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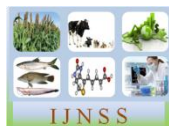
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Phytochemistry and pharmacological activities of *Clitoria ternatea*

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ARTICLE INFO

Article history

Accepted 03 Jan 2017

Online release 09 Jan 2017

Keyword

Clitoria ternatea

Morphology

Phytochemistry

Pharmacological activity

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ABSTRACT

Clitoria ternatea is a twining herbal medicinal plant mostly found in Asia. Various constituents are found in different parts of the plant. The plant *Clitoria ternatea* is traditionally used for food coloring, stress, infertility and gonorrhoea. The plant has been widely used in Ayurveda. Pharmacologically it is an anxiolytic, anti-inflammatory, analgesic, anti-microbial and anti-carcinogenic. It is also CNS depressant, nephroprotective and has anti-stress activities. Generally *Clitoria ternatea* has larvicidal activities, proteolytic activities, antihelmintic activities, antihyperglycemic activity, diuretic activity, antioxidant activity, antihistaminic activity and treat goiter. As *Clitoria ternatea* plant has great usefulness it should be cultivated, conserve and further research should be conducted for human well-being. This article will focus on pharmacological characterization of *Clitoria ternatea* with the traditional and pharmacological uses of *Clitoria ternatea*.

INTRODUCTION

Plants and herbs have been an important contributor to the quality of human life for thousands of years. Some of them are well known medicinal herbs. Butterfly pea or blue pea (*Clitoria ternatea*) from family of Fabaceae is a vine with vivid blue flowers 1 to 2 inches long, having wavy-rimmed standard and white centre, which is rather common in gardens of Hawaii (Neal, 1965). *Clitoria ternatea* flowers are commercially known as *Bunga telang* by the locals and are widely used as the food dyes in Nasi kerabu (the local dish in Kelantan, Malaysia) and a Baba and Nyonya kueh known as kueh tekan. *Clitoria ternatea* is a member of the family Papilionaceae; commonly known as 'Aparajita' or 'Girikarnika' (Ramaswamy et al., 2011). It is a perennial climber widely used in the traditional ayurvedic system of Indian medicine for treating a wide variety of diseases (Ramaswamy et al., 2011). In the traditional system of medicine, 'Aparajita' is considered as a 'Medhya' drug to improve intelligence and enhance memory

function (Ramaswamy et al., 2011). It is also used in the treatment of chronic bronchitis, dropsy, goiter, leprosy, mucous disorders, sight weakness, skin diseases, sore throat and tumors (Ramaswamy et al., 2011). The root powder is used as one of the ingredients in the preparation of the drug "SULAK" and its ointment to treat leprosy (Srivastava et al., 2009). Chemical identity comparison is made with standard allopathic anti-leprosy agents like clofazimine, dapsone, and rifampicin to assess their activity equivalence to treat leprosy by adopting Indian pharmacopoeial (IP) methods. Use of plant based drugs and chemicals for curing various ailments and personal adornment is as old as human civilization. *Clitoria ternatea* is used for curing various diseases and symptoms (Chauhan et al., 2012). The extracts of different parts of *Clitoria ternatea* showed different efficacy against the tested microorganisms. These differences could be due to the nature and level of the antimicrobial agents present in the extracts and their mode of action on the different test microorganisms (Barbour et al., 2004). The phytochemical constituents of these

plants revealed that various secondary metabolites like flavonoids, anthocyanin glycosides, pentacyclic triterpenoids and phytosterols have been isolated from this plant (Mukherjee et al., 2002). A protein designated as 'finotin' has been isolated from *Clitoria ternatea* seeds and reported to have antifungal, antibacterial and insectidal properties (Kelemu et al., 2004). It is possible that this compound was mainly responsible for the observed antimicrobial effects in this study (Kamilla et al., 2009). The plant *Clitoria ternatea* has not received much attention as antioxidant sources or sources of medicinal uses compared to others plants due to the lack of cumulative information about it. The cumulative information on morphological and chemical characteristics of this plant will be helpful for many new medical treatments. This article will focus on pharmacological characterization of *Clitoria ternatea* with the traditional and pharmacological uses of *Clitoria ternatea*.

Clitoria ternatea

Synonyms

Bengali: Aparajita, English: Butterfly pea, blue pea vine, mussel- shell climber, pigeon wings, Sanskrit: Sankhapushpi, aparajita, saukarnika, ardrakarni, girikarnika, supuspi, mohanasini, vishadoshaghni, shwetanama, Vishnukranta, ashwakhura, Hindi: Koyala, Telugu: Dintena, Malayalam: sangupushpam, Kannada: Nagar hedi, Marathi: Gokarna, Portuguese: Fulacriqua, (Pendbhaje, 2011).

Morphology

Drug generally occurs in the form of leaves and leaflets, rachis broken with or without intact leaflets; it is a perennial twining herb having 7 leaflets, which are elliptic and obtuse (Figure 1). Leaves are pinnate 5-9 foliolate. Flowers are showy, blue or white petals are unequal, style bearded below the stigma. Fruits pods are linear and compressed. The pods are 5-7 cm long, flat with 6 to 10 seed, in each pod. Seeds are 6-10 and black in color. Plant flowers in rainy season and fruits in winter. *Clitoria purpurea* has dark blue colored papilionaceous flowers and *Clitoria*

ternatea has creamy white coloured flowers which are solitary and very attractive.



Figure 1
Morphology of *Clitoria ternatea*.

Traditional use

Clitoria ternatea is known as Aparajita in Bengali which is used as a well known Ayurvedic medicine. All the part of the herb (leaf, root, shoot) is used as medicine. In traditional Ayurvedic medicine, it has been used for centuries as a memory enhancer, nootropic, antistress, anxiolytic, antidepressant, anticonvulsant, tranquilizing and sedative agent (Mukherjee et al., 2008). It is also used in neurological disorders (Gupta et al., 2010). Some other traditional uses are given in Table 1.

Table 1
Traditional uses of *Clitoria ternatea*.

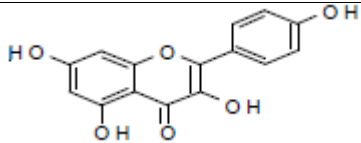
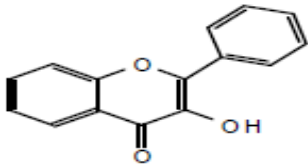
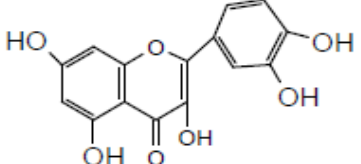
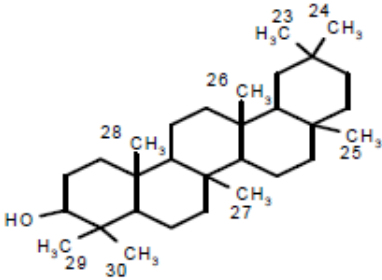
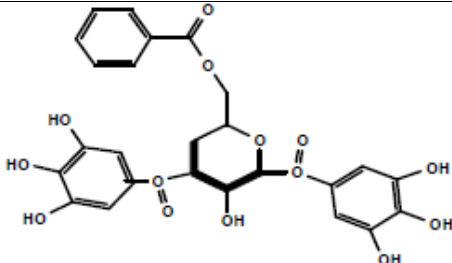
Useable part of <i>Clitoria ternatea</i>	Function	References
Flower	Color food	Jain et al., 2003
Root	Nootropic, anxiolytic, antidepressant, anticonvulsant and antistress activity	Jain et al., 2003
Whole plant	Treat sexual ailments such as: infertility and gonorrhea	Fantz, 1991
<i>Clitoria ternatea</i> extract	Heat stable function	Nguyen et al., 2011

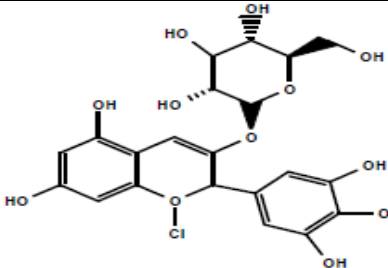
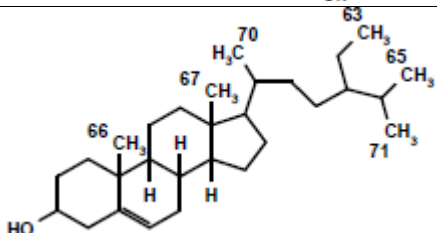
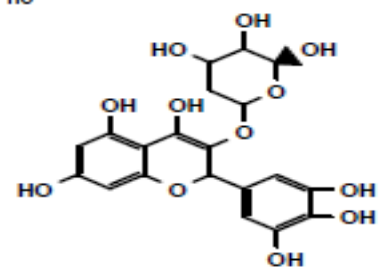
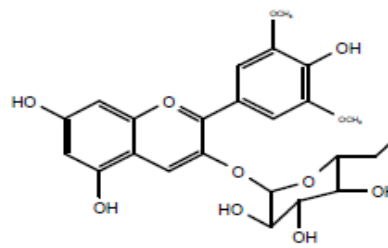
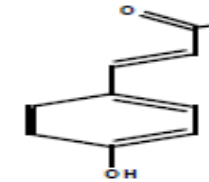
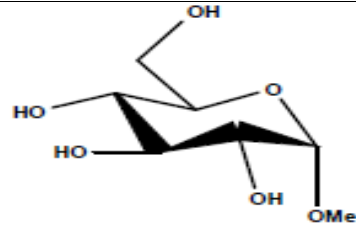
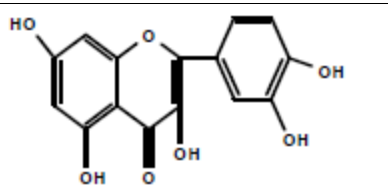
Phytochemical constituents

The major phyto-constituents found in the plant are the pentacyclic triterpenoids such as taraxerol and taraxerone (Banerjee et al., 1963; Banerjee et al., 1964). Ethanol extract of *Clitoria ternatea* shows presence of terpenoid, flavonoid, tannin and steroid which may act as antioxidant (Rai, 2010). The major phytoconstituents found in *Clitoria ternatea* are the pentacyclic triterpenoids such as

taraxerol and taraxerone. Phytochemical screening of the roots shows the presence of ternatins, alkaloids, flavonoids, saponins, tannins, carbohydrates, proteins, resins, starch, taraxerol and taraxerone (Trease and Evans, 1983). The Chemical compounds found in *Clitoria ternatea* given in Table 2. The function and phytochemical constituents of *Clitoria ternatea* were also shown in Table 3.

Table 2
Chemical compounds found in *Clitoria ternatea*.

Serial no	Name of the compound	Structure	References
1.	Kaempferol		Pendbhaje, 2011
2.	Quercetin		
3.	Myriceti		
4.	Taxaxerol		
5.	Tannic acid		

6.	3-monoglucoside		
7.	β -Sitosterol		
8.	Delphinidin-3,5-diglucoside		
9.	Malvidin-3 β -glucoside		Pendbhaje, 2011
10.	p-hydroxycinnamic acid		
11.	Ethyl- α -D-galactopyranoside		
12.	Anthoxanthin glucoside		

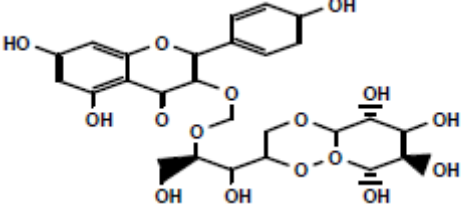
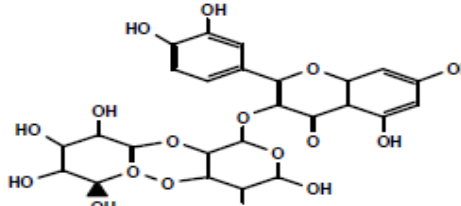
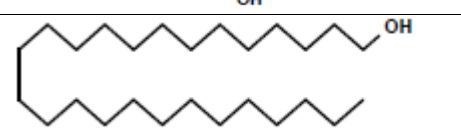
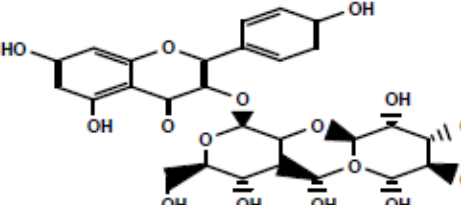
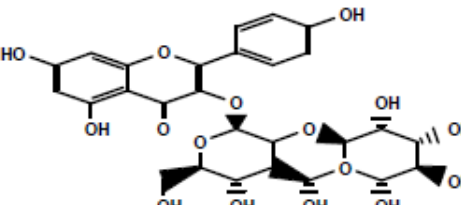
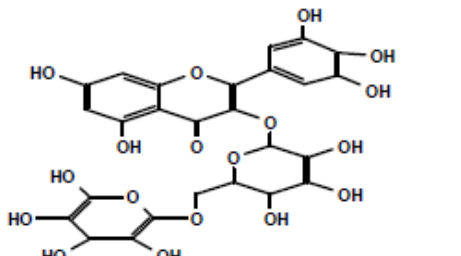
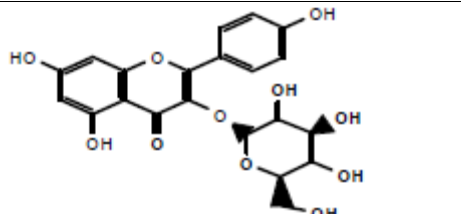
13.	Kaempferol 3-neohesperidoside		Pendbhaje, 2011
14.	Quercetin 3-neohesperidoside		
15.	Hexacosanol		
16.	Hexacosanol		
17.	Myricetin,3-neohesperidoside		
18.	Myricetin 3-rutinoside		
19.	Kaempferol 3-glucoside		

Table 3
Phytochemical constituents in *Clitoria ternatea*

Plant parts	Phytochemicals	Functions	References
Leaf	Alkaloids, reducing sugars, flavonoids, steroids, glycosides	1. Prevention of neurodegenerative diseases and diabetes mellitus 2. Effectively controls the excessive sweating	Scalbert et al., (2005) and Nadkarni, (1992)
Flower	Saponin, Tanin, Alkaloids, Glycosides, Phytosterols, Carbohydrads	1. Anti inflammatory, analgesic 2. Ethanol extract is used as antidiabetic	Srivastava et al., (2009) and Malic et al., (2008)
Root	1,1-diphenyl-2-picrylhydrazyl (DPPH)	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	Braca et al., (2002) and Kirtika and Basu, (1980).
Seed	The seeds contain nucleoprotein with its amino-acid sequence similar to insulin, delphinidin-3,3,5-triglucoside, essential amino-acids, pentosan, water soluble mucilage, adenosine, an anthoxanthin glucoside, greenish yellow fixed oil a phenol glycoside, 3,5,7,4-tetrahydroxy-flavone-3-rhamoglycoside, an alkaloid, ethyl D-galactopyranoside, p-hydroxy cinnamic acid polypeptide, a highly basic protein-finotin, a bitter acid resin, tannic acid, 6% ash and a toxic alkaloid.	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	Kirtika and Basu, (1980) and Yoganarasimhan, (2000).

Pharmacological studies

Anxiolytic activities

Oral treatment with alcoholic extract of *Clitoria ternatea* at a dose of 460 mg/kg significantly prolonged the time taken to traverse the maze as produced by chlorpromazine in rat (Chauhan et al., 2012) demonstrated significant effect on anxiety. The animals treated with *Clitoria ternatea* (100mg/kg) showed a significant increase in the inflexion ratio and discrimination index which provides evidence for the species nootropic activity.

Anti inflammatory and analgesic activity

According to Chauhan et al., (2012), the anti inflammatory, analgesic studies of petroleum ether extract (60-80°C) from the flowers of *Clitoria ternatea* showed that it exhibited significant anti

inflammatory activity at both the dose level (200 and 400 mg/kg body weight) ($P < 0.01$). The methanol extract of *Clitoria ternatea* showed a significant antipyretic activity. *Clitoria 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 (Devi et al., 2003).

Anti-microbial activities

The methanolic extracts of the leaves and root of *Clitoria ternatea* were tested for their antibacterial activity against different pathogenic drug resistant Gram-positive and Gram-negative clinical isolates (Chauhan et al., 2012). The leaf was found to possess powerful antibacterial activity against *Escherichia coli* and *Vibrio cholera*, known for causing dysentery, and *Staphylococcus aureus*, causative agent of fever. The leaf extract showed stronger antibacterial activity than root extract.

Both extracts were shown to be bactericidal in their mode of action. Quercetin may contribute to the activity of leaf extract. In another study, it was reported that crude extract from seeds of *Clitoria ternatea* showed maximum zone of inhibition (22 ± 0.5 mm) against *Escherichia coli* at 0.75 mg concentration and minimum (14 ± 1.0 mm) with *Micrococcus flavus*. The callus extract showed maximum zones of inhibition (16 ± 2 mm) against *Salmonella typhi* while the lowest with *Escherichia coli* and *Staphylococcus aureus* (12 ± 1 mm and 12 ± 0.9 mm respectively) (Mhaskar et al., 2010). Alcoholic and aqueous extracts from in vitro raised calli were tested for antibacterial activity by agar well diffusion method against Gram-negative bacteria. Antibacterial activity was shown against *Salmonella* spp. and *Shigella dysenteriae*; organisms causing enteric fever (Shahid et al., 2009). In addition, the methanol crude extracts showed anti-bacterial activity against *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* (Shekawat and Vijayvergia, 2010). The crude extract from seeds of *Clitoria ternatea* showed strong antimicrobial activity. This plant's root is specially used for leucoderma (Pendbhaje, 2011).

Anti carcinogenic activity

Recent reports have cited that plants and its components could act as tumor suppressor, apoptotic inducer in cancer cells and the most commonly used herbal medicine have tumor suppressing activity, interfere with cell cycle progression, enhance immune activity and suppress tumor angiogenesis (Devita, 1983). *Clitoria ternatea* extracts is well correlated with other reports from different plant extracts on cancer suppressing activity or anti carcinogenic activity (Ramaswamy et al., 2011). The purified lectin was found to be potential tool for cancer studies (Naeem et al., 2007).

CNS depressant activity

The *Clitoria ternatea* extract was found to possess nootropic, anxiolytic, antidepressant and anti-stress activities. The nootropic drugs facilitate intellectual performance, learning and memory (Gupta, 2010; Mukherjee, 2008). It has reported that *Clitoria ternatea* has tranquillizing effect on

the brain hence it is used in symptoms like syncope, vertigo and brain weakness. The *Clitoria ternatea* was studied for its effect on cognitive behavior, anxiety, depression, stress and convulsions. By using Pentylentetrazol (PTZ) and maximum electroshock (MES), the methanolic extract of *Clitoria ternatea* was found to possess nootropic, anxiolytic, antidepressant, anticonvulsant and antistress activity (Taranalli, 2003).

Nephroprotective

It is shown that the administration of ethanol extract of *Clitoria ternatea* has nephroprotective potential against APAP-induced nephrotoxicity. It provides experimental evidence that *Clitoria ternatea* augmented the myocardial antioxidant enzymes level, preserved histoarchitecture and improved cardiac performance following APAP administration reported in evaluation of phytoconstituents, nephro-protective and antioxidant activities of *Clitoria ternatea* by Sarumathy et al. (2011).

Anti-stress activities

The anti-stress activity of aerial parts was assessed using cold restraint stress (CRS) induced ulcers, lithium-induced head twitches, clonidine-induced hypothermia, sodium nitrite-induced respiratory arrest and haloperidol-induced catalepsy in rat and mice (Chauhan et al., 2012).

Effect on general behavior

Ethanol extract of the root of *Clitoria ternatea* shows significant neuropharmacological activity (Gupta, 2010).

Larvicidal activities

Clitoria ternatea showed the most promising mosquito larvicidal activity. The methanol extracts of *Clitoria ternatea* seed extract was effective against the larvae of all the three species with LC₅₀ values 65.2, 154.5 and 54.4 ppm, respectively for *Anopheles stephensi*, *Anopheles aegypti* and *Culex quinquefasciatus* (Chauhan et al., 2012 and Pendbhaje, 2011).

Proteolytic activities

The activities of endopeptidases (hemoglobin pH 3.5 and azocasein pH 6.0) carboxypeptidase benzyloxy carbonyl (CBZ-Phe-AlaPh5.2), arylamidases lysophosphatidic acid and a-N-benzoyl-L-arginine P-nitro-analide (LPA 7.0 and BAPA 7.6) were observed in extracts of cotyledons and axis of resting and germinating seeds of *Clitoria ternatea* but the endopeptidases at pH 3.5 and the arylamidase at 7.0 were high in cotyledons (Chauhan et al., 2012). The activities of carboxypeptidase and the arylamidase increased in cotyledons reaching a maximum at the day 9, while the endopeptidases showed an increase at the day 3 followed by a decrease (Chauhan et al., 2012). In the axial tissue the endopeptidases and carboxypeptidase activities showed an increase until the day 9 followed by a decrease and arylamidase were low. The increase of acidic endopeptidases and carboxypeptidase activities in germinating cotyledons is an indication of their participation in the degradation of the storage proteins.

Antihelmintic activities

There are so many studies which have been reported on antihelmintic activity of *Clitoria ternatea*. It was indicated that crude alcoholic extract of *Clitoria ternatea* and its ethyl acetate and methanol fractions significantly demonstrated paralysis and also caused death of worms especially at higher concentration of 50 mg/ml, as compared to standard reference piperazine citrate (Chauhan et al., 2012). Inhibitory effect of *Clitoria ternatea* leaves on free-living nematodes was evaluated using aqueous and methanol extract. In another study, flowers, leaves, stems and roots of *Clitoria ternatea* were evaluated for antihelmintic activity on adult Indian earthworms *Pheretima posthuma*. Methanol extract of root is most potent and required very less time to paralysis and death of worms as compared to other extracts. The potency increases from flowers, leaves, stems to roots (Chauhan et al., 2012). Methanol extract of the *Clitoria ternatea* root shows anthelmintic activity is might be because of active principles present in methanol extract of the root (Pendbhaje, 2011).

Antihyperglycemic

Clitoria ternatea showed antihyperglycemic activity reported by Patil et al., (2011).

Effect on digestive system

It is an antiemetic, antidyspeptic 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 (Pendbhaje, 2011).

Diuretic activity

The powdered form of dried whole root and ethanol extract were evaluated for diuretic activity and only single I.V. dose of extract produce moderate increase in urinary excretion of Na, K and decrease in Cl but no change in urine volume. Also, an appreciable effect was seen on oral dosing (Chauhan et al., 2012).

Urinary system

Clitoria ternatea increases urination. Decoction is used in dysuria and urinary troubles even in cattle, ulcer and antidotal properties (Pendbhaje, 2011).

Antioxidant

Extracts of *Clitoria ternatea* (butterfly pea) flowers are used in Thailand as a component of cosmetics and the chemical composition of the flowers suggest that they may have antioxidant activity. The aqueous extracts of *Clitoria ternatea* were shown to have stronger antioxidant activity than ethanol extracts (Kamkaen and Wilkinson, 2009).

Antihistaminic

Clitoria ternatea showed antihistaminic activity using clonidine and haloperidol induced catalepsy in mice (Taur and Patil, 2011). Besides this *Clitoria ternatea* is also used in the treatment of filariasis, eye infections habitual abortion, to control menstrual discharge. The roots of white variety of this plant mashed in milk are given orally to avert the abortion and stabilize the foetus. The plant is considered as a good brain tonic and

'Sankhapushpi' one of the formulations in Ayurveda consists of the roots and seeds of *Clitoria ternatea* and is used as a 'tonic of the nerves', alterative and laxative. It is also used to cure sexual ailments. Extracts of *Clitoria ternatea* have been used as an ingredient in 'Medhya Rasayana' a rejuvenating recipe used for treatment of neurological disorders and considered as wholesome for intellect. The juice of its leaves mitigates the toxins. The fresh leaves juice, combined with ginger juice, effectively controls the excessive sweating (Pendbhaje, 2011).

Effect on circulatory system

Being haemostatic and blood purifier, it is useful in haemorrhagic disorders and gout (vatarakta). Hot infusion of prickly plant (dhamasa) is given to prevent small pox (Neelamma et al., 2016).

Respiratory system

It is used in common cold, cough, asthma as it acts as an expectorant and reduces the irritation of respiratory organs. Besides this, whole plant is used for smoking. Decoction is used for gargling in throat manifestations. The sticky phlegm in cough and asthma is relieved, when the root juice with milk is given. It is also capable of curing whooping cough if taken orally (Neelamma et al., 2016).

Effect on miscellaneous diseases

It has also been reported that the extract from the white-flowered plant can cure goiter (Pendbhaje, 2011). The juice of the root of white flowered variety is blown up the nostrils as a remedy for hemicranias (Pendbhaje, 2011).

CONCLUSION

Clitoria ternatea is not only a wild herb but also a medicinal plant. It has so many traditional usages as well a number of medicinal usages. Even, it is useful in treatment of some incurable diseases such as cancer, neurological disorder, nephrological disorder, hyperglycemia, urinary disorder, goiter, respiratory disorders etc. The exploring the active component of this plant responsible for the pharmacological activities

along with their mode of action will be guided by the accumulative information presented in this article.

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