatea* contains numerous bioactive compounds that exhibit powerful anti-inflammatory, antidiabetic, antibacterial, antioxidant, and antiproliferative/anticancer activities (Al-Snafi, 2016; López Prado et al., 2019; Mahmad et al., 2018; Neda et al., 2013; Rajamanickam et al., 2015). Several studies have been conducted to explore, identify, and isolate bioactive components from *Clitoria ternatea* flowers. The percentages of protein, fiber, carbs, and lipids in *Clitoria ternatea* flower were 0.32%, 2.1%, 2.2%, and 2.5%, respectively, with a water content of 92.4%. Calcium (3.09 mg/g), magnesium (2.23 mg/g), potassium (1.25 mg/g), zinc (0.59 mg/g), sodium (0.14 mg/g), and iron (0.14 mg/g) are additionally abundant in the flower (Neda et al., 2013).

Acute toxicity studies using Wistar albino rats given ethanol extract of *Clitoria ternatea* flower (2000 mg/kg body weight) showed no acute toxic effects and are safe for consumption

(Srichaikul, 2018). *Clitoria ternatea* flowers have the potential to be used as functional food incorporated into various food products or even as supplements or pharmaceutical drugs combined with commercial medications to enhance therapeutic efficacy in patients (Rajamanickam et al., 2015). Various triterpenoids, flavonols, glycosides, anthocyanins, and steroids have been identified from *Clitoria ternatea*. The thermally stable fraction of *Clitoria ternatea* extract was used to isolate cyclotides, also known as cliotides. Furthermore, the blue hue of *Clitoria ternatea* is due to anthocyanins, specifically ternatin, a polyacylated derivative of 3,3′,5′-triglucoside delphinidin (Da-T) (Neda et al., 2013).

Anthocyanins are malonylated delphinidin 3,3',5'-triglucosides, which have a 3',5' side chain with alternating D-glucose and p-coumaric acid units at R and R1, respectively. All blue petal lines contain a total of 15 (poly) delphinidin acylated glucoside derivatives, notably ternatin A1-A3, B1-B4, C1-C4, and D1-D3, with additional delphinidin derivatives detected in some experiments (Suveena et al., 2022; Shen et al., 2016; Zakaria et al., 2018). Ternatin A1, A2, B1, B2, D1, and D2 are the flower's six main anthocyanins (Mukherjee et al., 2008). Fourteen kaempferol, quercetin, and myricetin glycosides with H or OH at R1 and R2, and H, rhamnosyl, or malonyl at R3 and R4 are discovered in the petals (Kazuma et al., 2003; Mukherjee et al., 2008). Shen et al. (2016) isolated fatty acids (palmitic acid, stearic acid, petroselinic acid, linoleic acid, arachidic acid, behenic acid, and phytanic acid), phytosterols (campesterol, stigmasterol, -sitosterol, and sitostanol), and tocopherols (-tocopherol and -tocopherol) from *Clitoria ternatea*. Neda et al. (2013) detected additional components such as mome inositol, pentanal, cyclohexene, 1-methyl-4-(1-methylethylidene), and hirsutene. Additionally, these compounds are utilized to treat tumors, chronic bronchitis, goiter, leprosy, visual problems, skin conditions, and sore throats. The herb can also create leprosy ointments (Singh et al., 2018).

The flower also includes flavonol glycosides, such as 3-O-(2″,6″-di-O-rhamnosyl)-glucoside of kaempferol, quercetin, and myricetin, which were extracted from the petals. The flower

included eight anthocyanins (ternatin C1, C2, C3, C4, C5, and D3, as well as preternatin A3 and C4), delphinidin glycosides, 3-O-glucoside, 3-O-(2″-O-rhamnosyl)-glucoside, and 3-O-(2″-O-rhamnosyl-6″-O-malonyl)-glucoside. Mome inositol (38.7%) and pentanal (14.3%) were found in the water extract of *Clitoria ternatea* flowers. In comparison, mome inositol (33.6%), cyclohexene, 1-methyl-4-(1-methylethylidene) (7.1%), acetic acid, cyanide (6.5%), and hirsutene (5.7%) were found in the methanol extract of the same flowers. Organic compounds such as 1H-Cycloprop[e] azulene and 1a,2,3,5,6,7,7a,7b-octahydro-1,1,4,7-tetramethyl[1aR-(1aà,7à,7aá,7bà)]- (alternative spelling: varidifloren), Pterocarpin, 6H-Benzofuro[3,2-c]Isoparvifuran, [1]benzopyran, 6a,11a-dihydro-3,9-dimethoxy-, [1]benzopyran (6aR-cis)-, hexadecanoic acid, Myo-Inositol. The ethanol extract of the aerial portions of *Clitoria ternatea* yielded 4-C-methyl-1,2,3,5-cyclohexanetetrol (1à, 2à, 3à, 5á)- and 1-diethoxypropane (Vankar & Srivastava, 2010).

Numerous ternatins have been isolated from *Clitoria ternatea* flowers, and their structures have been identified as delphinidin 3-malonylG with 3′-GCG-5′-GC, 3′-GCG-5′-GC, 3′-GCGCG-5′-GC, 3′-GCGCG-5′-GC, and 3′-GCGC-5′-GC side chains, where G is D-glucose and C is p-coumaric acid. Raw ripe seeds have low levels of condensed tannins (0–2.48 mg catechin/g) and precipitable polyphenol proteins (0.16–0.77 mg tannic acid/g). *Clitoria ternatea* methanol extract presented anxiolytic, depressive, anticonvulsant, and antistress effects in animal studies. Tannins, resins, starch, taraxerol, and taraxerone are among the active compounds (Al-Snafi, 2016; Vankar & Srivastava, 2010).

Klitorienolactone A and B improve memory and inhibit acetylcholinesterase. (Z)-9,17-octadecadienal and n-hexadecenoic acid inhibit monoamine oxidase, thus potentially combating depression, anxiety, and cognitive disorders in Alzheimer's and Parkinson's diseases. Flavanol glycoside 3,5,40-trihydroxy-7-methoxyflavonol-3-O-β-d-xylopyranosyl-(1,3)-O-β-d-galactopyranoside exhibits antimicrobial activity, while delphinidin and malvidin have inhibitory activity against various types of cancer (Chayaratanasin et al., 2019; Mohamed & Taha, 2011; Rajamanickam et al., 2015; Singh et al., 2018; Vidana Gamage et al., 2021).

Table 3. Phytochemical Components of *Clitoria ternatea* Flower

No.	Compound	Plant Sources (countries)	Reference
1	Protein, fiber, carbohydrates, lipids, calcium, magnesium, potassium, zinc, sodium, iron, mome inositol, pentanal, cyclohexene, 1-methyl-4-(1-methylethylidene) and hirsutene	Malaysia	(Neda et al., 2013)
2	Saponins, tannins, alkaloids, glycosides, phytosterols, carbohydrates	Bangladesh	(Chayaratanasin et al., 2019; Vankar & Srivastava, 2010)
3	A group of fatty acids including palmitic acid, stearic acid, petroselinic acid, linoleic acid, arachidic acid, behenic acid, and phytanic acid	China	(Shen et al., 2016)
4	Quercetin-3β-D-glucoside	India	(Adhikary et al., 2018)
5	Anthelmintic	Thailand	(Nirmal et al., 2015)
6	Kaempferol, quercetin, and myricetin glycosides	India	(Mukherjee et al., 2008)
7	Ternatin A1-A3, B1-B4, C1-C4, D1-D3, and other delphinidin derivatives	China	(Shen et al., 2016; Zakaria et al., 2018)
8	Anthocyanins, primarily ternatin, a polyacylated 3,3',5'-triglucoside delphinidin (Da-T)	India	(Suveena et al., 2022)
9	6"-malonilastragalin, phenylalanine, sucrose coumaroyl, tryptophan, and glucose coumaroyl	Thailand	(Zakaria et al., 2018)
10	Mome inositol, pentanal, cyclohexene, 1-methyl-4-(1-methylethylidene), and hirsutene	India	(Kazuma et al., 2003; Mukherjee et al., 2008)

7. Several bioactive compounds have been investigated in *Clitoria ternatea* flowers

Clitoria ternatea flowers have diuretic and laxative effects. They are commonly used to alleviate stomach cramps and exhibit anti-helminthic, anti-inflammatory, antipyretic, analgesic, antidepressant, anxiolytic, sedative, anticonvulsant, antineoplastic, and hypoglycemic activities. In conventional Ayurvedic medicine, these flowers have been used for hundreds of years as memory enhancers, nootropics, anti-stress agents, anxiolytics, antidepressants, anticonvulsants, and tranquilizers. Active constituents include resin, tannins, taraxerone, starch, and taraxerol. The plant contains numerous secondary metabolites, including kaempferol and clitorin glucosides, taraxerol, and aparajitin lactone. The seeds contain hexacosanal, stigmasterol, and anthoxanthin.

Flowers of *Clitoria ternatea* have been showed to have antioxidant, antibacterial, anticancer, and antidiabetic properties. Various research, however, have looked into their potential for other positive functions. Adhikary et al. (2018) discovered in a rat model that a 100% methanol extract of *Clitoria ternatea* flowers and its pure component, quercetin-3-D-glucoside, have anti-rheumatic potential. The extract was less effective than quercetin-3-D-glucoside in significantly decreasing myeloperoxidase activity, pro-inflammatory cytokine and chemokine release, and reactive oxygen species (ROS)/reactive nitrogen species formation. It also lowered the expression of tumor necrosis factor receptor 1, toll-like receptor 2, the inducible isoform of nitric oxide synthase, COX-2, and matrix metalloproteinase-2. Singh et al. (2018) discovered that *Clitoria ternatea* floral extract had anti-allergic properties—the 98% ethanol extract reduced histamine-induced contractions in goat tracheal chains and isolated guinea pig ileum preparations. The extract also reduced histamine-induced dyspnea in animal models and regulated different ovalbumin-induced inflammatory cytokines. The extract inhibited inflammation in carrageenan- and acetic acid-induced challenges in rodent models, as well as antitussive efficacy in sulfur dioxide- and citric acid-induced cough in experimental

animals. *Clitoria ternatea* flower extract has also been reported to exhibit anthelmintic activity, larvicidal activity, anti-aging qualities, hepatoprotective effects, testicular injury protection, anti-adipogenesis activity, and starch digestion in other investigations (Chayaratanasin et al., 2019; Nirmal et al., 2015; Zakaria et al., 2018).

The flower contains tannins, phlobatannins, carbohydrates, saponins, triterpenoids, phenols, flavonoids, flavanols, glycosides, cardiac glycosides, proteins, alkaloids, anthraquinones, anthocyanins, stigmast-4-ene-3,6-dione, essential oil, and steroids (Al-Snafi, 2016). Fresh floral extracts have a higher level of anthocyanin than processed powders. The anthocyanins in the blooms degrade when they are heated or boiled. The flowers contain flavanol glycosides such kaempferol 3-O-(200-O-a-rhamnosyl-600-O-malonyl)-glucoside, myricetin 3-O-(200,600-di-O-a-rhamnosyl)-glucoside, and quercetin 3-O-(200-O-a-rhamnosyl-600-O-malonil)-glucoside. The delphinidin derivatives rutin, quercetin 3-O-dirhamnoside, manghaslin quercetin 3-[2G], ternatin B3, ternatin D3, and numerous others are produced by the flowers-rhamnosylrutinoside, ternatins B2, B4, C2, and D1, as well as ternatins (Suveena et al., 2022).

The emergence of antibiotic-resistant microbes significantly limits the effectiveness of current drugs, leading to treatment failures. In light of these challenges, alternative approaches must be developed apart from searching for new antibacterial compounds. The use of medicinal plants and botanical chemicals to heal various diseases and personal adornment is as old as human civilization (Dewatisari, 2022; Dewatisari, 2009). Extracts from different parts of *Clitoria ternatea* have shown varying efficacy against tested microorganisms. These differences may be attributed to the nature and level of antimicrobial agents in the extracts and their mode of action on different test microorganisms (Barbour et al., 2004). Therefore, *Clitoria ternatea* flowers can be used as a natural antibacterial source or as a supplement in the development of the food or pharmaceutical industry (Chayaratanasin et al., 2019; Shen et al., 2016).

CONCLUSION

Clitoria ternatea is a versatile plant traditionally known for its medicinal, beverage, and food colouring purposes. Numerous studies have identified its various potential uses. Most research has focused on the phytochemicals in *Clitoria ternatea* flowers, particularly anthocyanins, quercetin, and kaempferol glycosides, which may be responsible for the significant biological effects observed, including antibacterial activity. Therefore, the flowers of *Clitoria ternatea* hold potential for exploring the compounds present, such as anthocyanins or flavonols, for developing natural-based drugs. *Clitoria ternatea* flower bioactive compounds are promising avenues for development as new and effective pharmacological agents and applications in functional foods to improve human health and well-being.

REFERENCES

Adhikary, R., Sultana, S., & Bishayi, B. (2018). *Clitoria ternatea* flower petals: Effect on TNFR1 neutralization via downregulation of synovial matrix metalloproteases. *Journal of Ethnopharmacology*, *210*, 209–222.

Al-Snafi, A. E. (2016). Pharmacological importance of *Clitoria ternatea*–A review. *IOSR Journal of Pharmacy*, *6*(3), 68–83.

Arya, S., Kumar, R., & Anju, V. S. (2018). A study on the different pigments in *Clitoria ternatea* L. Varities (Fabaceae). *Journal of Pharmacognosy and Phytochemistry*, *7*(1), 1107–1109.

Balouiri, M., Sadiki, M., & Ibnsouda, S. K. (2016). Methods for in vitro evaluating antimicrobial activity: A review. *Journal of Pharmaceutical Analysis*, *6*(2), 71–79. https://doi.org/https://doi.org/10.1016/j.jpha.2015.11.005

Chakraborty, S., Sahoo, S., Bhagat, A., & Dixit, S. (2017). Studies on antimicrobial activity, phytochemical screening tests, biochemical evaluation of *Clitorea ternatea* Linn. plant extracts. *International Journal of Research-Granthaalayah*, *5*(10), 197–208.

Chayaratanasin, P., Caobi, A., Suparpprom, C., Saenset, S., Pasukamonset, P., Suanpairintr, N., Barbieri, M. A., & Adisakwattana, S. (2019). *Clitoria ternatea* flower petal extract inhibits adipogenesis and lipid accumulation in 3T3-L1 preadipocytes by downregulating adipogenic gene expression. *Molecules*, *24*(10), 1894.

Dewatisari, W. (2022). Antibacterial and Anti-biofilm- Forming Activity of Secondary Metabolites from *Sansevieria trifasciata*- Leaves Against *Pseudomonas aeruginosa*. *Indonesian Journal of Pharmacy*, *0*(0 SE-Research Article). https://doi.org/10.22146/ijp.2815

Dewatisari, W. F. (2009). *Uji anatomi, metabolit sekunder dan molekuler Sansevieria trifasciata*. Surakarta: Universitas Sebelas Maret.

Dhanasekaran, S., Rajesh, A., Mathimani, T., Samuel, S. M., Shanmuganathan, R., & Brindhadevi, K. (2019). Efficacy of crude extracts of *Clitoria ternatea* for antibacterial activity against gram negative bacterium (*Proteus mirabilis*). *Biocatalysis and Agricultural Biotechnology*, *21*, 101328.

Dhanraj, P., Gowda, A. P. M., & Ashoka, N. (2019). *Effect of plant growth promoting rhizobacteria on plant nutrient content and uptake in Clitorea ternatea L.*

Ganesan, S., Sabran, S. F., & Mazlun, M. H. (2019). Plant diversity assessment and traditional knowledge documentation of home gardens in Parit Raja, Batu Pahat, Johor. *IOP Conference Series: Earth and Environmental Science*, *269*(1), 012018.

Havananda, T., & Luengwilai, K. (2019). Variation in floral antioxidant activities and phytochemical properties among butterfly pea (*Clitoria ternatea* L.) germplasm. *Genetic Resources and Crop Evolution*, *66*, 645–658.

Imayanti, R. A., Rochmah, Z., Aisyah, S. N., & Alfaris, M. R. (2019). Pemberdayaan Masyarakat dalam Pengolahan Bunga Telang di Desa Panggreh Kecamatan Jabon Kabupaten Sidoarjo. *Conference on Innovation and Application of Science and Technology (CIASTECH)*, 2(1), 77–82.

Jamil, N., & Pa'ee, F. (2018). Antimicrobial activity from leaf, flower, stem, and root of *Clitoria ternatea*–A review. *AIP Conference Proceedings*, 2002(1), 020044.

Jeyaraj, E. J., Lim, Y. Y., & Choo, W. S. (2021). Extraction methods of butterfly pea (*Clitoria ternatea*) flower and biological activities of its phytochemicals. *Journal of Food Science and Technology*, *58*(6), 2054–2067.

Kamilla, L., Mnsor, S. M., Ramanathan, S., & Sasidharan, S. (2009). Antimicrobial activity of *Clitoria ternatea* (L.) extracts. *Pharmacologyonline*, *1*, 731–738.

Kazuma, K., Noda, N., & Suzuki, M. (2003). Flavonoid composition related to petal color in different lines of *Clitoria ternatea*. *Phytochemistry*, *64*(6), 1133–1139.

Kelemu, S., Cardona, C., & Segura, G. (2004). Antimicrobial and insecticidal protein isolated from seeds of *Clitoria ternatea*, a tropical forage legume. *Plant Physiology and Biochemistry*, *42*(11), 867–873.

Kyaw, Y. M. M., Bi, Y., Oo, T. N., & Yang, X. (2021). Traditional medicinal plants used by the Mon people in Myanmar. *Journal of Ethnopharmacology*, *265*, 113253.

Leong, C.-R., Azizi, M. A. K., Taher, M. A., Wahidin, S., Lee, K.-C., Tan, W.-N., & Tong, W.-Y. (2017). Anthocyanins from *Clitoria ternatea* attenuate food-borne Penicillium expansum and its potential application as food biopreservative. *Natural Product Sciences*, *23*(2), 125–131.

Lijon, M. B., Meghla, N. S., Jahedi, E., Rahman, M. A., & Hossain, I. (2017). Phytochemistry and pharmacological activities of *Clitoria ternatea*. *International Journal of Natural and Social Sciences*, *4*(1), 1–10.

López Prado, A. S., Shen, Y., Ardoin, R., Osorio, L. F., Cardona, J., Xu, Z., & Prinyawiwatkul, W. (2019). Effects of different solvents on total phenolic and total anthocyanin contents of *Clitoria ternatea* L. petal and their anti-cholesterol oxidation capabilities. *International Journal of Food Science & Technology*, *54*(2), 424–431.

LUONG, N. T. H. I., VAN HOP, N., VAN QUY, N., & HOAN, V. O. M. (2023). Diversity of plant species for food coloring in Vietnam. *Nusantara Bioscience*, *15*(1).

Luu-Dam, N. A., Ninh, B. K., & Sumimura, Y. (2016). Ethnobotany of colorant plants in ethnic communities in Northern Vietnam. *Anthropology*, *4*(158), 2332–2915.

Maghirang, R. G., Oraye, C. D., Antonio, M. A., Cacal, M. S., & City, B. (2018). Ethnobotanical studies of some plants commonly used as vegetables in selected provinces of the Philippines. *J Nat Stud*, *17*(2), 30–43.

Mahmad, N., Taha, R. M., Othman, R., Abdullah, S., Anuar, N., Elias, H., & Rawi, N. (2018). Anthocyanin as potential source for antimicrobial activity in *Clitoria ternatea* L. and Dioscorea alata L. *Pigment & Resin Technology*, *47*(6), 490–495.

Manjula, P., Mohan, C. H., Sreekanth, D., Keerthi, B., & Devi, B. P. (2013). Phytochemical analysis of *Clitoria ternatea* Linn., a valuable medicinal plant. *The Journal of Indian Botanical Society*, *92*(3and4), 173–178.

Marpaung, A. M. (2020). Tinjauan manfaat bunga telang (*Clitoria ternatea* L.) bagi kesehatan manusia. *Journal of Functional Food and Nutraceutical*, 63–85.

Miyaura, R., Ohno, T., Maenaka, H., Sumiartha, K., & Yamaguchi, H. (2015). A particular silhouette of human-influenced coconut trees in Hindu Bali, Indonesia: an ethnobotanical field note. *Ethnobotany Research and Applications*, *14*, 405–421.

Mohamed, N., & Taha, R. M. (2011). Plant regeneration of *Clitoria ternatea* from leaf explants cultured in vitro. *Journal of Food, Agriculture & Environment*, *9*(3 & 4), 268–270.

Muhammad Ezzudin, R., & Rabeta, M. S. (2018). A potential of telang tree (*Clitoria ternatea*) in human health. *Food Research*, *2*(5), 415–420.

Mukherjee, P. K., Kumar, V., Kumar, N. S., & Heinrich, M. (2008). The Ayurvedic medicine *Clitoria ternatea*—From traditional use to scientific assessment. *Journal of Ethnopharmacology*, *120*(3), 291–301.

Muniroh, M., Kusumaningrum, N., Farmaditya, E. P. M., & Yuniati, R. (2023). *Clitoria ternatea* L. Extract as Adjuvant Therapy on Reducing IL–6 Levels in Reversal Reaction. *Biosaintifika: Journal of Biology & Biology Education*, *15*(1).

Neda, G. D., Rabeta, M. S., & Ong, M. T. (2013). Chemical composition and anti-proliferative properties of flowers of *Clitoria ternatea*. *International Food Research Journal*, *20*(3).

Nirmal, N. P., Rajput, M. S., Prasad, R. G. S. V, & Ahmad, M. (2015). Brazilin from *Caesalpinia sappan* heartwood and its pharmacological activities: A review. *Asian Pacific Journal of Tropical Medicine*, *8*(6), 421–430. https://doi.org/https://doi.org/10.1016/j.apjtm.2015.05.014

NParks Flora & Fauna Web (2023). *Clitoria ternatea flower*. Retrieved from https://www.nparks.gov.sg/florafaunaweb/flora/1/3/1372#gallery-1

Oguis, G. K., Gilding, E. K., Jackson, M. A., & Craik, D. J. (2019). Butterfly pea (*Clitoria ternatea*), a cyclotide-bearing plant with applications in agriculture and medicine. *Frontiers in Plant Science*, *10*, 645.

Pham, T. N., Le, X. T., Nguyen, P. T. N., Tran, T. H., Dao, T. P., Nguyen, D. H., Danh, V. T., & Anh, H. L. T. (2020). Effects of storage conditions on total anthocyanin content of Butterfly pea flower (*Clitoria ternatea* L.). *IOP Conference Series: Materials Science and Engineering*, *736*(6), 062005.

Purba, E. C. (2020). Kembang telang (*Clitoria ternatea* L.): pemanfaatan dan bioaktivitas. *Jurnal EduMatSains*, *4*(2), 111–124.

Rahayu, S. M., & Andini, A. S. (2019). Ethnobotanical study on medicinal plants in sesaot forest, narmada, West Lombok, Indonesia. *Biosaintifika: Journal of Biology & Biology Education*, *11*(2), 234–242.

Rajamanickam, M., Kalaivanan, P., & Sivagnanam, I. (2015). Evaluation of anti-oxidant and anti-diabetic activity of flower extract of *Clitoria ternatea* L. *Journal of Applied Pharmaceutical Science*, *5*(8), 131–138.

Rezaldi, F., Agustiansyah, L. D., Safitri, E., Oktavia, S., & Novi, C. (2022). Antifungi *Candida albicans*, *Aspergilus fumigatus*, dan *Pitosporum ovale* dari Sediaan Sampo Probiotik Kombucha Bunga Telang (*Clitoria ternatea* L) sebagai Produk Bioteknologi Farmasi. *Pharmaqueous: Jurnal Ilmiah Kefarmasian*, 4(1), 45–52.

Rosli, N., Ismail, Z., & Lepun, P. (n.d.). Belaga Sarawak, Malaysia. *International Journal of Curren*.

Shen, Y., Du, L., Zeng, H., Zhang, X., Prinyawiwatkul, W., Alonso-Marenco, J. R., & Xu, Z. (2016). Butterfly pea (*Clitoria ternatea*) seed and petal extracts decreased HE p-2 carcinoma cell viability. *International Journal of Food Science & Technology*, 51(8), 1860–1868.

Silalahi, M. (2021). *Clitoria ternatea* L. Fabaceae. In *Ethnobotany of the Mountain Regions of Southeast Asia* (pp. 317–322). Springer.

Singh, N. K., Garabadu, D., Sharma, P., Shrivastava, S. K., & Mishra, P. (2018). Anti-allergy and anti-tussive activity of *Clitoria ternatea* L. in experimental animals. *Journal of Ethnopharmacology*, 224, 15–26.

Srichaikul, B. (2018). Ultrasonication extraction, bioactivity, antioxidant activity, total flavonoid, total phenolic and antioxidant of *Clitoria ternatea* linn flower extract for anti-aging drinks. *Pharmacognosy Magazine*, 14(56).

Suarna, I. W., & Wijaya, I. M. S. (2021). Butterfly pea (*Clitoria ternatea* L.: Fabaceae) and its morphological variations in Bali. *Journal of Tropical Biodiversity and Biotechnology*, 6(2), 63013.

Suveena, S., Saraswathy, V., Junaidi, M., Vinod, M. P., Nair, A.S., SUdhakaran, P.R., & Oommen V. (2022). In silico screening of the phytochemicals present in *Clitoria ternatea* L. as the inhibitors of snake venom phospholipase A 2 (PLA 2). *Journal of Biomolecular Structure & Dynamics*, 1–10.

Vankar, P. S., & Srivastava, J. (2010). Evaluation of anthocyanin content in red and blue flowers. *International Journal of Food Engineering*, 6(4).

Vidana Gamage, G. C., Lim, Y. Y., & Choo, W. S. (2021). Anthocyanins from *Clitoria ternatea* flower: Biosynthesis, extraction, stability, antioxidant activity, and applications. *Frontiers in Plant Science*, 12, 792303.

Wijana, N., Rahmawati, P. I., Setiawan, G. A. N., & Mulyadiharja, S. (2019). Plants of body symbols in tri mandala Tenganan Pegringsingan Village, Karangasem (in ethnobotany learning perspective). *International Journal of Natural Science and Engineering*, 3(1), 1–11.

Zakaria, N. N. A., Okello, E. J., Howes, M., Birch-Machin, M. A., & Bowman, A. (2018). In vitro protective effects of an aqueous extract of *Clitoria ternatea* L. flower against hydrogen peroxide-induced cytotoxicity and UV-induced mtDNA damage in human keratinocytes. *Phytotherapy Research*, 32(6), 1064–1072.