WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Exploring the Versatile Potential of Butterfly Pea – An Emerging Plant with Diverse Applications

Sonal Balasaheb Bangar*, Soham Sunil Lad, Sakshi Sunil Gaikwad, Abhishek Sanjay Masal, Parag Ganesh Bayaskar, Dnyaneshwari Bappa Misal and Dr. Shrutika Patil*

TMV's Lokmanya Tilak Institute of Pharmacy, Kharghar (Navi Mumbai)

ABSTRACT:

Medicinal plants and their parts are important for both individual and community health, with many long known for their anti-diabetic, anti-fertility, anti-inflammatory, anti-cancer, hepatoprotective, and immune-modulating characteristics. Butterfly Pea (Clitoria ternatea L.) is a twining herbal plant from the Fabaceae family. This tropical vine is recognized for its bright blue blossoms and is gaining popularity for its several applications. Traditionally utilized in Ayurvedic and Asian medicine, current scientific study has demonstrated its potential in medications, cosmetics, food, and agriculture. The various extracts of Clitoria ternatea flower were analysed for their bioactive compounds such as flavonoids, anthocyanins, phenolic acid, terpenoids, and saponins, which exhibit significant antioxidant, anti-inflammatory, antimicrobial, and immune modulating properties, highlighting their potential as a therapeutic agent through both qualitative and quantitative analysis. Butterfly pea is a popular natural dye and functional ingredient in the culinary industry due to its bright colour and health advantages. Its colour-changing characteristics when subjected to pH changes have also made it popular in beverages and inventive culinary dishes. Butterfly pea extract is also gaining popularity in the cosmetic sector because to its skin-soothing and anti-aging effects, making it an important ingredient in skincare formulations. Butterfly pea's wide-ranging potential as a sustainable and eco-friendly plant resource is still being investigated, and its applications are spreading across industries as consumer demand for natural, multifunctional ingredients increases. The plant's adaptability makes it an important resource for future advancements in health, food, and environmental sustainability.

Key words: Clitoria ternatea L, Flavonoids, Terpenoids, Antioxidant, Anti-inflammatory, Ayurvedic, Traditional medicine

1. INTRODUCTION:

Since ancient times, aromatic and medicinal herbs have been employed for medical, spiritual, cosmetic, dietary, and aesthetic purposes. The perennial leguminous twiner Clitoria ternatea, also referred to as butterfly pea, is a member of the Fabaceae and sub-family Papilionaceae. It originated in tropical Asia and later spread widely throughout South and Central America, the East and West Indies, China, and India, where it has since become naturalized.[1] Clitoria ternatea is sometimes referred to as blue-pea, Kordofan, or Clitoria. Peas (in South Africa), Cunha (in Brazil), and pokindong (in the Philippines) are robust summer legumes with ancient origins. The most identifiable feature of the butterfly pea plant is its vibrantly coloured blossom. The most common variety is the colour blue [2]. Although some of the 60 species that comprise Clitoria L. are found in temperate climates, the majority of these species are located in the tropical zone. 23 species of clitoria have practical applications as anti-helminthic and diuretic refrigerants. The adaptable Butterfly Pea (Clitoria ternatea) grows well in a range of soil conditions, including calcareous soils, with a pH of 5.5 to 8.9.[3] It can withstand protracted droughts as well as significant rainfall, and it demonstrates exceptional recovery following cutting or grazing. features five or seven leaflets on its pinnate leaves. With its vivid white, dark blue, or purple blossoms and oblong, speckled seeds, this multifunctional plant fulfils a variety of purposes. It is used for its nitrogen-fixing properties in animal feed, cover crops, herbal beverages, and traditional medicine [4]. The plant is important for agriculture and overall health because it is used in Ayurveda to cure a variety of maladies, from skin conditions to respiratory problems. Butterfly peas include other potent antioxidants such as flavonoids, phenolic acid, procyanidin, and flavanol glycosides in addition to anthocyanin [5]. The entire butterfly pea plant is used medicinally, and the extract from the blossom of C. ternatea is useful in treating skin conditions and insect bites. The roots are used to heal burns, inflammation, and dementia.[6] Clitoria ternatea is abundant in antioxidant qualities as compared to other flowers and medicinal ingredients, according to numerous indications. Clitoria ternatea has been utilized to treat neurological conditions from the dawn of human civilization. In addition, Clitoriaternatea's anthocyanin pigment demonstrated antiviral, anti-inflammatory, antioxidant, anti-allergic, and antimicrobial qualities. It also prevented diabetes, shielded the cardiovascular system from harm, and provided numerous other health advantages. [7] Additionally, studies have indicated that anthocyanin functions as an antiaging agent, shields cells from harm, and supports eye health. It was also discovered that the flower contained high levels of iron, calcium, magnesium, potassium, zinc, and sodium. Numerous investigations looked into, recognized, and separated the bioactive substances found in C. ternatea flowers. The nutritive and esthetic benefits of the C. ternatea flower are attributed to its elemental and phytochemical composition [8].

2.TAXONOMICAL CLASSIFICATION:

Kingdome: Plantae

Division: Magnoliophyte

Class: Magnoliopsida

Order: Fables

Family: Fabceae

Subfamily: Papilionoideae

Genus: Clitoria

Species: Clitoria ternate L

Fig no.1:- Clitoria Ternatea

2.1 SYNONYMS:

Table no. 1:- Synonyms of butterfly pea plant

Bengali	Aparajita
English	Butterfly pea, Blue Pea Vine, Mussel Shell Climber, Pigeon Wings
Sanskrit	Sankha Pushpi, Aparijita, saukarnika, Ardra Karni, girikarnika, supuspi, mohanasini, vishadoshaghni, Shweta Nama, Vishnukranta, ashwakhura.
Hindi	Koyal
Telgu	Dintena
Malayalam	sangupushpam
Kannada	Nagar hedi
Marathi	Gokarna
Portuguese	Fulacriqua

2.2 BOTANICAL DESCRIPTION:

Habit: Twining climber

Root: Branched tap root system having nodules

Stem: Aerial, weak stem and a twiner

Leaf: pinnately compound, alternate, stipulate showing reticulate venation. Leaflets are stipellate. Petiolate and stipels are pulvinated.

Inflorescence: Solitary and axillary.

Flower: Bracteate, bracteolate, bracteoles usually large, pedicellate, heterochlamydeous, complete, bisexual, pentamerous, zygomorphic and hypogynous.

Calyx: Sepals 5, sympetalous, green showing valvate aestivation. Odd sepal is anterior in position.

Corolla: Petals 5, white or blue apopetalous, irregular papilionaceous corolla showing descendingly imbricate aestivation.

Androecium: Stamens 10, diadelphous (9) +1 nine stamens fused to form a bundle and the tenth stamen is free. Anthers are dithecous, basifixed, introse and dechiscing by longitudinal slits.

3. MORPHOLOGY:

Clitoria ternatea, or butterfly pea, is a perennial herb with normal heights of 90 to 162 cm. Its growth habit is erect, and its characteristic blue flowers are linear and flat, with a length of 6 to 12 cm. The plant has a strong, two-meter-long horizontal root system. Its leathery leaves have three to five leaflets on average. Eventually drive out a lot of weeds. However, during the early development period, cultivation or hand weeding may be required for a pure stand. To manage weeds during establishment, it is advised to apply a pre-emergence herbicide, such as Spinnaker, 200–400 ml/ha, two to eight weeks before to seeding. Because of its excellent palatability, butterfly peas are susceptible to heavy grazing. It displays both self-pollinating (cleistogamous) and insect-pollinated (chasmogamous) flowers, with variations in colour, structure, and arrangement among the several species.[10]

4. TRADITIONAL USES:

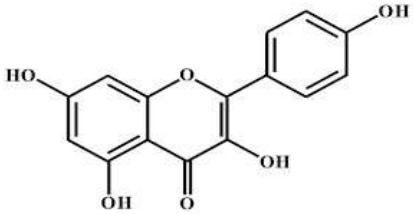
The entire plant, including the leaf, flower, root, and shoot, is used medicinally in traditional Indian medicine. It is thought to enhance memory and is a brain tonic.[11] The flower of Clitoria ternatea is rich in phytochemicals that have excellent antibacterial, antioxidant, antidiabetic, 2763nti-inflammatory, and antiproliferative/anticancer qualities. [12]. For millennia, people have utilized it as a sedative, memory booster, nootropic, antistress, anxiolytic, antidepressant, and anticonvulsant.[13]. It has antidotal qualities and is helpful for ulcers, skin conditions, urinary issues (even in cattle), throat and eye infections, and skin problems. Butterfly peas are rich in phytochemicals in addition to their therapeutic qualities. It has been demonstrated that it is homologous to plant defensins and contains antifungal proteins.[14]

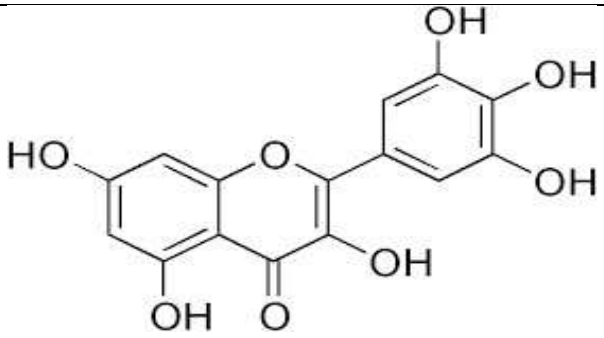
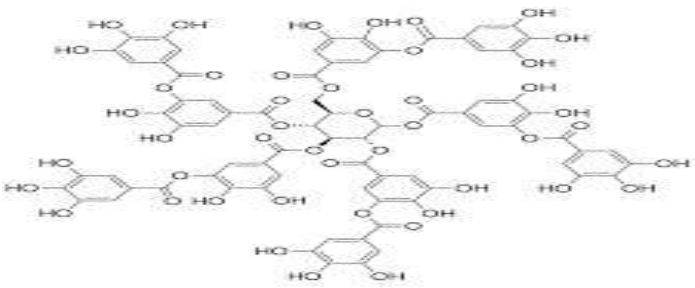
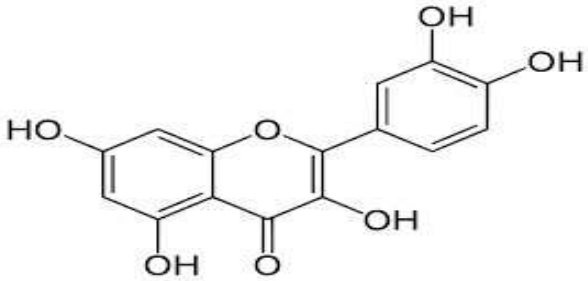
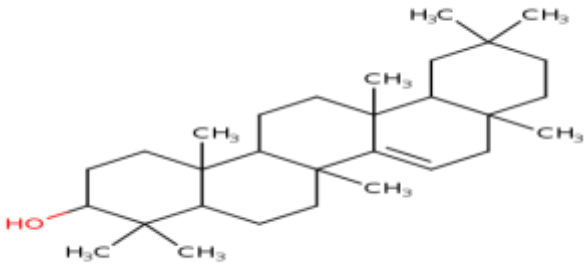
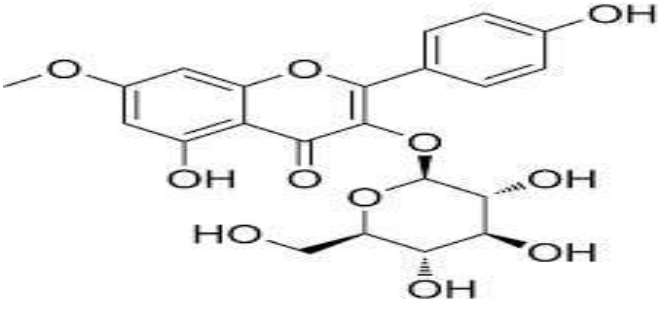
5. PHYTOCHEMICAL CONSTITUENTS:

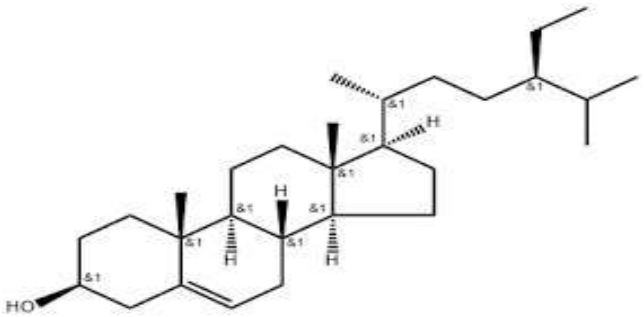
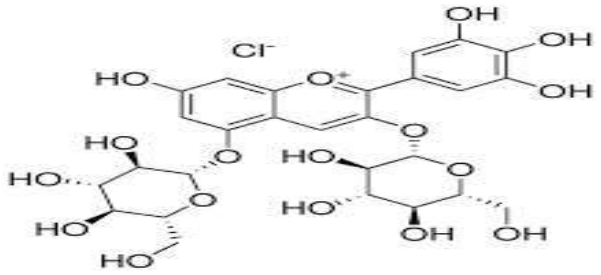
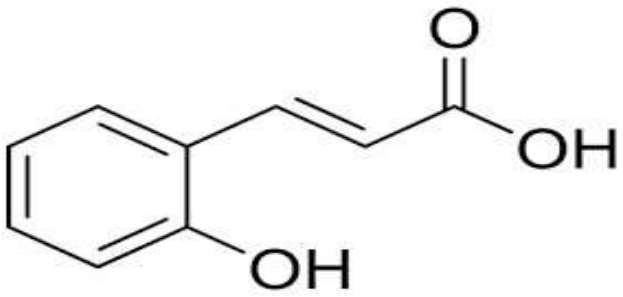
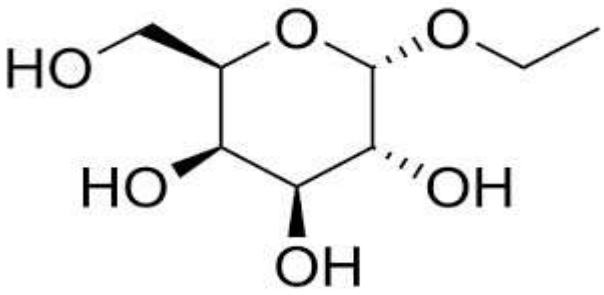
Butterfly pea (Clitoria ternatea) contains a wide range of chemical compounds, each contributing to its therapeutic benefits. The plant's chemical composition includes tannins, phlobatannins, carbohydrates, saponins, triterpenoids, phenols, flavonoids, flavanol glycosides, proteins, alkaloids, anthraquinones, anthocyanins, cardiac glycosides, Stigmast-4-ene-3,6-dione, volatile oils, and steroids. The medicinal properties of butterfly pea are greatly impacted by these various chemical components. The main chemical components of this plant are listed below.

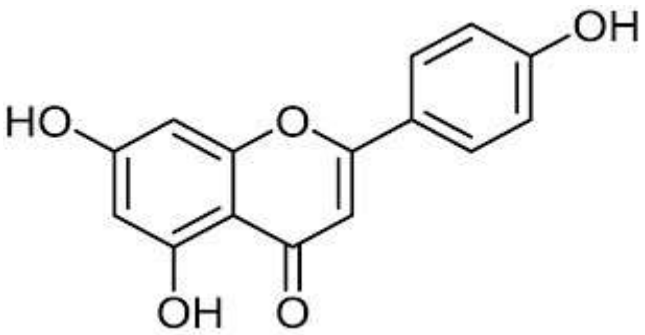
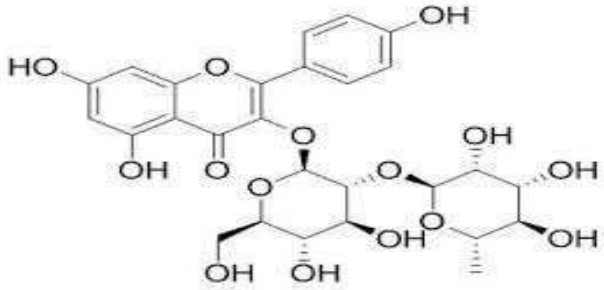
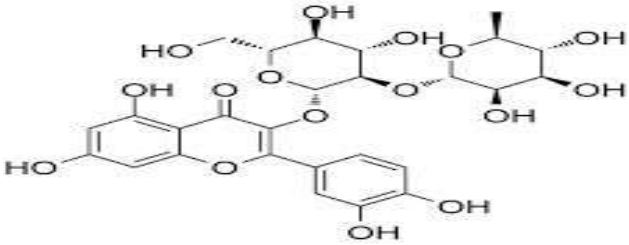
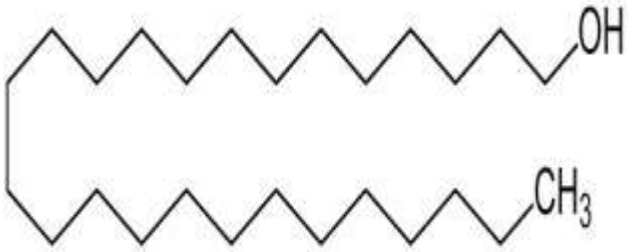
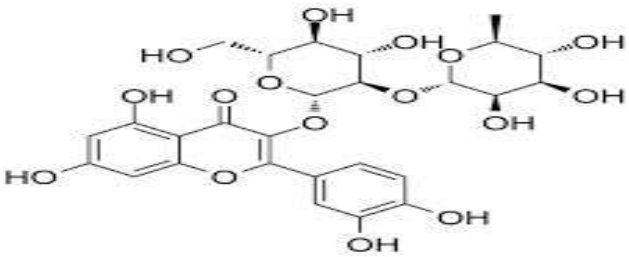
5.1 CHEMICAL COMPOUND FOUND IN CLITORIA TERNATEA:

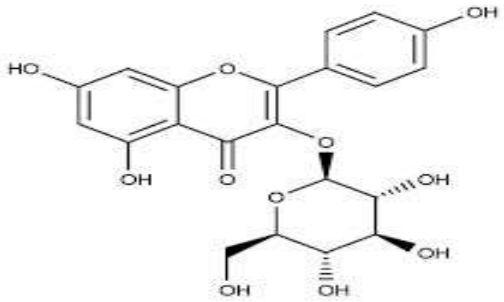
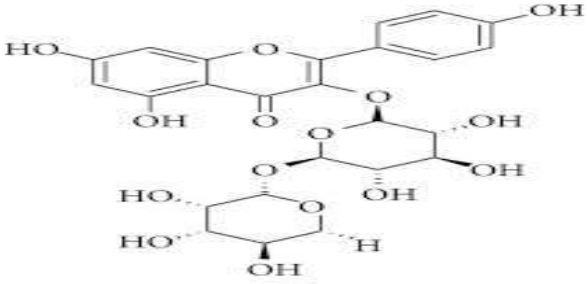
Table no 2:- various chemical compound found in clitoria ternatea.

Sr.No	Name of compound	Structure	Reference
1.	1Kaempferol		[15]

2.	Myricetin		[15]
3.	Tannic acid		[15]
4.	Quercetin		[15]
5.	Taraxerol		[15]
6.	3-monoglucoside		[15]

7.	β-Sitosterol		[15]
8.	Delphinidin-3,5-diglucoside		[15]
9.	Malvidin- 3βglucoside		[15]
10.	phydroxycinnamic acid		[15]
11.	Ethyl-α-Dgalactopyranoside		[15]

12.	Anthoxanthin glucoside		[15]
13.	Kaempferol 3-neohesperidoside		[15]
14.	Quercetin 3-neohesperidoside		[15]
15.	Hexacosanol		[15]
16.	Myricetin,3-neohesperidoside		[15]

17.	Kaempferol 3-glucoside		[15]
18.	Myricetin 3-rutinoside		[15]

5.2 PHYTOCHEMICAL CONSTITUENTS FOUND IN CLITORIA TERNATEA:

Table no. 3: - Various phytochemical constituents present in clitoria ternatea

Parts	**Phytochemical constituents**	**Function**	**Reference**
Leave  Fig no 2	Alkaloids, reducing sugars, flavonoids, steroids, glycoside, phenols, terpenoids, coumarins, catechol, quinines, gum, mucilage, and protein	1. Prevention of neurodegenerative diseases and diabetes mellitus 2.Effectively controls the excessive sweating	[16]and [17],[23]
Flower  Fig.no:3	Carbohydrates, phenolic acid, tocol, fatty acid,6″-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose **Flavanoids(petals):** - delphinidin 3-O-(2"-O-α-rhamnosyl6' '-O-malonyl)-βglucoside, delphinidin 3-O-(6"-O-malonyl)- α-glucoside, delphinidin 3-neohesperidoside, and delphinidin 3O-glucoside, anthocyanins. **Flavanoids glycosides :-** kaempferol 3-O-(2"O-α-rhamnosyl-6"O-malonyl)-βglucoside, quercetin 3-O-(2"-O-αrhamnosyl-6"-Omalonyl)-β-	2.Ethanol extract is used as antidiabetic 3antioxidant activity 4anti-diabetic activity 5antimicrobial activity 6larvicidal activity 7antipyretic activity 8hepatoprotective activity 9anticytotoxicity activity,	[18] and [19] ,[24],[25],[26], 27]

	glucoside, and myricetin 3-3-O- (2"-O-α-rhamnosyl- 6"-O-malonyl)-β- glucoside and eleven additional flavanol, Ternatins, the blue acylated anthocyanins found in flowers are derivatives of delphinidin. A total of 15 (poly) acylated delphinidin glucosides, including ternatins A1, A3, B1, B2, C1, C2, and D1, D3, were found in all blue petal lines.		
Root  Fig no 4	1,1-diphenyl-2picrylhydrazyl (DPPH),ternatins, alkaloids, flavonoids, saponins, tannins, carbohydrates, proteins, resins, starch, taraxerol, and taraxerone **Root Bark: -**resin, tannin, starch, and flavonol glycosides **Root nodules:** glycine, alanine, valine, leucine, aminobutyric acid, aspartic acid, glutamic acid, arginine, ornithine, histadine, and Gama-aminobutyric acid	1. Antioxidant 2.The root bark is diuretic and laxative; a decoction is given as a demulcent in the irritation of the bladder and urethra	[20]and[21],[28], [24],[29]
Seed  Fig no 5	The seeds contain nucleoprotein with its amino-acid sequence similar to insulin, delphinidin- 3,3,5-triglucoside, essential aminoacids, pentosan, water soluble mucilage, adenosine, anthoxanthin glucoside, greenish yellow fixed oil a phenol glycoside, 3,5,7,4tetrahydroxyflavone3-rhamoglycoside, alkaloid, ethyl Dgalactopyranoside, p-hydroxy cinnamic acid polypeptide, a highly basic proteinfinotin, a bitter acid resin, tannic acid, 6% ash and three unidentified trypsin inhibitors, watersoluble mucilage, phydroxycinnamic acid, flavonol-3- glycoside, adenosine, a polypeptide, hexacosanol, βsitosterol, γsitosterol, and anthoxanthin glucoside, as oligosaccharides and sterols, glycosides, saponins, tannins, carbohydrates,	1. Seeds are cathartic and the root diuretic. 2. Seeds are purgative and aperients 3. Seeds are used in swollen joints, dropsy and enlargement of abdominal viscera	[21]and [22],[30],[31],[32]

	protein, flavonoids, and phenolic compounds		

5.4 CONSTITUENTS FOUND IN VARIOUS EXTRACT METHOD:

Table no.4: -Various constituents found in different extract method

Plant parts	Extraction method	Extraction solvent	Phytochemicals reported	References
Flower	1.Maceration	1. Water	Phenolics, flavonoids, anthocyanins	[33]
		2. 70% ethanol:30% water	Anthocyanins.	[34]
		3. 40% ethanol: 60% water	Flavonoids.	[35]
		4. Methanol	Anthocyanins (Ternatin and delphinidin derivatives), kaempferol.	[36]
		5. Methanol: Chloroform	dl-Glyceraldehyde dimer, 1,2Dioxolan-3-one, 5-ethyl-5methyl-4-methylene.	[37]
		6. Dichloromethane: cyclohexane: ethyl acetate (2:3:0.5)	Phenols, flavonoids, tannins, alkaloids, terpenoids, cardiac glycosides, and steroids.	[38]
	2.Ultrasonic	Water.	Phenolics and flavonoids	[39]
		50% ethanol: 50% water	Phenolics.	[35]
Leaves	1.Maceration	50% methanol: 50% water,	Tannins, saponins, flavonoids, alkaloids glycosides, phenols	[40]
		Acetone.	Carbohydrate, terpenoids, alkaloids, tannin, saponin, phenols	[41]
		Water	Carbohydrate, alkaloids, tannin, saponin, phenols, flavonoid	[41]
		60% methanol: 40% water.	Alkaloids, flavonoid, resins, tannin, saponin, steroid, phenol, glycosides	[42]
	2.Soxhlet.	70% ethanol: 30% water	Alkaloids, flavonoids, glycosides, tannins, steroids, phenol	[43]
Root	Maceration	Water.	Carbohydrate, terpenoids, alkaloids, steroids, phenol	[41]
		Acetone	Carbohydrate, terpenoids, alkaloids, saponin, flavonoid, phenol	[41]
		Chloroform: Methanol (15:1).	Alkaloids	[44]
		Hexane : ethyl acetate (80:20)	Taraxerol	[29]

		Toluene: ethyl acetate (7:1)	Alkaloids, flavonoids, steroid, carbohydrates, coumarins, and resin.	[45]
	Soxhlet	Ethanol	Phenolic, flavonoids, alkaloids glycosides, tannins	[46]

5.5 PHYTOCHEMICAL ANALYSIS REPORTED FOR CLITORIA TERNATEA:

Leaves: -

Quercetin, kaempferol, gallic acid, ferulic acid ,caffeic acid, n-Hexadecanoic acid, 1-butanol, 3methylacetate, propane, 1,1,3-triethoxy, Z, Z, Z-1, 4, 6, 9-nonadecatetraene, undecanoic acid, 3trifluoroacetoxy pentadecane, and 4- ethyl - 5-octyl- 2, 2- bis(trifluoromethyl) - cis 1, 3 – dioxalone obtained from 80% aqueous methanol extract, 100% methanol extract by various analytival method such as RP-HPLC, GCMS. [47],[48],[49],[50]

Flower: -

Phenolic acids (Gallic acid, protocatechuic acid, chlorogenic acid), Anthocyanidin (Delphinidin), Flavonoids (kaempferol, quercetin, myricetin, rutin, epicatechin),phenol acids(gallic acid syringic acid, 2-Hydroxycinnamic acid protocatechuic acid 2,4-Dihydrobenzoic acid, p-Coumaric acid, caffeic acid, ferulic acid),flavonoids(quercetin-3-rutinoside procyanidin A2 ()-Epicatechin), anthocyanins, delphinidin-3-Oglucoside others (ellagic acid),phenolics, gallic acid and rutin, protocatechuic acid, chlorogenic acid, and delphinidin,preternatin A3, ternatin B2, ternatin D2, quercetin-3-rutinoside, ternatin D1, kaemferol-3-O-(2-rhamnosyl) rutinoside, delphinidin-3-glucoside, kaemferol-3-O-rutinoside, delphinidin-3- O-(6-O-p-coumaryl) glucoside pyruvic acid, (+)-catechin 7-O-β-glucoside, syringetin-3-O-glucoside, quercetin triglycoside and delphinidin derivatives extracted by 80% aqueous extract, ethanol extract, aqueous methanol, 100% methanol extract by LC-MS/MS, RP-HPLC [51],[35],[52],[53],[25],[54]

Root: -

Tannins, alkaloids, saponins, steroids, carbohydrate, protein, flavonoids, and triterpenoids. Root β-sitosterol and taraxerol extracted by specific solvent by using LCMS, HPTLC 21.[48]

6. PHARMACOLOGICAL PROPERTY:

6.1 ANTI-INFLAMMATORY:

Research on C. ternatea flowers suggests that they may have beneficial anti-inflammatory qualities via a variety of methods. The petroleum ether extracts significantly reduced paw edema in rats in the first research, indicating a protective action against inflammatory mediators such as prostaglandins and kinin. Another indicator of possible analgesic effects is the Eddy's hot plate method's longer reaction time.The second study evaluated the anti-inflammatory properties of the anthocyanin and flavonol fractions on LPSinduced inflammation in RAW-264.7 macrophage cells. The results demonstrated that anthocyanins successfully blocked the generation of nitric oxide and the translocation of nuclear factor-κB, two processes critical to inflammatory reactions. In contrast to anthocyanins, flavonols mainly suppressed COX-2 expression while having less of an effect on the generation of reactive oxygen species (ROS) [55]. C. ternatea methanol extract has strong anti-inflammatory, analgesic, and antipyretic properties. Additionally, by inhibiting cyclooxygenase-2 (COX-2) activity, reducing reactive oxygen species (ROS) production, preventing nuclear NFκB translocation, decreasing inducible nitric oxide synthase (iNOS) protein expression, and nitric oxide (NO) production, quercetin glycosides and ternatin anthocyanins from the blue flower petals of CT ameliorated the lipopolysaccharide (LPS)-induced inflammation in macrophage cells [56]. These findings suggest that CT could be useful in the development of medications or 16nutraceuticals that protect against inflammatory chronic illnesses.

6.2 ANTIOXIDANT PROPERTY

Antioxidant fights free radicals. So, these can protect your skin and hair from damage. By using butterfly pea flower products in skincare or hair care, you may be able to reap the benefits of its antioxidants. Butterfly pea, or Clitoria ternatea, is renowned for having strong antioxidant qualities, especially in its petals. Packed with flavonoids, anthocyanins, phenolics, and other glycosides, these substances fight oxidative stress, which is associated to a number of diseases because oxidative radicals cause damage. Recent research has evaluated C. ternatea extracts' in vitro antioxidant potential by contrasting them with well-known antioxidants such as ascorbic acid and butylated hydroxytoluene (BHT). According to the findings, C. ternatea extracts have a significant amount of antioxidant activity. For example, a recent analysis discovered that each gram of extract has a total phenolic content of 53.08 mg gallic acid equivalents and an anthocyanin content of 1.08 mg delphinidin-3-glucoside equivalents. Anthocyanins and other flavonoids are important for scavenging free radicals, which reduces oxidative stress and inflammation[57] .Thailand uses Clitoria ternatea flower extracts in cosmetic products, and the flowers' chemical makeup raises the possibility that the extracts contain antioxidant properties .It was demonstrated that aqueous extracts have more potent antioxidant action than extracts of ethanol [58] .

6.3 ANTI MICROBIAL ACTIVITY

The antibacterial activity of Clitoria ternatea's methanolic extracts of its leaves and root was evaluated against a variety of drug-resistant pathogens. Clinical isolates that are Gram-positive and Gram-negative [59].It was discovered that the leaf have strong antibacterial properties against Vibrio cholera and Escherichia coli, well-known for resulting in diarrhea, and Staphylococcus aureus, agent that causes fever. The leaf extract revealed more potent antibacterial action compared to root extract. It was demonstrated that the two extracts' modes of action were bactericidal. It's possible that quercetin enhances the effects of leaf extract. In an additional investigation, it was revealed that a crude extract derived from Clitoria seeds maximal zone of inhibition in ternatea (22±0.5 mm) at 0.75 mg against Escherichia coli focus and the lowest (14±1.0 mm) with Flavus micrococcus. The extract of callus revealed maximal inhibition zones (16±2 mm) against Typhi salmonella, but the lowest with Saintaphylococcus aureus and Escherichia coli (12±1) and 12±0.9 mm, in that order) (Mhaskar et al., 2010). Additionally, Shekawat and Vijayvergia (2010) reported that the methanol crude extracts exhibited antibacterial efficacy against Pseudomonas aeruginosa and Klebsiella pneumoniae. Strong antimicrobial activity was demonstrated by the crude extract from Clitoria ternate seeds. The root of this plant is specifically used to treat leucoderma.[60]

6.4 ANTI DIABETIC ACTIVITY

Oral administration of aqueous extract of CT leaves (400mg/kg body weight) and flowers (400mg/kg body weight) for 84 days showed significantly reduced serum glucose, glycosylated hemoglobin, total cholesterol, triglycerides, urea, creatinine and the activity of gluconeogenic enzyme glucose-6-phosphatase, but increased serum insulin, HDLcholesterol, protein, liver and skeletal muscle glycogen content and the activity of glycolytic enzyme glucokinase. For all the above biochemical parameters investigated, Clitoria ternatea leaves treated rat showed a little better activity than Clitoria ternatea flowers treated diabetic rats [61]. Research indicates that postprandial hyperglycemia can be managed by delaying the digestion and absorption of carbohydrates by blocking pancreatic α-amylase. Intestinal α-glucosidase and amylase [62]. According to research findings, extracts from Clitoria ternatea have demonstrated ability to control the biochemical indicators linked to diabetic mellitus. Plant bioactive substances such as Pancreatic α-amylase and α-glucosidase activity are inhibited by anthocyanins and polyphenols, which has antidiabetic properties.It's shown that the phenolic chemicals found in C.ternatea may function similarly and cause a delay in after-meal glucose [63] .

6.5 ANTIHELMINTIC ACTIONS

Numerous investigations on Clitoria ternatea's antihelmintic activity have been published. Evidence suggested that the unrefined alcoholic extract of CT and Its methanol and ethyl acetate fractions clearly showed paralytic And also killed worms, particularly at concentrations greater than 50 mg/ml. in contrast to piperazine citrate, the conventional reference.Restrictive action Of CT leaves on nematodes that were free-living was assessed using aqueous and Methanol extract [64]. In a different investigation, the anti-helmintic properties of CT's flowers, leaves, stems, and roots were assessed against adult Pheretima posthuma Indian earthworms. Root methanol extract is the most effective and requires very little. Worms' time to paralysis and death in comparison to alternative extracts. The From flowers, leaves, stems, to roots, potency rises. [65].

6.6 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 [66].

6.7 CNS DEPRESSANT ACTIVITY STUDIES

The central nervous system (CNS) is one of the several pharmacological qualities of butterfly pea that have drawn attention. Its potential to treat cognitive behavior, anxiety, depression, stress, and convulsive disorders has been investigated in recent investigations. Studies have indicated that Clitoria ternatea extracts can have a notable effect on a range of behavioral indicators linked to central nervous system activity. In the elevated plus maze, for example, it has been demonstrated that the extract shortens the time needed to occupy the central platform, suggesting improved cognitive function and nootropic activity. It also enhances performance on object identification tests, indicating positive benefits on memory and learning.Additionally, the extract demonstrates anxiolytic and antidepressant qualities as demonstrated by a decrease in stress-induced ulcers and a shorter period of immobility in the tail suspension test. Moreover, Clitoria ternatea has shown promise in reducing convulsions brought on by maximum electroshock (MES) and pentylenetetrazol (PTZ), suggesting that it may have neuroprotective properties.[103]

7.MECHANISM OF ACTION:

7.1 FLAVONOIDS:

Anti-oxidant activity:

Flavonoids, especially flavones and catechins, are powerful antioxidants that protect body cells from damage caused by free radicals and reactive oxygen species (ROS), produced during metabolism or from external sources. ROS can lead to lipid peroxidation, damaging cell membranes and causing cell death, as well as triggering inflammation. The body defends itself with antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase) and

nonenzymatic antioxidants (glutathione, vitamin C, α-tocopherol). During injury, ROS levels rise, depleting these antioxidants. Flavonoids may bolster this defense, aiding endogenous antioxidants and disrupting multiple free radical–producing systems.[67],[68],[69]

Direct radical scavenging:

Flavonoids protect against free radical damage by directly scavenging these reactive molecules. Their hydroxyl groups react with free radicals, creating more stable and less harmful compounds. Some flavonoids target superoxide radicals, while others neutralize peroxynitrite, a highly reactive oxygen species. Epicatechin and rutin, for example, are potent scavengers, with rutin inhibiting the enzyme xanthine oxidase. This antioxidant action prevents LDL oxidation, potentially offering protective effects against atherosclerosis. [[70],[71],[72].

Xanthine oxidase:

The xanthine oxidase pathway is a key source of oxidative injury to tissues, especially following ischemia-reperfusion. Under normal conditions, xanthine dehydrogenase helps convert xanthine to uric acid, but during ischemia, it shifts to xanthine oxidase, generating superoxide radicals upon reoxygenation. Flavonoids like quercetin, silibin, and luteolin inhibit xanthine oxidase, reducing oxidative damage. Luteolin is reported as a particularly strong inhibitor of this enzyme.[73],[74],[75],[76],[77].

Leukocyte immobilization:

Leukocyte adhesion to the endothelium, particularly during ischemia and inflammation, leads to the release of oxidants and inflammatory mediators, causing tissue injury. Flavonoids help reduce this adhesion, likely by lowering serum complement levels, offering protection against reperfusion injury and similar inflammatory conditions. Some flavonoids also inhibit neutrophil and mast cell degranulation by modulating calcium channels, reducing inflammatory responses without affecting superoxide production.[78],[79],[80],[81]

7.2 ALKALOIDS:

Neurotransmitter Interaction:

Many alkaloids act by binding to neurotransmitter receptors, such as acetylcholine, serotonin, and dopamine receptors, leading to effects on mood, cognition, and perception. For instance, morphine, a well-known alkaloid, binds to opioid receptors in the brain to produce analgesic effects.[82]

Ion Channel Modulation:

Some alkaloids, such as quinine and tubocurarine, interact with ion channels, altering cellular excitability. Quinine blocks sodium and potassium channels, leading to anti-malarial and anti-arrhythmic effects, while tubocurarine blocks acetylcholine receptors in muscle, inducing paralysis.[83]

Enzyme Inhibition:

Certain alkaloids inhibit key enzymes in metabolic pathways. For example, berberine inhibits topoisomerase, affecting DNA replication, and is used for its antimicrobial properties. Similarly, caffeine inhibits phosphodiesterase, leading to increased levels of cyclic AMP (cAMP) and enhanced stimulation of the central nervous system.

Antioxidant and Anti-inflammatory Effects:

Some alkaloids, like capsaicin, exhibit antioxidant and anti-inflammatory properties. Capsaicin binds to the TRPV1 receptor, inducing analgesic effects and modulating inflammatory responses, which is useful in pain management. [84]

7.3 SAPONIN:

Immune Modulation: Saponins can stimulate the immune system by activating macrophages, increasing cytokine production, and enhancing antibody responses. This immune-stimulating action is thought to occur through interactions with cell membranes and modulation of signaling pathways involved in immune function, making them useful in vaccine adjuvants. [85]

Cholesterol-Lowering Effect: Saponins can reduce cholesterol levels by binding to bile acids in the intestine, which are then excreted rather than reabsorbed. This process forces the liver to convert more cholesterol into bile acids, reducing circulating cholesterol. [86]

Antioxidant and Anti-inflammatory Properties: Saponins also possess antioxidant properties, scavenging free radicals and reducing oxidative stress, which in turn may lower inflammation levels and protect against tissue damage.[87]

Anticancer Activity: Some saponins exhibit cytotoxic effects against cancer cells by inducing apoptosis or inhibiting cancer cell proliferation. This effect is thought to be due to saponins' interaction with cell membranes, affecting membrane integrity and signaling [88]

7.4 TANIN:

Antioxidant Activity:

Tannins neutralize free radicals and reduce oxidative stress by donating hydrogen atoms or chelating metal ions, which helps in stabilizing reactive oxygen species (ROS). This action may protect cells from oxidative damage, which is linked to aging and various diseases such as cardiovascular and neurodegenerative conditions.[89]

Protein Binding:

Tannins can bind to proteins, affecting their structure and function. This action is particularly evident in the gastrointestinal tract, where tannins interact with dietary proteins, digestive enzymes, and gut microbiota. This binding limit enzyme activity, slows digestion, and may help manage blood sugar levels by reducing carbohydrate breakdown. [90]

Antimicrobial Properties:

Tannins exhibit antimicrobial effects by binding to bacterial cell walls and proteins, which can inhibit the growth of various pathogens. This action may benefit gastrointestinal health by inhibiting harmful bacteria while sparing beneficial microbes, thereby maintaining gut balance.[91]

Anti-inflammatory Effects:

Tannins may inhibit inflammatory pathways by modulating immune cell function and cytokine production. For example, they have been shown to inhibit nuclear factor-kappa B (NF-κB) signaling, a pathway that plays a crucial role in inflammation. This anti-inflammatory effect is beneficial in reducing chronic inflammation associated with conditions like arthritis and inflammatory bowel disease. [92]

7.5 STEROIDS:

Steroids, particularly glucocorticoids, exert their effects by binding to the glucocorticoid receptor (GR) in target cells. This receptor, when activated by steroids, translocates to the nucleus, where it influences gene expression. The mechanism involves two primary actions:

Genomic effects: The steroid-receptor complex binds to glucocorticoid response elements (GREs) in the DNA, leading to the upregulation or downregulation of target genes involved in inflammation, immune responses, and metabolism. For example, glucocorticoids inhibit pro-inflammatory cytokines (e.g., TNF-α, IL-1) and enzymes like cyclooxygenase-2 (COX-2), which are involved in the inflammatory process.[93]

Non-genomic effects: Glucocorticoids can also exert rapid, non-genomic effects by interacting with cell membranes, influencing ion channels, and altering signal transduction pathways, which contribute to their anti-inflammatory and immunosuppressive properties.[94]

7.6 POLYSACCHARIDS:

Immunomodulation:

Polysaccharides, particularly beta-glucans, stimulate immune cells like macrophages, dendritic cells, and natural killer cells. These interactions enhance immune responses, improving resistance to infections and cancer.[95]

Antioxidant Activity:

Some polysaccharides, such as those from medicinal mushrooms or seaweeds, possess antioxidant properties, scavenging free radicals and reducing oxidative stress in the body.[96]

7.7 AMINO ACIDS:

Protein Synthesis:

Amino acids are the building blocks of proteins. They are incorporated into polypeptides through the process of translation at ribosomes, where mRNA guides the synthesis of proteins by matching codons with the appropriate amino acids.[96]

Regulation of Gene Expression:

Amino acids influence gene expression through mTOR (mechanistic target of rapamycin) signaling, which regulates cell growth, protein synthesis, and autophagy in response to nutrient availability.[97]

Acid-Base Balance:

Amino acids such as histidine play a role in maintaining the body's acid-base balance by acting as buffers in the blood, helping to stabilize pH levels.[98]

8.APPLICATION OF BUTTERFLY

Multipurpose cream : blue colour butterfly pea flower indicates the presence of anthocyanins which are natural antioxidants that slow down the aging p rocess, prevents skin aging and helps skin [99],[100]

Eye gel: antioxidant activity of aqueous ethanol extracts of Clitoria ternatea flowers was determined. flower extract also incorporated into gel base for use as an eye gel.

Drink of butterfly pea: The flower has been recognized to have health benefits such as antioxidants, antidiabetes, antiinflammation and anticancer. The bioactive compound of butterfly pea flower nine types of polyacrylate anthocyanins called ternatins add 15 types of flavonol glucosides.The combination of exotic colour and health benefits promoted butterfly pea flower as functional drink.

Antidandruff shampoo: butterfly pea flower known for its antifungal ,antimicrobial, anti-inflammatory and antioxidant properties contain flavonoids known as cystocele. Antifungal protein (CRAFP). CRAFP has been studied agains candida albicans its effect on malasszia spp. In dandruff remain unexplored [101],[102]

Hair oil : it use preserving hair follicle health,Encouraging rebust health hair grow.,very important for Premature hair graying , help hair retain its natural black colour for an extended amount of time , used top reat hair loss

Pharmaceutical:

Anti-depressant, Anti-helmintics,Anti-diabetic,Anti-ulcer,Diuretics,Anti-pyretic

9.Safety and toxicity: -

Butterfly pea flower is generally considered safe for most people when consumed in moderation. It often used in teas and culinary dishes. The flower rich in antioxidant properties and may provide various health benefits. It has low-risk but concentrated extract should be approached with caution. It has rare allergic reaction may occur. Symptoms include skin rashes or GIT disturbance. Avoid used in pregnancy without consulting healthcare provider.

Toxicity: No significant toxic effects have been reported in studies while some individual experience allergic reactions or sensitivity. Safety and precaution taken during pregnancy it advised to consult with healthcare. Drug interaction as with many herbal supplements there may be interactions with medications, particularly those affecting blood pressure and blood sugar levels.

10.Conclusion: -

Clitoria ternatea, also known as Butterfly Pea, is gaining popularity as a medicinal plant with a diverse range of bioactive components, including flavonoids, anthocyanins, terpenoids, and alkaloids. These components provide the plant with powerful antioxidant, anti-inflammatory, nootropic, anxiolytic, and antibacterial effects, making it useful for treating cognitive deficits, anxiety, depression, infections, and inflammatory diseases.

One of the most prominent medical advantages of Butterfly Pea is its neuroprotective properties. According to research, it can improve cognitive function, memory, and protect against neurodegenerative illnesses like Alzheimer's, owing to chemicals like cyclotides, which assist modify brain pathways and protect neurons from oxidative damage.Butterfly Pea has been utilized in ancient systems such as Ayurveda to treat respiratory problems, skin diseases, and fevers. Modern research also supports its function in blood sugar regulation, which may provide benefits for diabetes management. Its capacity to scavenge free radicals and bind transition metals enhances its anti-aging and anticancer capabilities.

Overall, Clitoria ternatea has a positive safety profile, with few negative effects when used at appropriate levels. However, further human clinical trials are required to thoroughly investigate its long-term safety and potential interactions with medications.

Reference: -

1. Barik, D. P., Naik, S. K., Mudgal, A., & Chand, P. K. (2007). Rapid plant regeneration through in vitro axillary shoot proliferation of butterfly pea (Clitoria ternatea L.)—a twinning legume. *In Vitro Cellular & Developmental Biology-Plant*, *43*, 144-148.
2. Fantz, P. R. (1977). *A Monograph of the Genus Clitoria (Leguminosae: Glycineae)* (Doctoral dissertation, University of Florida).
3. Gupta, G. K., Chahal, J., & Bhatia, M. (2010). Clitoria ternatea (L.): Old and new aspects. *J Pharm Res*, *3*(11), 2610-2614.
4. Conway, M. (2005). Planting and establishment. *The Butterfly Pea Book: a Guide to Establishing and Managing Butterfly Pea Pastures in Central Queensland*, 19-27.
5. Gupta, G. K., Chahal, J., & Bhatia, M. (2010). Clitoria ternatea (L.): Old and new aspects. *J Pharm Res*, *3*(11), 2610-2614.
6. Jamil, N., Zairi, M. N. M., Nasim, N. A. I. M., & Pa'ee, F. (2018). Influences of environmental conditions to phytoconstituents in Clitoria ternatea (butterfly pea flower)–A review. *Journal of Science and Technology*, *10*(2).
7. Agrawal, P., Deshmukh, S., Ali, A., Patil, S., Magdum, C. S., Mohite, S. K., & Nandgude, T. D. (2007). Wild flowers as medicine. *International Journal of Green Pharmacy (IJGP)*, *1*(1).
8. Khadatkar, S., Manwar, J., & Bhajipale, N. (2008). In-vitro anthelmintic activity of root of Clitoria ternatea Linn. *Pharmacognosy magazine*, *4*(13), 148.
9. 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).
10. Kalamani, A., & GOMEZ, M. (2003). S. Exploitation of new ornamental types in Clitoria (Clitoria spp.). *International Journal Mendel*, *20*(2), 41-42.
11. Taranalli, A. D., & Cheeramkuzhy, T. C. (2000). Influence of Clitoria ternatea extracts on memory and central cholinergic activity in rats. *Pharmaceutical biology*, *38*(1), 51-56.
12. 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.
13. 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.
14. Malabadi, R. B., & Nataraja, K. (2001). Shoot regeneration in leaf explants of Clitoria ternatea L. cultured in vitro. Phytomorphology, 51: 169-171.
15. Pendbhaje, N. S., Sudheendra, G., Pathan, S. M., & Musmade, D. S. (2011). Ethnopharmacology, pharmacogosy and phytochemical profile of Clitorea ternatea Linn: an overview. *Pharmacologyonline*, *3*, 166-175.
16. Scalbert, A., Manach, C., Morand, C., Rémésy, C., & Jiménez, L. (2005). Dietary polyphenols and the prevention of diseases. *Critical reviews in food science and nutrition*, *45*(4), 287-306.
17. Nadkarni AK (1992). Indian Materia Madica, 3rd Ed, Popular Prakashan, Bombay, Vol-I, 354.
18. Srivastava V, Khaan S and Banerjee S (2009). An evaluation of genetic fidelity of encapsulation microshoots of the medicinal plant: Cineraria maritime following six months of strong. Plant Cell, Tissue and Organ Culture, 99: 193-198.
19. Malic K, Manvi FV and Agarwadi KR (2008). Evaluation of anti-inflammatory activity of Gymnema sylvestre leaves extract in rats. International Journal of green pharmacy, 114-115.
20. Braca A, Sortino C, Politi M, Morelli I and Mendez J (2002). Antioxidant activity of flavonoids from Licania linaniaeflora. Journal of Ethnopharmacology, 79: 379-381
21. Kirtikar KR and Basu BD (1980). Indian Medicinal Plants; Publisher: Bishen Singh, Mahandra Pal Singh; Dehradun, India, 1: 802-803.

22. Yoganarasimhan SN (2000). Medicinal Plant of India, Bangalore, India, Interline Publishing Co, 2: 146- 147.
23. Kumar N. (2017). A review on Clitoria ternatea (Linn.): chemistry and pharmacology. Med Plants Ther Uses.
24. Singh, N. K., Gupta, J. K., Shah, K., Mishra, P. M., Tripathi, A., Chauhan, N. S., & Upmanyu, N. (2017). A review on Clitoria ternatea (Linn.): chemistry and pharmacology. *Medicinal Plants and its Therapeutic Uses. Hyderabad, India: OMICS International*.
25. Kazuma, K., Noda, N., & Suzuki, M. (2003). Malonylated flavonol glycosides from the petals of Clitoria ternatea. *Phytochemistry*, *62*(2), 229-237.
26. Kazuma, K., Noda, N., & Suzuki, M. (2003). Flavonoid composition related to petal color in different lines of Clitoria ternatea. *Phytochemistry*, *64*(6), 1133-1139.
27. Zakaria, N. N. A., Okello, E. J., Howes, M. J., 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.
28. 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.
29. Kumar, V., Mukherjee, K., Kumar, S., Mal, M., & Mukherjee, P. K. (2008). Validation of HPTLC method for the analysis of taraxerol in Clitoria ternatea. *Phytochemical Analysis: An International Journal of Plant Chemical and Biochemical Techniques*, *19*(3), 244-250.
30. 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.
31. Gupta, G. K., Chahal, J., & Bhatia, M. (2010). Clitoria ternatea (L.): Old and new aspects. *J Pharm Res*, *3*(11), 2610-2614.
32. Kalyan, B. V., Kothandam, H., Palaniyappan, V., & Praveen, A. R. (2011). Hypoglycaemic Activity of Seed Extract of Clitoria ternatea Linn in Streptozotocin-Induced Diabetic Rats. *Pharmacognosy Journal*, *3*(19), 45-47.
33. Lakshan, S. A. T., Jayanath, N. Y., Abeysekera, W. P. K. M., & Abeysekera, W. K. S. M. (2019). A commercial potential blue pea (Clitoria ternatea L.) flower extract incorporated beverage having functional properties. *Evidence-Based Complementary and Alternative Medicine*, *2019*(1), 2916914.
34. Ludin, N. A., Al-Alwani, M. A., Mohamad, A. B., Kadhum, A. A. H., Hamid, N. H., Ibrahim, M. A., ... & Sopian, K. (2018). Utilization of natural dyes from Zingiber officinale leaves and Clitoria ternatea flowers to prepare new photosensitisers for dye-sensitised solar cells. *International Journal of Electrochemical Science*, *13*(8), 7451-7465.
35. 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).
36. 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.
37. Ravindran DR, Bharathithasan M, Ramaiah P, Rasat MSM, Rajendran D, Srikumar S, et al. (2020)Chemical composition and larvicidal activity of flower extracts from Clitoria ternatea against aedes (Diptera: Culicidae). J Chem; 2020:1-9.
38. Buddhika, H. D. K., Menuka Arawwawala, L. D. A., Dharmadasa, R. M., & Pakeerathan, K. (2021). Phytochemical Properties of Clitoria ternatea L.(Fabaceae)-A Distinct Flower Morphometric Plants Available in Sri Lanka. 1st International Electronic Conference Agronomy Volume: 1.
39. Mehmood, A., Ishaq, M., Zhao, L., Yaqoob, S., Safdar, B., Nadeem, M., ... & Wang, C. (2019). Impact of ultrasound and conventional extraction techniques on bioactive compounds and biological activities of blue butterfly pea flower (Clitoria ternatea L.). *Ultrasonics sonochemistry*, *51*, 12-19.
40. Lee, R. X., Hassan, Z., Subramaniam, S., & Chew, B. L. (2021). Adventitious root cultures of Clitoria ternatea L. and its potential as a memory enhancer alternative. *Plant Biotechnology Reports*, *15*, 163-176.
41. Kumar, R., & Anju, V. S. (2017). Phytochemical and antibacterial activities of crude leaf and root extracts of Clitoria ternatea varieties (Fabaceae). *Journal of Pharmacognosy and Phytochemistry*, *6*(6), 1104-1108.
42. Lakshmi, N. D. M., Mahitha, B., Madhavi, T., & Sushma, J. (2015). Phytochemical screening and FTIR analysis of Clitoria ternatea leaves. *International Journal of Scientific & Engineering Research*, *6*(2), 287-290.
43. Kavitha, R., & Premalakshmi, V. (2013). Phytochemical analysis of ethanolic extract of leaves of Clitoria ternatea L.
44. Ashraf, K., Adlin, N. F., Basri, A. N., Ahmad, W., & Sultan, S. (2024). The Traditional Uses, Phytochemistry, and Pharmacological Effects of Clitoria ternatea: A Review. *Ind. J. Pharm. Edu. Res*, *58*(1), 1-14.

45. Almeida, P. M. D., Rai, K. S., Kamath, S. U., Adiga, S., Jasphin, S., & Kishore, A. PHYTOCHEMICAL EVALUATION AND HPTLC FINGERPRINT PROFILE OF CLITORIA TERNATEA L. ROOT [WHITE FLOWERING VARIETY] GROWN IN UDUPI DISTRICT, KARNATAKA, INDIA.

46. Deorankar, P., Gangiwale, R., Chintamani, R., & Singh, R. P. (2020). Evaluation of ethanolic and aqueous extract of Clitoria ternatea for antimicrobial activity. *Indian Journal of Natural Products and Resources (IJNPR)[Formerly Natural Product Radiance (NPR)]*, *11*(3), 194-198.

47. Jayanthi, M. K., Aswathi, K., Krishna, K. L., & Ramu, R. (2021). Evaluation of antioxidant and diuretic activities of Clitoria ternatea leaf extracts in Wistar albino rats. *Journal of Applied Pharmaceutical Science*, *11*(1), 152-157.

48. Makasana, J., Dholakiya, B. Z., Gajbhiye, N. A., Bishoyi, A. K., & Raju, S. (2016). Assessment of chemical diversity in Clitoria ternatea accessions by an improved and validated HPTLC method. *Indian Journal of Agricultural Sciences*, *86*(9), 1133-1139.

49. Tripathi S, Reddy AS, Sahoo S. (2021)Isolation and purification of gallic acid, caffeic acid and ferulic acid using high-performance liquid chromatography from Clitoria ternatea Linn. Life Sci Leaflets.; 135-136: 21-6.

50. Sarumathy, K., Rajan, M. D., Vijay, T., & Jayakanthi, J. (2011). Evaluation of phytoconstituents, nephro-protective and antioxidant activities of Clitoria ternatea. *Journal of Applied Pharmaceutical Science*, (Issue), 164-172.

51. Azima, A. S., Noriham, A., & Manshoor, N. (2017). Phenolics, antioxidants and color properties of aqueous pigmented plant extracts: Ardisia colorata var. elliptica, Clitoria ternatea, Garcinia mangostana and Syzygium cumini. *Journal of Functional Foods*, *38*, 232-241.

52. 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.

53. Escher, G. B., Marques, M. B., do Carmo, M. A. V., Azevedo, L., Furtado, M. M., Sant'Ana, A. S., ... & Granato, D. (2020). Clitoria ternatea L. petal bioactive compounds display antioxidant, antihemolytic and antihypertensive effects, inhibit α-amylase and α-glucosidase activities and reduce human LDL cholesterol and DNA induced oxidation. *Food research international*, *128*, 108763.

54. Chayaratanasin, P., Caobi, A., Suparpprom, C., Saenset, S., Pasukamonset, P., Suanpairintr, N., ... & 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.

55. Shyamkumar, I. B., & Ishwar, B. (2012). Anti-inflammatory, analgesic, and phytochemical studies of Clitoria ternatea Linn flower extract. *Int Res J Pharm*, *3*(3), 208-210.

56. Nair, V., Bang, W. Y., Schreckinger, E., Andarwulan, N., & Cisneros-Zevallos, L. (2015). Protective role of ternatin anthocyanins and quercetin glycosides from butterfly pea (Clitoria ternatea Leguminosae) blue flower petals against lipopolysaccharide (LPS)-induced inflammation in macrophage cells. *Journal of Agricultural and Food Chemistry*, *63*(28), 6355-6365.

57. 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.

58. Kamkaen, N., & Wilkinson, J. M. (2009). The antioxidant activity of Clitoria ternatea flower petal extracts and eye gel. *Phytotherapy Research*, *23*(11), 1624-1625.

59. Chauhan, N., Rajvaidhya, S., & Dubey, B. K. (2012). Pharmacognostical, phytochemical and pharmacological review on Clitoria ternatea for antiasthmatic activity. *International Journal of Pharmaceutical Sciences and Research*, *3*(2), 398.

60. Pendbhaje, N. S., Sudheendra, G., Pathan, S. M., & Musmade, D. S. (2011). Ethnopharmacology, pharmacogosy and phytochemical profile of Clitorea ternatea Linn: an overview. *Pharmacologyonline*, *3*, 166-175.

61. Terahara, N., Oda, M., Matsui, T., Osajima, Y., Saito, N., Toki, K., & Honda, T. (1996). Five new anthocyanins, ternatins A3, B4, B3, B2, and D2, from Clitoria ternatea flowers. *Journal of natural products*, *59*(2), 139-144.

62. Akpoveso, O. O. P., Ubah, E. E., & Obasanmi, G. (2023). Antioxidant phytochemicals as potential therapy for diabetic complications. *Antioxidants*, *12*(1), 123.

63. Peng, X., Zhang, G., Liao, Y., & Gong, D. (2016). Inhibitory kinetics and mechanism of kaempferol on α-glucosidase. *Food Chemistry*, *190*, 207-215.

64. Das, P., Sinhababu, S. P., & Dam, T. (2006). Screening of antihelminthic effects of Indian plant extracts: a preliminary report. *Journal of Alternative & Complementary Medicine*, *12*(3), 299-301.

65. Nirmal, S. A., Bhalke, R. D., Jadhav, R. S., & Tambe, V. D. (2008). Anthelmintic activity of Clitoria ternatea. *Pharmacologyonline*, *1*, 114-119.

66. Pendbhaje NS, Sudheendra G, Pthan SM and Musmade DS (2011). Ethanopharmacology, pharmacognosy And phytochemical profile of Clitorea ternatea Linn: An overview. Pharmacology online, 3: 166-175.

67. De Groot, H. (1994). Reactive oxygen species in tissue injury. *Hepato-gastroenterology*, *41*(4), 328-332

68. Grace, P. A. (1994). Ischaemia-reperfusion injury. *British Journal of Surgery*, *81*(5), 637-647..

69. Halliwell, B. (1995, November). How to characterize an antioxidant: an update. In *Biochemical Society Symposia* (Vol. 61, pp. 73-101). Portland Press Limited.

70. Korkina, L. G., & Afanas' Ev, I. B. (1996). Antioxidant and chelating properties of flavonoids. *Advances in pharmacology*, *38*, 151-163.

71. Hanasaki, Y., Ogawa, S., & Fukui, S. (1994). The correlation between active oxygens scavenging and antioxidative effects of flavonoids. *Free Radical Biology and Medicine*, *16*(6), 845-850.

72. Kerry, N. L., & Abbey, M. (1997). Red wine and fractionated phenolic compounds prepared from red wine inhibit low density lipoprotein oxidation in vitro. *Atherosclerosis*, *135*(1), 93-102.

73. Shoskes, D. A. (1998). Effect of bioflavonoids quercetin and curcumin on ischemic renal injury: A New Class of Renoprotective Agents: 1. *Transplantation*, *66*(2), 147-152.

74. Sanhueza, J., Valdes, J., Campos, R., Garrido, A., & Valenzuela, A. (1992). Changes in the xanthine dehydrogenase/xanthine oxidase ratio in the rat kidney subjected to ischemia-reperfusion stress: preventive effect of some flavonoids. *Research communications in chemical pathology and pharmacology*, *78*(2), 211-218.

75. Chang, W. S., Lee, Y. J., Lu, F. J., & Chiang, H. C. (1993). Inhibitory effects of flavonoids on xanthine oxidase. Anticancer research, 13(6A), 2165-2170.

76. IIO, M., ONO, Y., KAI, S., & FUKUMOTO, M. (1986). Effects of flavonoids on xanthine oxidation as well as on cytochrome c reduction by milk xanthine oxidase. *Journal of nutritional science and vitaminology*, *32*(6), 635-642.

77. Cos, P., Ying, L., Calomme, M., Hu, J. P., Cimanga, K., Van Poel, B., ... & Berghe, D. V. (1998). Structure− activity relationship and classification of flavonoids as inhibitors of xanthine oxidase and superoxide scavengers. *Journal of natural products*, *61*(1), 71-76.

78. Friesenecker, B., Tsai, A. G., Allegra, C., & Intaglietta, M. (1994). Oral administration of purified micronized flavonoid fraction suppresses leukocyte adhesion in ischemia-reperfusion injury: in vivo observations in the hamster skin fold. *Journal of Vascular Research*, *14*(1-2), 50-55.

79. Friesenecker, B., Tsai, A. G., & Intaglietta, M. (1995). Cellular basis of inflammation, edema and the activity of Daflon 500 mg. *INTERNATIONAL JOURNAL OF MICROCIRCULATION CLINICAL AND EXPERIMENTAL*, *15*, 17-21.

80. Ferrándiz, M. L., Gil, B., Sanz, M. J., Ubeda, A., Erazo, S., González, E., ... & Alcaraz, M. J. (1996). Effect of bakuchiol on leukocyte functions and some inflammatory responses in mice. *Journal of pharmacy and pharmacology*, *48*(9), 975-980.

81. Bennett, J. P., Gomperts, B. D., & Wollenweber, E. (1981). Inhibitory effects of natural flavonoids on secretion from mast cells and neutrophils. *Arzneimittel-forschung*, *31*(3), 433-437.

82. Lee, E. J., Hagel, J. M., & Facchini, P. J. (2013). Role of the phloem in the biochemistry and ecophysiology of benzylisoquinoline alkaloid metabolism. *Frontiers in plant science*, *4*, 182.

83. Gupta, R., Thakur, B., Singh, P., Singh, H. B., Sharma, V. D., Katoch, V. M., & Chauhan, S. V. S. (2010). Anti-tuberculosis activity of selected medicinal plants against multi-drug resistant Mycobacterium tuberculosis isolates. *Indian Journal of Medical Research*, *131*(6), 809-813.

84. Yang, D., Luo, Z., Ma, S., Wong, W. T., Ma, L., Zhong, J., ... & Zhu, Z. (2010). Activation of TRPV1 by dietary capsaicin improves endothelium-dependent vasorelaxation and prevents hypertension. *Cell metabolism*, *12*(2), 130-141.

85. Shi, J., Arunasalam, K., Yeung, D., Kakuda, Y., Mittal, G., & Jiang, Y. (2004). Saponins from edible legumes: chemistry, processing, and health benefits. *Journal of medicinal food*, *7*(1), 67-78.

86. Güçlü-Üstündağ, Ö., & Mazza, G. (2007). Saponins: properties, applications and processing. *Critical reviews in food science and nutrition*, *47*(3), 231-258.

87. Sparg, S., Light, M. E., & Van Staden, J. (2004). Biological activities and distribution of plant saponins. *Journal of ethnopharmacology*, *94*(2-3), 219-243.

88. Man, S., Gao, W., Zhang, Y., Huang, L., & Liu, C. (2010). Chemical study and medical application of saponins as anticancer agents. *Fitoterapia*, 81(7), 703-714.

89. Serrano, J., Puupponen-Pimiä, R., Dauer, A., Aura, A. M., & Saura-Calixto, F. (2009). Tannins: current knowledge of food sources, intake, bioavailability and biological effects. *Molecular nutrition & food research*, *53*(S2), S310-S329.

90. Daglia, M. (2012). Polyphenols as antimicrobial agents. *Current Opinion in Biotechnology*, 23(2), 174-181

91. Scalbert, A. (1991). Antimicrobial properties of tannins. *Phytochemistry*, 30(12), 3875-3883.

92. Gurib-Fakim, A. (2006). Medicinal plants: traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine*, 27(1), 1-93.

93. Oakley, R. H., & Cidlowski, J. A. (2013). The biology of the glucocorticoid receptor: New signaling mechanisms in health and disease. Journal of Clinical Investigation, 123(9), 3842-3853.

94. Vetvicka, V., Vannucci, L., Sima, P., & Richter, J. (2019). Beta glucan: supplement or drug? From laboratory to clinical trials. *Molecules*, *24*(7), 1251.

95. Zhang, Y., & Lee, J. (2015). *Antioxidant properties of polysaccharides from plants*. Food Research International.

96. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). An overview of the cell cycle. *Molecular Biology of the Cell. 4th edition*.

97. Laplante, M., & Sabatini, D. M. (2012). *mTOR signaling in growth control and disease*. *Cell*, 149(2), 274-293.

98. Rennie, M. J., & Tipton, K. D. (2000). Protein and amino acid metabolism during and after exercise and the effects of nutrition. *Annual review of nutrition*, *20*(1), 457-483.

99. Gupta, G. K., Chahal, J., & Bhatia, M. (2010). Clitoria ternatea (L.): Old and new aspects. *J Pharm Res*, *3*(11), 2610-2614.

100. Daisy, P., & Rajathi, M. (2009). Hypoglycemic effects of Clitoria ternatea Linn.(Fabaceae) in alloxan-induced diabetes in rats. *Tropical Journal of Pharmaceutical Research*, *8*(5).

101. Marpaung, A. M. (2020). Tinjauan manfaat bunga telang (clitoria ternatea l.) bagi kesehatan manusia. *Journal of Functional Food and Nutraceutical*, 63-85.

102. Chauhan NS, Singh NK, Gupta JK, et al. (2016) A review on Clitoria ternatea (Linn.): Chemistry and pharmacology. Medicinal plants and its therapeutic uses, 1st ed. Foster City: OMICS Group eBooks;.

103. Jain, N. N., Ohal, C. C., Shroff, S. K., Bhutada, R. H., Somani, R. S., Kasture, V. S., & Kasture, S. B. (2003). Clitoria ternatea and the CNS. *Pharmacology Biochemistry and Behavior*, *75*(3), 529-536.