Medicinal Plants and its Therapeutic Uses

Chapter: A Review on *Clitoria ternatea*(Linn.): Chemistry and Pharmacology

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A Review on *Clitoria ternatea*(Linn.): Chemistry and Pharmacology

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Abstract

The value of mankind is inextricably linked with the wellbeing through natural resources specially the plants around him. Medicinal plants are gift of God, to cure infinite number of diseases in human beings and other living organism. These Plant materials have been extensively used in the indigenous system of medicine which is mention in the Ayurveda and other Indian literature. In all ancient scriptures of Ayurveda, Aparajita is mentioned as one of the important herb. It is a good looking twing herb and very common garden flower plant found all over India especially in southern India Aparajita's botanical name is *Clitoria ternatea* and belongs to Fabaceae (Pipilionaceae) family. *C. ternatea* is a garden plant of India, which has been used the traditional and folkloric medicine in the various diseases. It is scientifically evaluated for anti-inflammatory, antipyretic, analgesic, larvicidal, insecticidal, antimicrobial, anxiolytic, antidepressant, hepatoprotective, tranquilizing and sedative property. This paper reviews plant distribution, agronomic characteristics, pharmacognostical description, ornamental value, traditional properties and uses, phyto-contituents, pharmacological activity of butterfly pea. Thus, the present study is an effort to compile a detailed account and literature survey of *Clitoria ternatea* plant.

Keywords: *Clitoria ternatea*; Pharmacological Properties; Phyto-Constituents; Traditional Uses

Introduction

Since long time immemorial nature has been a mere source of medicinal plants. These medicinal plants are gift of God, to cure infinite number of diseases in human beings and other living organism. They have been the major source of drugs in all system of medicine and

other ancient systems in the world. Such exhaustible source of active ingredients invaluable in the management of many intractable diseases which is harbored by plant kingdom. In the various systems of medicine, many plantsandherbs are used to treat various infirmities. In all ancient scriptures of Ayurveda, Aparajita is mentioned as one of the important herb. It is a good looking twing herb. Aparajita's botanical name is *Clitoria ternatea* and belongs to Fabaceae (Pipilionaceae) family (Figure 1). It is probably originated in tropical Asia [1]. It is widely distributed throughout the humid, lowland tropics of Africa, Asia and Central America. It is found in low and medium altitudes of the settled areas. *C. ternatea* is a strongly persistent, sparsely pubescent, legume. It is perennial climber with slender downy stem, found throughout the tropical regions of the country being cultivated in gardens everywhere and often also found growing over hedges and thickets. It is seen that Aparajita is being adapted to clay soils and has been tested as a forage and cover crop, but never developed as a pasture cultivar [2].In various Ayurvedic preparations different parts of this plant have been used as an active ingredient which is used for treatment of several disorders. There are several reported Ayurvedic 'medha' drugs which contain *C. ternatea* along with other plants. This plant has been scientifically studied for various pharmacological activities like antihistaminic, anthelmintic, hypoglycemic, antidepressant, sedative etc. [3].

Figure 1: Plant of *Clitoria ternatea* (Linn).

Vernacular names

The shape of flowers of the Clitoria plant is a reflection of its genus name. The flowers of this plant resemble in shape with human female clitoris, hence the Latin name of the genus "Clitoria" belongs to "clitoris" and "Ternatea", the name of the species, which comes from Ternate, an Eastern Indonesian island. Similarly in different languages various vernacular names of the flowers are based on reference to a woman's genital organ.

In India:

Sanskrit: Ashphota, Aparajita Saukarnika, Ardrakarni, Girikarnika, Supuspi, Mohanasini Vishadoshaghni, Shwetanama , Vishnu-Kranta, Ashwakhura.

Hindi, Beng, and Oriya: Aparajita or Aparajit.

Gug: Bismar, Garani, Koyala

Kan: Billisaiuga, Satugadagida.

Tel: Dintana, Gilarnika, Neela-ghentana, Sankhupuvvu.

Tam: Kakkanam, Kakatan, Kavachi, Kuruvilai.

Punjab: Dhanattar.

Rajasthan: Koyalri, Titlimatar.

Mar.: Gokurna

Mal.: Aral, Shankapuspam, Malai-amukki.

English: Butterfly pea, Blue pea vine, Mussel-shell climber, Pigeon wings.

In other countries: Butterfly-pea (Australia); Blue-pea, Cordofan-pea, honte (French); blaue Klitorie (German); Fula criqua, Clitoriaazul (Portugese); Azulejo, Conchitis, Papito, Zapatico de la reina, Zapotillo, Conchita azul, Campanilla, bandera, Choroque, Lupita, pito de parra, Bejuco de conchitas (Spanish); Cunha (Brazil); Pokindang (Philippines); Zapatillo de la reina (El Salvador); Kordofan pea (Sudan); Nagar hedi (Kannada); Mavi Kelebek Sarmaşığı (Turkish).

Geographic distribution

Clitoria genus is inconsequential, indigenous climber and a common garden flower found throughout the tropical and subtropical regions of the world. Now the genus becomes rare in humid and sub-humid lands of Asia, America, and Africa and also in semi-arid tropical Australia [1]. It grows from sea level to 1800 and also grown as an ornamental in the warmer parts of the world and outspread from about 20°North latitude to the Salta district in Argentina at about 24°South latitude.

In Africa it grows in grasslands, often on seasonally-waterlogged black clays and in old cultivations whereas in Sudan it is grown for fodder or grazing and in Kenya it is grown in a mixture with *Chloris gayana* [2]. In America, the species of this plant is spread from Florida to Texas and from New Jersey to Kentucky & Arkansas. It is commonly found in Jamaica, Puerto Rico, Turks, and Caicos Islands etc. It is found in all over India, especially in southern India up to an altitude of 1,500 m and in the Andaman Islands [4].

Taxonomic hierarchy

Kingdom: Plantae

Phylum: Angiosperms

Order: Fabales

Family: Fabaceae

Genus: *Clitoria*

Species: *C. ternatea*

Other species of Clitoria

Clitoria albiflora Mattei
*Clitoria amazonum*Benth
Clitoria Andrei Fantz
*Clitoria angustifolia*Kunth
Clitoria annua J. Graham
Clitoria arborea Benth.
Clitoria arborescens R. Br.
Clitoria australis Benth.
Clitoria biflora Dalziel
Clitoria brachystegia Benth.
Clitoria bracteata Poir.
Clitoria brasiliana L.
Clitoria cajanifolia (*C. Presl*) Benth.

Clitoria capitata Rich.
Clitoria dendrina Pittier
Clitoria fairchildiana R. A. Howard
Clitoria falcata Lam.
Clitoria fragrans Small
Clitoria glycinoides DC.
Clitoria guianensis (Aubl.) Benth.
Clitoria javitensis subsp. *javitensis*
Clitoria laurifolia Poir.
Clitoria linearis Gagnep.
Clitoria mariana L.
Clitoria mearnsii De Wild.
Clitoria mexicana Link
Clitoria moyobambensis Fantz
Clitoria nana Benth.
Clitoria pedunculata Bojer ex Benth
Clitoria pinnata (Pers.) R. H. Sm. & G. P. Lewis
Clitoria plumieri Turpin ex Pers.
Clitoria polyphylla Poir.
Clitoria racemosa G. Don
Clitoria racemosa Benth.
Clitoria rubiginosa Pers.
Clitoria sagotii Fantz
Clitoria schiedeana Schltdl.
Clitoria stipularis Benth.
Clitoria tanganicensis Micheli
Clitoria ternatea L.
Clitoria virginiana L.
Clitoria woytkowskii Fantz
Clitoria zanzibarensis Vatke
Clitoria zanzibarensis mengkoemieng

Agronomic characteristics

Soil: *Clitoria* is well adapted to grow in wide range of soil types (in between pH range 5.5-8.9) from deep alluvial to sandy including calcareous soils. It extremely well adapted to heavy clay alkaline soils, and especially on clay soils but also grows well in moderate fertile soils [1]. *Clitoria ternatea* likes a rich, moist soil (peat moss: loam: part sand or perlite 2:1:1) therefore the soil should be evenly moist at all times for well growth.

Water: It requires approximately 400 mm of rainfall but also performs well under irrigation areas and grows from drier areas like Kordofan in the Sudan to the fairly drought tolerant in Zambia. Due to the nature of *C. ternetea,* it cannot tolerate prolonged inundation or water logging but can tolerate short term flooding.

Sun light: It is moderately shade-tolerant but can normally grow in full sunlight.

Temperature: It needs moderate temperature down to 25ºC but not suited to locations with frequent or severe frosts, but it stands up well in hot summer temperatures and having low frost tolerance.

Fertilizer: *C. ternetea* is normally grown in soil containing phosphorous (P) and sulphur (S) which may be required as fertilizers if sown in the infertile soils.

Propagation: It contains around 20% of hard seed according to the seasonal conditions in where it is produced and grows rapidly in warm-moist weather. It is harvested manually by hands and is propagated from seed by cuttings [5]. The seeds of *Clitoria ternatea* are covered by hard seed coats therefore do not germinate or imbibe water, but when stored for 6 months 15-20% germination can be obtained. The use of hot water, sulphuric acid (H_2SO_4), potassium hydroxide and soaking in 100 mg/L solution of Sodium cyanide (NaCN) has also improved germination and early plant growth while mechanical scarification increased germination of 6-month-old seed from 30% to 71% [2].

Pharmacognostical description

Different growing conditions can affect its morphology. It is extensively grown in gardens for its flowers as an ornamental plant and it belongs to the sub family papilionaceae and family Fabaceae (Leguminoseae) botanically, butterfly pea (*C. ternatea*) [6].It has various synonyms like *C. purpurea and C. ternatea,* some have potential for foraging use and some are partially domesticated. The plant is a long-lived perennial herb 90 to 162 cm tall with an erect habit. It has two types one has white-flower and other blue flower. *Clitoria* have cleistogamous and chasmogamous flowers i.e., self-pollinating and insect pollinating respectively. Physical properties of flower like color, structure and position vary from species to species they may 60 to 120 mm long like beans and blue scabbards flat and linear [1]. The flowers of this plant are papilionaceous, axillary, solitary, pedicel 0.8 to 1.3 cm long with bright blue or white with yellow or orange center. Calyx 13 to 20 mm long, corolla 38 to 50 mm, oblong, seeds 8 to 11/pod, Pods 50 to 100 mm by 0.8 to 1.3 cm, nearly straight, somewhat flattened, sharply beaked sparsely hairy, 0.3 to 0.4 cm wide, shiny, often mottled, minutely pitted, olive brown to almost black. Pinnate leaves with 5 or 7 leaflets; stipules persistent, narrowly triangular, 1 to 6 mm long, subulate, prominently 3-nerved; rachis 10 to 70 mm long; petioles are 15 to 30 mm long; stipels are filiform, leaflets are elliptic, oblong, ovate or nearly orbicular, 20 to 50 mm long, 3to 30 mm wide, with apex acute or rounded, often notched, and base cuneate or rounded, both surfaces sparsely appressed pubescent [7].

Flattened pods are 40 to 130 mm long, linear to oblong and 8 to 12 mm wide, are style persistent, pale brown, dehiscent when dry, sparsely pubescent when mature and with thickened margins. The bracteoles are persistent and 0.4 to 1.2 cm long, broadly ovate or rounded, calyx is 17 to 22 mm long with a few fine hairs; lobes triangular or oblong; tube campanulate, 8 to 12 mm long 7 to 10 mm long, acute or acuminate [8]. The physiochemical properties of roots are buffy brown in color, with characteristic odor and bitter in taste. *Clitoria ternatea* have both primary and secondary roots are thick, hard with smooth surface and later are thin, fibrous in nature respectively. Its roots fix nitrogen; therefore this plant has been used to improve soil quality. The thick horizontal roots may grow bearing one to several purplish, glaucous, wiry stems with more than 2 m length.

Ornamental values

C. ternatea widely grows in the warm climatic conditions as an ornamental plant, attractive for its blue flowers and requires very little care while cultivation. It has various types of species of *Clitoria* present in the world which improves the quality of soil by fixing the nitrogen through its roots, but out of them only *C. ternatea* has attractive flowers. The physiological characters of flowers are creamy white and dark blue colored papilionaceous flowers which are very attractive and solitary. It is very valued plant for garden lovers as an important ornamental crop due to its attractive nature. New hybrids were developed

between *C. ternatea* and *C. purpurea* which produced somewhat bigger in flower size when compared with parents and intermediate colored (light blue) flowers. In the segregating progenies variation in flower colors were noticed viz., medium blue, cream flower with blue, light pink color, dark blue with velvety appearance, borders, violet, dark violet, besides the parent colors [1]. For ornamental purposes species with less numbers of leaves and medium heighted segregants with attractive flower such as light pink, deep violet, and velvety blue can be exploited.

Traditional properties and uses

Clitoria is pungent in the post digestive effect, has cold potency, bitter in taste, and possesses light dry and sharp attributes. In Ayurveda 'Sankhapushpi' is one of the formulations which consists of the seeds and roots of *C. ternatea*, is used as a 'nerve tonic', alternative and laxative. It has been used for the treatment of various neurological disorders as an active ingredient in 'Medhya Rasayana'. By various group of persons it is considered as medicine which is useful in skin diseases, eye and throat infections also in urinary disorders, ulcers and antidote activity [9].

Root: The roots have a sharp bitter or acrid taste and credited with cooling, laxative, diuretic, anthelmintic, anti-inflammatory properties. In the scientific studies it was found that extracts of *C. ternatea* can raise the acetyl choline content and acetyl choline esterase activity in rat brain in a similar fashion to the standard cerebral drug pyritinol [9]. In other treatments of various ailments like infections, as anthelmintics, antidote to animal stings, urinogenital disorders and body aches *C. ternatea* is also used [10]. Especially the roots of *C. ternatea* are useful in severe asthma, remittent fever and bronchitis. These are used to administer with ghee and honey as a tonic to children for boost up in their mental abilities, muscular strength, complexation, whooping cough, goiter and epilepsy [11]. Roots used by tribal to cause abortion and its paste applied on cattle stomach for curing abdominal swelling [12]. Research suggested that the methanolic extract of *C. ternatea* roots shown nootropic, anxiolytic, anti-depressant, anticonvulsant and anti-stress activity in animals. The decoction or powder of root is given in rheumatism and ear disease. Root and leaves have emetic and antiperiodic [13].

Seed: The use of seeds of *Clitoria ternatea* for medicinal purpose is both for external and internal applications. Fried seeds are recommended in ascites when given orally with hot water in powdered form with ghee and fennel [13]. Seeds are also used in digestive disorders because they have purgative, cathartic and laxative action when used in combination with ginger powder. Seeds are also prescribed in cough, hepatic disorders, spleen and rheumatic infections. The seeds are safe for abdominal viscera, colic, dropsy and also for arthritis.

Leaves: Leaves are used as emetic, diuretic, antiperiodic and laxative. The leaves are also very useful in the inflammation of mastoid lymph nodes when used with salt in paste form. The juice form has the ability to mitigate the toxins [10]. In combination with ginger juice, the fresh leaves are useful in hepatic fever, excessive sweating and also useful in inflammation around the ear and neighboring glands in juice form with common salt.

Flower: Flowers are suggested and used for the treatment of scorpion sting and snake bite. In Cuba decoction of flowers with roots are considered emmenagogue [10]. An infusion of flowers is used to promote menstruation and induce certain contraction. Flowers are also used to treat chlorosis and intestinal problem [13]. In experimentally induced diabetic mice, the ethanolic extract of flowers significantly lowers the serum sugar level.

Stem: Stem is recommended for the treatment of snake bite and scorpion sting. The stem of the plant contains the phytochemicals which are mainly considered as brain tonic and is also useful for eye and throat infections, skin diseases, urinary troubles [13].

Phyto-contituents

Butterfly pea yields up to 30 tons dry matter per hectare per year in favorable conditions. Plant can be exploited as a source of calcium in herbal drink due to its high calcium concentration. It contains antifungal proteins (Figure 2-12).

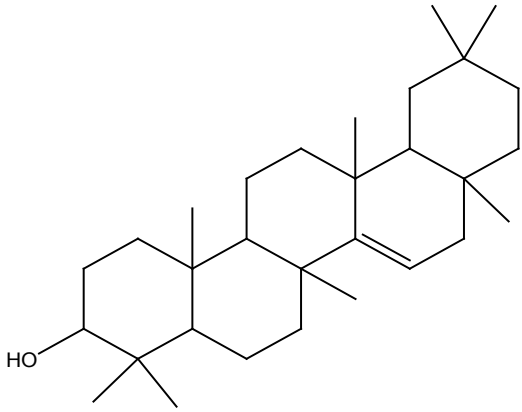

Figure 2: Taraxerol.

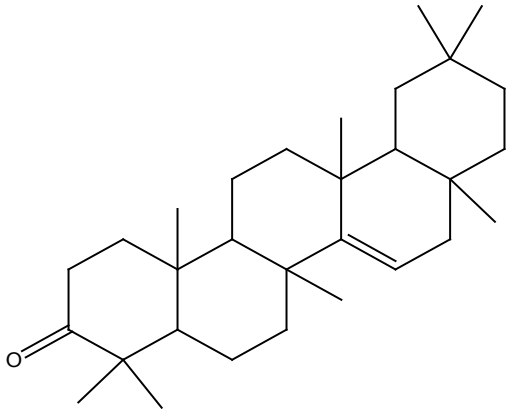

Figure 3: Taraxerone.

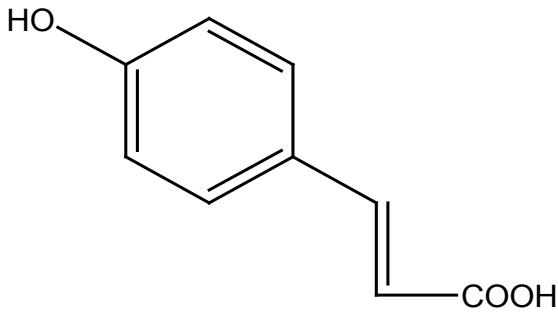

Figure 4: p-Hydroxycinnamic acid.

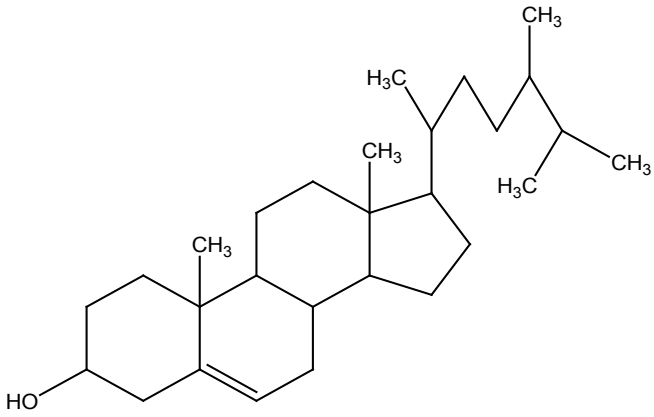

Figure 5: β-sitosterol.

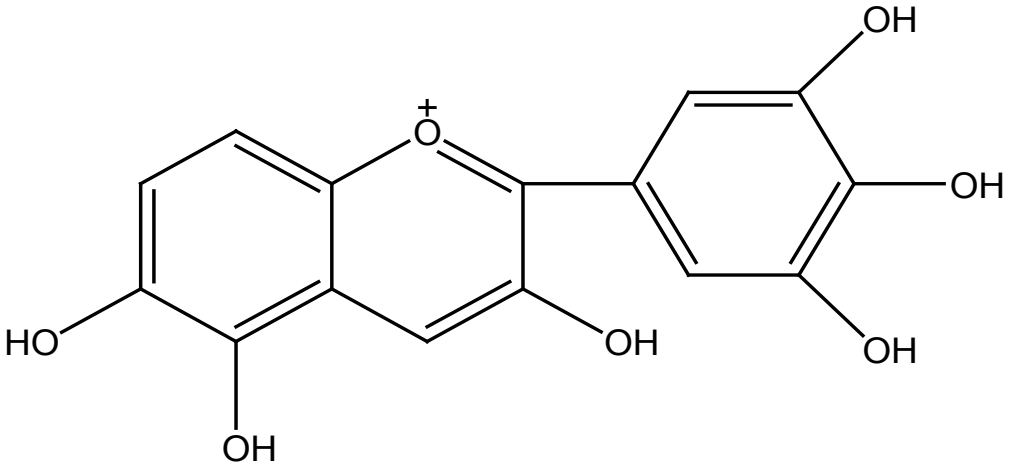

Figure 6: Delphinidin.

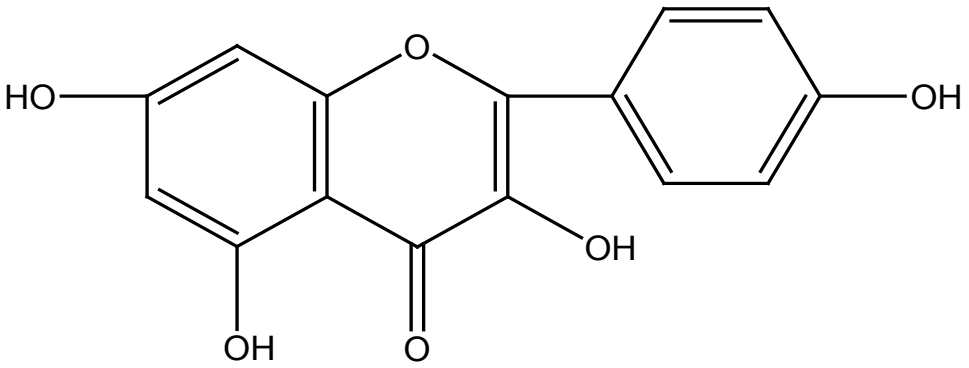

Figure 7: Kaempferol.

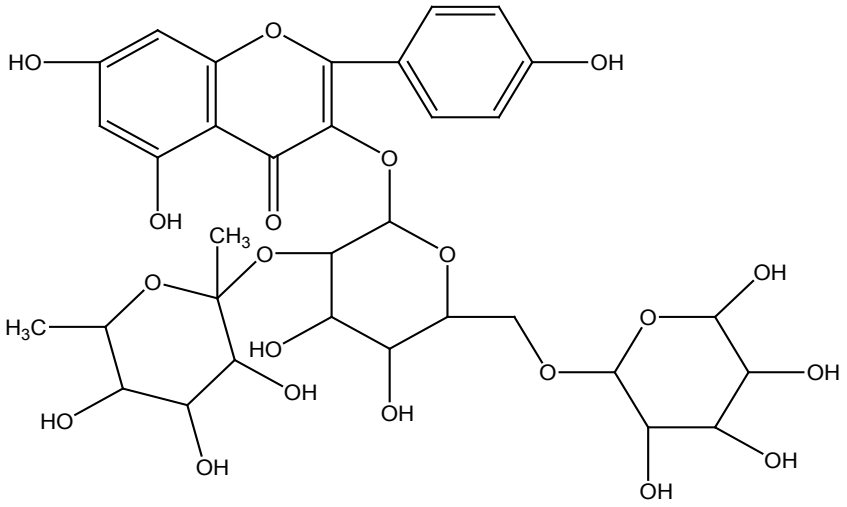

Figure 8: Clitorin.

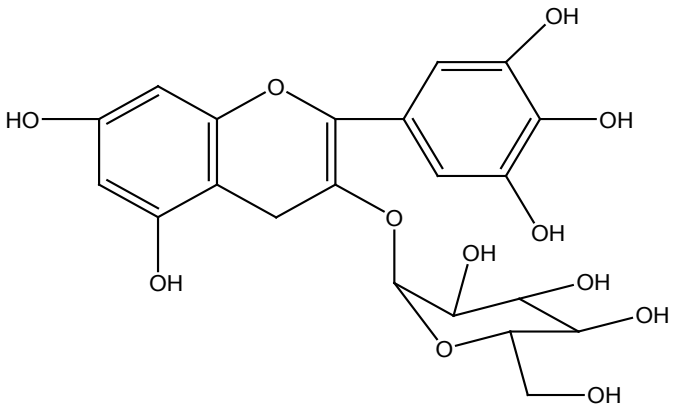

Figure 9: Delphinidin 3-O-β-glycoside (anthocyanins).

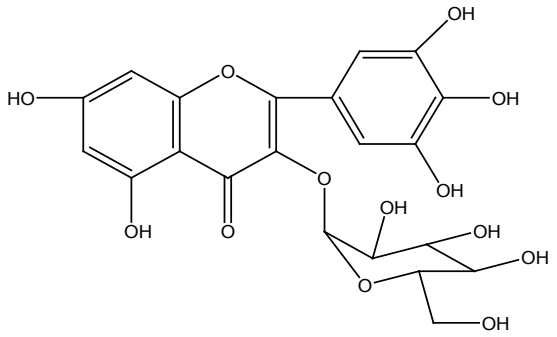

Figure 10: Myricetin 3-glycoside.

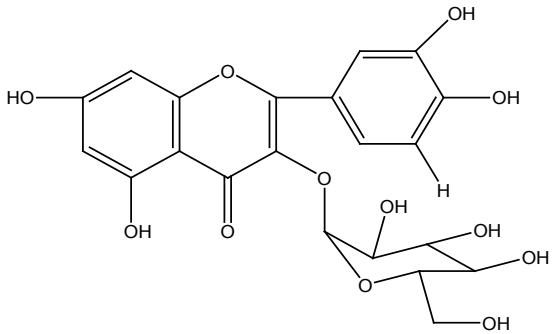

Figure 11: Quercetin 3-glocoside.

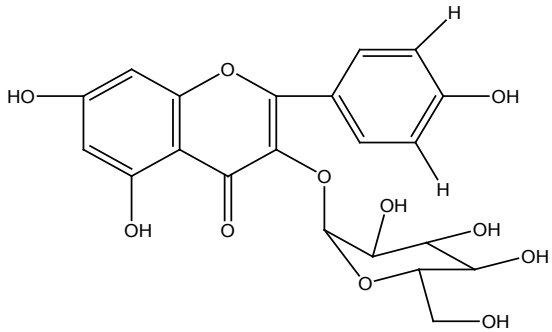

Figure 12: Kaempferol 3-glocoside.

Leaf: The content of crude fiber and protein in the leaves were 21.5% and 21.5-29% respectively. From leaves, clitorin and kaempferol have been isolated [1]. The leaves also contain 3-monoglucoside, 3-rutinoside, 3- neohesperidoside, 3-o-rhamnosyl-glucoside, 3-o-rhamnosylgalactoside of kaemferol, besides kaemferol-3-o-rhamnosylo- rhamnosyl-glucoside. It also contains aparajitin and β- sitosterol [13]. The flowers (blue in color) contain delphinidin-3,5- diglucoside, delphinidin-3β-glucoside, and its 3 methyl derivative, malvidin-3β-glucoside, kaemferol and cynidin chloride. A lactone- aparajitin from leaves [1].

Root: Taxaxerol and taxaxerone are present in the roots of plant. The bark of roots contains sresin, tannin, starchand flavonol glycosides. The root nodule contains glycine, alanine, valine, lecine, α-aminobutyric acid, aspartic acid, glutamic acid, arginine, ornithine, histadine, γ-aminobutyric acid [10,14].

Seed: The seed contains bitter acid resin as an active principle with fixed oil, tannic acid and glucose, also contains a cotyledon, which is full of granular starch and bitter in taste. There are two chemicals which are isolated from seeds viz. Sitosterol and anthoxanthin. Other than that seed-oil yields palmitic, stearic, oleic, linoleic and linolenic acids. Oils from blue and white-flower varieties have been found to have almost similar composition. Seeds also contain cinnamc acid, hexacosanol, nucleoprotein with its amino acid sequence somewhat similar to insulin [12].

The seeds are very high in protein content (15-25%). The seeds contains p-hydroxycinnamic acid, flavonol-3-glycoside, ethyl-α-D-galactopyranoside, adenosine, 3,5,7,4-tetrahydroxyflavone-3-rhamnoglucoside, polypeptide, hand exacosanol. Oligosaccharides or flatulene are also present in seeds. A food dye, delphinidin 3,3',5'-triglucoside also reported in seeds [4]. Lecin represents about 2.8% of the total extractable

protein from seed meal or 30 mg of lectin/30 g of *C. ternatea* seeds in contrast 9 mg fetuin/30 g of seeds. Tryptophan and tyrosine is also reported in the seeds [15].

Flower: Two acyl moieties were determined as E-4-0-β-D-glucopyranosyl-p-coumaric acid and 6—0-malonyl-D-glucopyranose. Other six ternatins A1, A2, B1, B2, D1 and D2 in *C. ternatea* flower ware isolated by reverse phase HPLC [16]. The white flower yield only kaeferol. From the petals of *Clitoria ternatea* L. some flavonol glycosides isolated are kaempferol 3-O-(200-O-a-rhamnosyl-600- O-malonyl)-b-glucoside; quercetin 3-O-(200-O-arhamnosyl- 600 -O- malonyl) -b- glucoside; myricetin 3 -2G -rhamnosylrutinoside; quercetin 3-2G-rhamnosylrutinoside 4. Flower also contains kaempferol 3-2G-rhamnosylrutinoside; kaempferol 3- neohesperidoside; quercetin 3-neohesperidoside; myricetin 3-neohesperidoside; kaempferol 3-rutinoside; quercetin 3-rutinoside; myricetin 3-rutinoside; kaempferol 3- glucoside; quercetin 3- glucoside; myricetin 3-glucoside [13]. Cyanine chloride and kaempferol are isolated and identified from the flowers. Isolation of Six acylated anthocyanins A, B, C, D, E and F from blue flowers has been done with the partial characterization of kaempferol and its 3- glucoside, robinin, quercetin and 3-glucoside and ternatins A and B [17]. Blue flower of butterfly pea also contain lobelinins, which has the 3,5,3',5'-tetraglucoside substituted pattern. Deacylternatin is also reported in the blue flower petals [18].

Various types of *C. ternatea* lines with different petal have been investigated for flavonoids. The newly isolated glucoside from the petals of mauve line is Delphinidin 3-O-(2″-O-α-rhamnosyl-6″-O-malonyl)-β-glucoside. Also, a group of ternatins identified from the entire blue petal lines i.e. 15 (poly) acylated delphinidin. The white petal lines do not contain anthocyanins.While ternatins are identified in all blue petal lines as 3′,5′-disubstituted polyacylanthocyanins, the mauve petal line accumulated delphinidin 3-O-(6″-O-myl)-β-glucoside instead [19]. Researchers found that the difference in flower color from blue to mauve is due to the lack of (polyacylated) glucosyl group substitutions at both the 3′- and 5′-positions of ternatins but not due to a change in the structure of an anthocyanidin from delphinidin.

Pharmacological properties

Anthelmintic activity: Anthelmintic activity was found in ethanolic and aqueous extract of *C. ternatea* leaves at the dose of 100 mg/ml. This was performed at three different concentrations (100, 50, 25 mg/ml) of ethanolic and aqueous extracts respectively by using *Eisenia foetida.* The study was focused at the *in-vitro* comparative study of aqueous and ethanolic extracts of leaves of *C. ternatea* for anthelmintic activity. Thus, the study involved in the determination of time of paralysis (P) and time of death (D) of the worms. While determination for both extracts, the time of paralysis and death time of aqueous extract was observed as 18 ± 1.57 and 53.33 ± 0.33 and in case of ethanolic extracts 12.33 ± 0.80 and 32.33 ± 0.71 respectively. At last, the anthelmintic activity of ethanolic extract of *C. ternatea* was found more potent than aqueous extract of *C. ternatea* [5].

Antihistaminic activity: Antihistaminic activity was found in the ethanolic extract of *C. ternatea* roots in dose dependent manner. Evaluation for antihistaminic activity was done using clonidine and haloperidol induced catalepsy in mice for Ethanol Extract of *C. ternatea* Root (ECTR) at doses 100, 125 and 150 mg/kg IP. Dose dependent catalepsy was induced in mice by Clonidine, a α_2 adrenoreceptor agonist which was inhibited by histamine H1 receptor antagonists but not by H_2 receptor antagonist. Clonidine, which is responsible for the release of histamine from mast cells, is responsible for different asthmatic conditions. A non-selective D_2 dopamine antagonist (Haloperidol) induces catalepsy is primarily due to blockade of dopamine receptors in the straiatum. The agents responsible for increase in dopamine transmission inhibit haloperidol-induced catalepsy. Findings showed that ethanol Extract of *C. ternatea* Root (ECTR) and Chlorpheniramine Maleate (CPM) inhibit clonidine induced catalepsy significantly $P < 0.001$ when compare to control group, while

ECTR and CPM fail to inhibit haloperidol induced catalepsy. So it is concluded that the agents increasing dopamine transmission inhibits haloperidol-induced catalepsy and the present study shows ECTR possesses antihistaminic activity [20].

Antimicrobial activity: The antimicrobial screening was evaluated against Extended Spectrum Beta Lactamase (ESBL) producing *Salmonella enteritidis, Salmonella typhimurium, Klesiella pneumonia,* Enteropathogenic *E.coli,* Uro-pathogenic *E.coli,* and *Pseudomonas aureginosa* isolated from patients with urinary tract infection and acute gastroenteritis. Disc diffusion method was used to test the above mentioned extracts for their activity. Water, methanol and chloroform extracts of *C. ternatea* flowers was exhibited activity against uropathogenic *E.coli,* Enteropathogenic *E.coli*, Enterotoxigenic *E.coli, Salmonella typhimurium*, *Klesiella pneumoniae* and *Pseudomonas aureginosa.* Methanol extract of *C. ternatea* exhibits comparatively high activity as compared with chloroform and aqueous extracts. The inhibitory zone produced by water, methanol and chloroform extracts at a concentration of 4 mg/disc was found 12 mm, 16 to 26 mm and 14 mm to 18 mm respectively while petroleum ether and hexane extracts did not exhibit any activity [21].

Cytotoxic activity: The crude methanol extract of stem-bark, leaves and seeds of *C. ternatea* demonstrated a significant cytotoxic activity in a brine shrimp lethality bioassay test. The LC_{50} values of the crude methanol extract of stem-bark, leaves and seeds were found to be 179.89, 25.82, 110.92 µgm/ml) respectively. Among them crude methanol extract of leaves (25.82 µgm/ml) and methanol fraction of leaves (22.28 µgm/ml) showed a very promising cytotoxic activity [22].

Central cholinergic activity in rats: Researcher has reported the alcoholic extract of roots of *C. ternatea* on spatial memory retention and associated changes in Acetylcholine (ACh) and Acetylcholinesterase (AChE) activity in the brain after electroshock or scopolamine induced amnesia. The preselected trained rats were administered with either alcoholic extract of *C. ternatea* or standard Shankhapushpi syrup for 10 days once a day. The animals of respective groups were subjected to electroshock or scopolamine treatment followed by radial arm maze task performance1 h after the last dose. Thereafter, the brain were immediately isolated and ACh as well as AChE levels were estimated. Study shows significant memory retention against scopolamine and electroshock induced amnesia in root extract treated rats. The extract was found to be more effective in scopolamine induced amnesia model. This action was found to be associated with significant decrease in AChE activity and increase in ACh content of whole brain in different regions of the brain compared to respective controls qualitatively [23].

Hypoglycemic Effect: The effect of orally administered aqueous extracts (400 mg/kg body weight) of *C. ternatea* leaves and flowers were examined in control and test group of rats on insulin, glycosylated hemoglobin and serum glucose. The aqueous extracts of *C. ternatea* leaves and flowers significantly ($P<0.05$) increased the liver and skeletal muscle glycogen, the activity of the glycolytic enzyme and glucokinase serum insulin but able to reduce the serum glucose, glycosylated hemoglobin and the activities of gluconeogenic enzyme, glucose-6- phosphatase. After all the biochemical tests, the group of leaf extract-treated rats indicated essentially the same profile as those treated with the group of flower extract [24].

Previously, the leaves and flowers of *C. ternatea* have been reported for antidiabetic property; hence current study is an attempt to evaluate the antidiabetic potential in seeds of *C. ternatea.* Methods: Preliminary phytochemical investigations of Ethanol extract of seeds of *C. ternatea* Linn. was done. The seed extracts were screened for hypoglycaemic activity in Streptozotocin induced diabetic rats (60 mg/kg, i.p.) at two dose levels like 200 mg and 400 mg/kg body weight. Results: Presence of various phytoconstituents in ethanolic extract viz. alkaloids, glycosides, saponins, tannins, phenolic compounds, carbohydrates, proteins, sterols, and flavonoids. The ethanol extract at 400 mg/kg.b.wt dose showed significant

decreased blood glucose ($p < 0.001$), cholesterol ($p < 0.05$), alkaline phosphatase ($p < 0.001$), aspartate amino transferase ($p < 0.001$) and alanine amino transferase ($p < 0.001$), when compared to diabetic control. Further study is required to isolate active phytoconstituents from ethanolic extract of seeds of *C. ternatea* Linn [25].

Neurogenic potential: In Indian Ayurvedic system of medicine, extracts derived from *C. ternatea* Linn have been used as an ingredient of "Medhya rasayana", intentionally used for improving memory and longevity in humans and also in treatment of various neurological conditions. Our earlier experimental studies with oral intubation of *C. ternatea* aqueous root extract had shown significant increase in learning and memory of postnatal and young adult Wistar rats. In the present study we were designed to elucidate the *in vitro* effects of 200 mg/ml of *C. ternatea* aqueous root extract on proliferation, differentiation and growth of anterior sub ventricular zone neural stem cells derived from prenatal and postnatal rat pups. Results shown significant increase in proliferation and increase in the yield of differentiated neurons of a SVZ neural precursor cells at 7 days *in vitro* and growth of neurospheres when treated with 200 ng/ml of *C. ternatea* aqueous root extract as compared to age matched control. Results indicate that CTR has growth promoting neurogenic effect on a SVZ neural stem cells and their survival similar to neurotrophic factors like Survivin, Neuregulin 1, FGF-2, BDNF possibly the basis for enhanced learning and memory [26].

Proteolytic activities: The activities of endopeptidases (pH of hemoglobin is 3.5 and pH of azocasein is 6.0), carboxypeptidase (pH of CBZ-Phe-Ala is 5.2), and arylamidases (pH of LPA is 7.0 and pH of BAPA is 7.6) were assayed in extracts of cotyledons and axis of resting and germinating seeds of *C. ternatea* L. All the activities were low in resting seeds but the endopeptidases at pH 3.5 and the arylamidase at 7.0 were high in cotyledons. The activities of endopeptidases showed an increase at the day 3 followed by a decrease, while the carboxypeptidase and the arylamidases increased in cotyledons reaching a maximum at the day 9. In the axial tissue the endopeptidases and carboxypeptidase activities showed an increase until the day 9 followed by a decrease and the arylamidases were low. The increase of acidic endopeptidase and carboxypeptidase activities in germinating cotyledons has been suggested as an indication of their participation in the degradation of the storage proteins [27].

Wound healing activity: The effects on wound healing were investigated using excision, incision and dead-space models in rats. Seed and root extracts significantly improved wound healing property when administered orally by gavages as well applied topically as ointment which are comparable to that of cotrimoxazole ointment. The finding of this study suggested that plant possesses effects on all three phases of wound healing: inflammatory, proliferative and remodeling phase [28].

Larvicidal activity: Screening of natural products for mosquito larvicidal activity against three major mosquito vectors *Aedes aegypti, Anopheles stephensi,* and *Culex quinquefasciatus* resulted in the identification of three potential plants extracts viz., *Saraca indica/asoca, Nyctanthes arbortristis,* and *C. ternatea* for mosquito larval control. In the case of *S. indica/asoca*, the chloroform extract of the bark and the petroleum ether extract of the leaves were effective against the larvae of *C. quinquefasciatus* with respective LC_{50} values 227.9 and 290.5 ppm. The LC_{50} values of chloroform extract of *C. ternatea* leaves were 302.2, 517.2, and 422.2 ppm against *A. aegypti, A. stephensi,* and *C. quinquefasciatus*, respectively. The methanol and chloroform extracts of flowers of *C. ternatea* showed larvicidal activity against larvae of *A. stephensi* with the respective LC_{50} values of 245.4 and 748.7 ppm. Among the methanol extracts of *C. ternatea* leaves, roots, flowers, and seeds, the seed extract was effective against the larvae of all the three species with LC_{50} values 66.2, 155.5, and 55.4 ppm, respectively, for *A. stephensi, A. aegypti,* and *C. quinquefasciatus*. Among the three plant species studied for mosquito larvicidal activity, *C. ternatea* was showing the most promising mosquito larvicidal activity [29].

Enhancementof acetylcholine content in rat hippocampus: Significant increase in Acetylcholine (ACh) content in hippocampi as compared to age matched controls after the

treatment with 100 mg/kg of *C. ternatea* aqueous root extract (CTR), for 30 days in neonatal and young adult age groups of rat. Increase in ACh content in their hippocampus may be the neurochemical basis for their improved learning and memory [30].

Antipyretic activity: Evaluation of anti-pyretic potential Of Methanolic Extract of *C. ternatea* L. Root (MECTR) of blue flowered variety (Family: Fabaceae) on normal body temperature and yeast-induced pyrexia in albino rats. Increase in rectal temperature was observed after 19 hours of Yeast suspension (10 ml/kg body wt.) subcutaneous injection. The extract produced significant reduction in normal body temperature at doses of 200, 300 and 400 mg/kg body wt., p.o., and yeast-provoked elevated temperature in a dose-dependent manner. The effect extended up to 5 hours after the drug administration. The anti-pyretic effect of the extract was comparable to that of paracetamol (150 mg/kg body wt., p.o.), a standard anti-pyretic agent [31].

Effects on growth and morphogenesis of *Aspergillus niger:* *The extract showed a favorable antifungal activity against A. niger with a minimum inhibition concentration 0.9 mg/mL and minimum fungicidal concentration 1.7 mg/mL, respectively. The leaf extract exhibited considerable antifungal activity against filamentous fungi in a dose-dependent manner with 0.5 mg/mL IC_{50} value on hyphal growth of A. niger. The main changes observed under scanning electron microscopy after C. ternatea extract treatment were loss of cytoplasm in fungal hyphae and the hyphal wall and its diameter became markedly thinner, distorted, and resulted in cell wall disruption. In addition, conidiophore alterations were also observed when A. niger was treated with C. ternatea leaf extract [32].*

The effect of leaves extracts against the fish pathogens: The extracts of *C. ternatea* was tested against *P. aeruginosa, E. coli, K. pneumonia, B. subtilis, A. formicans, A. hydrophila* and *S. agalactiae* by the agar well diffusion method. Different extracts of *C. ternatea* showed inhibitory effects against *P. aeruginosa, E. coli, K. pneumonia, B. subtilis, A. formicans, A. hydrophila* and *S. agalactiae*. Ethyl acetate extracts of *C. ternatea* showed maximum of zone of inhibition against *A. formicans* (19 mm), *A. hydrophilia* (20 mm), *B. subtilis* (20 mm) and *P. aeruginosa* (22 mm) next to that ethanol extract of *C. ternatea* showed *A. formicans* (19 mm) and *E. coli* (15 mm) followed by Acetone extract showed maximum zone of inhibition *S. agalactiae* (20 mm) and *K. pneumonia* (19 mm) [33].

Hepatoprotective activity: The methanol, chloroform, and petrolium ether extracts of roots of blue and white flowered varieties of *C. ternatea* (CT) were found to have hepatoprotective property. This was assessed by evaluating their hepatoprotective potential against Carbon Tetrachloride (CCl_4) induced hepatotoxicity in rats. Methanolic extracts of roots of blue and white flowered varieties at dose 250 and 500 mg/kg b. w. were showed significant ($P<0.001$) reduction in the serum TB level. The white flowered variety of CT showed much more reduction in TB level as compared to blue flowered variety of CT [10]. Hepatoprotective activity of *C. ternatea* seed and root and *Vigna mungo* seed against acetaminophen- and carbon tetrachloride-intoxicated rats was investigated. *C. ternatea* and *V. mungo* seed extracts significantly ($p<0.05$) decreased SGOT, SGPT, ALP and Total Bilirubin (TB) in both acetaminophen and CCl_4 - intoxicated rats. The *C. ternatea* root extract, showed similar results only in CCl_4 - intoxicated rats. These findings were further supplemented by histopathological studies of liver tissues. Hepatic collagen content as evident from decreased ($p<0.05$) hydroxyproline levels and hepatic mast cell infiltration were significantly decreased in extracts pre-treated animals. In addition, *C. ternatea* and *V. mungo* seed extracts significantly ($p<0.05$) reduced hepatic lipid peroxidation as evident from the decreased MDA, increased antioxidant enzymes activities and GSH levels in the liver tissues. The findings of study suggested that *C. ternatea* and *V. mungo* possess potent hepatoprotective activity. The hepatoprotective activity of *C. ternatea* could be attributed to antioxidant properties and prevention of pre-inflammatory changes [34].

Antioxidant activity: The chemical composition of the flowers of *C. ternatea* suggest that they may have antioxidant activity, ethanopharmacological evidences shows that

the extracts of *C. ternatea* (butterfly pea) flowers are used in Thailand as a component of cosmetics. The aqueous and ethanolic extract of *C. ternatea* was found to have antioxidant potential. Aqueous extracts were shown to have stronger antioxidant activity than ethanol extracts (IC_{50} values were 2 mg/mL and 5 mg/mL, respectively). This was assessed by performing DPPH scavenging activity test. The total phenolic content was 2.0 mg/g extract as gallic acid equivalents. The data from this study support the use of *C. ternatea* extracts as antioxidant inclusions in cosmetic products [35].

***In-vitro* cytotoxic activity:** This study evaluates the *in-vitro* cytotoxic effect of petroleum ether and ethanolic flower extracts of *C. ternatea* Linn by using trypan blue dye exclusion method. Both extracts exhibit significant cell cytotoxic activity. For both the extracts decrease in cell count was observed with increase in concentration of the extract. There was a dose dependent increase in cytotoxic activity for all the concentrations tested [36].

Anti-inflammatory, analgesic and antipyretic Properties: *C. ternatea* roots methanol extract when given by oral route to rats was found to inhibit both the rat paw oedema caused by carrageenin and vascular permeability induced by acetic acid in rats. Moreover, the extract exhibited a significant inhibition in yeast-induced pyrexia in rats. In the acetic acid-induced writhing response, the extract markedly reduced the number of writhings at doses of 200 and 400 mg/kg (p.o.) in mice [3].

Conclusion and Future Perspectives

Nature has been a source of medicinal agents since time immemorial. The plant kingdom harbors an in exhaustible source of active ingredients invaluable in the management of many intractable diseases. They are well known in traditional herbal medicine for their diseases curing property. Aparajita is one of the herbs mentioned in all ancient scriptures of Ayurveda. *C. ternatea* belongs to family 'Fabaceae'; is cultivated throughout India. It is a perennial twing herb; steams are terete, more or less pubescent and persistent legume found in India, China, Philippines and Madagascar etc. It is native to tropical Asia and widely distributed thought the world mainly in tropical countries. It is a very common garden flower plant found all over India especially in southern India. Butterfly pea is recognized as being adapted to clay soils. It is reported to be a good "Medhya" (brain tonic) drug and, therefore, mainly used in the treatment of "Masasika" roga (mental illness). In Ayurveda, the roots, seeds and leaves of *C. ternatea* have long been widely used as a brain tonic and is believed to promote memory and intelligence. *C. ternatea* has been widely screened for its various pharmacological activities especially well documented for neuropharmacological action. The root and root barks are used in ascathartic, diuretics and has laxative effects. Juice of roots is used in the treatment of chronic bronchitis. The leaves are useful in otalgia and hepatopathy, whereas seeds are cathartic. The flowers and leaves are used to make collyrium, leaves are also used to relieve joint pain in arthritis, and hepatic disorder, the seeds have laxative effects, and are cathartic, and it contains antifungal proteins. *C. ternatea* plant has the most promising mosquito larvicidal activity. *C. ternatea* have number of pharmacological activities such as possessing nootropic, anxiolytic, antidepressant, anticonvulsant, sedative, antipyretic, anti-inflammatory and analgesic activities, memory enhancing, acetylcholine content increasing and acetylcholinesterase activity. Future scope of present investigation is isolate active phytoconstituents which is responsible for various pharmacological activities. The detailed chemical natures and structure of the active principles responsible for its activity are not known. Hence, further studies should be carried out to elucidate the active principles of *C. ternatea*.

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