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Butterfly Pea Flower: A Blue Bloom with Multifaceted Health Benefits

Gauri S. Salunke, NidaN. Mulla, Sanjay k. Bais
Fabtech college of pharmacy sangola, Dist. Solapur, Maharashtra 413307

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ABSTRACT
In both industrialized and developing nations, herbal medicine has become more and more popular in recent decades as a means of treating chronic illnesses. The evergreen herb C. pluricaulis, also known as thin-leaf and ground - hugging Forsk., is used as a traditional folk cure for a multiple medical issues . To find material regarding C. pluricaulis for this article, we conducted electronic searches using PubMed, SciFinder, and Google Scholar.This comprehensive review clarifies the phytochemistry, neuropharmacological, toxicological, and plant profile data of C. pluricaulis. The wholeherb and it's biochemical metabolite demonstratebeen shown to have a variety of neuropharmacologicaleffects observed in in-vivo in-vitro models such as, antidepressants, stress- relieving, neuroprotective, lowering inflammation, pain relief ,preventing seizure, and cognition enhancing action. These effects include memory enhancement, anxiolytic, and tranquilizing qualities. The secondary metabolites of C. pluricaulis interact with a variety of proteins, neurosynapses, signaling pathways, and serotonin-rgic synapses, which are important for neurotransmission, Alzheimer's disease, chronic depression, alcohol addiction, neurological deficits, mental health condition,and elevated serotonin concentration within synaptic region.

Key word: Clitoria ternatea,Butterfly pea ,Herbal medicine ,Phytochemistry ,Cognitive enhancement

I. INTRODUCTION

Often referred to as Butterfly pea (Clitoria ternatea) is characterized by its perennial growth habit. leguminous twiner which is Originating from equatorial regions of eastern world (Asia) . It became widely distributed across Southern Region and mid-american region,the East zones and Caribbean's island India, China, where it has established a native plant.Laxative, purgative, diuretic, inflammatory, indigestion, constipating, fever, arthritis, eyesight issues, and anthelmintic properties have all been applied to the root portion of C.ternatea[1,2,3]The striking blue color of Clitoria ternatea's petals is its most noticeable feature. Growing food and safety consciousness has led to new study areas, with the use of naturally occurring colorants from different plant-based sources being suggested as a healthy substitute for harmful synthetic dyes.As a leguminous plant, it derives from a mutualistic relationship together with soil microbes called underground stems , that converts atmospheric nitrogen into unstable form that is unstable for plants (a process known as nitrogen-fixation). As a result, this plant is utilized to enrich the soil quality by breaking down nitrogen-rich plant matter.The striking blue color of Clitoria ternatea's petals is its most noticeable feature. The addition of naturally occurring colorants from various plant-based fibrous root structure sources is advised as a healthy substitute for harmful synthetic dyes, and the increased awareness of food safety has opened up new study [4, 5,6].

Soiland climate parameters:It is well adapted in good loamy surface layer with aclustered root system,well-drained soil.Despite being easy to cultivate the plant has relatively short life span and , as a tropical species, it flourishes under moderate watering conditions (700–1500 mm) starting at 19° and 28° C. Furthermore, even in droughty conditions, this plant may live for seven to eight months. (Oguis and others, 2019)Clitoria ternatea (CT) goes by several names, including "blue pea," "butterfly pea," "bluebell," "Cordofan-pea," "Chandra kanta," Gamage, Vidana, et al., 2021[7, 8].

Plant profile:

- **Morphology:**

The species Clitoria ternatea's taxonomical classification

Kingdom	**Plantea**
Category	Angiosperm
Group	Dicotyledons
Taxonomic subgroup	Rosid group
Taxonomic order	Parables
Group of related genera	Leguminous
Sub division of	Faboideae

International Journal of Pharmaceutical Research and Applications
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family	
Genius	Butterfly pea genus
Organism group	Butterfly blue pea

- **Primary nutrients found in butterfly pea flower:**

The strinking blue shade is exihibited by the petals of butterfly pae floweris due to the arrival of ternatin, andflavonoid pigment component. In-vitro studies indicate that ternatin possess anti inflammatory properties and may inhibit cancer cell formation[9, 10].

The plant additionally possesses several other antioxidant compounds including :

A)Flavonol compound: whose ability to fight cancer has been well investigated. According to studies done in test tubes, it might stop cancer cells from growing.

B) P-coumaric acid: This component's antiviral, antibacterial, and anti-inflammatory properties may aid in illness prevention.

C)Delphin-3,5-glucoside: This antioxidant may increase immunity and promote colorectal cancer cell death.

- **Parts of Clitoria ternatea plant:**

Under ideal circumstances, butterfly peas produce 25–30 tons of dry materials per acre annually. The C. ternatea plant is used to manufacture herbal drinks that are a great source of calcium because of its high calcium content [11, 12].

- **Leaf:**

In addition the botanicalfoliage butterfly pea flower yield , a variety of phytochemicals, including catechol, quinines, gum, mucilage, protein. Comparing aqueous extracts to other solvents, such as acetone, the majority of the compounds were found. Another investigation found the leafy part of blue petaled plant contained quinines, andmucilage[13, 14].

F.1 Leaves of Clitoria ternatea

Revealed that the hydromethanolic extract of C. ternatea leaf extract contained protein, carbohydrates,saponins, , alkaloids, steroids, phenols, and glycosides. The extract prepared with methanol of the butterfly pea foliage contained minor levels of alkaloids, terpenoids, and phenols in addition to tannin and glycosides, according to another initial phytochemical screening research. 18 Chandra and associates[15, 16].

- **Seed:**

p-hydroxycinnamic acid, are among the many metabolites found in C. ternatea seeds. 8,14 Another study also revealed that the seeds of C. ternatea contain phenolic chemicals, alkaloids, glycosides, sterols, protein, carbohydrates, flavonoids, and saponins.

F.2 Seeds of clitoria ternatea

- **Root:**

Numerous phytochemicals are present in the root. Numerous researches studied and determined various functional components found in roots. .[17,18].Also identified taraxerol from C. ternatea root by employing a hydroalcoholic extract. [19,20].A study revealed that the root extract prepared with ethanol of butterfly pea flower made using the continuous hot solvent extraction method contained phenolics, flavonoids, alkaloids, glycosides, and tannins.Several phytoconstituents, including alkaloids, flavonoids, steroids, carbohydrates, coumarins, and resin, were identified by Almeida and colleagues in first analysis of plant bioactive compound studies a hydroalcoholic of the root of butterfly pea flower.[21, 22]. revealed a existence the number of substances, includingphenolics, alkaloids, terpenoids, an extract prepared with ethanol of butterfly pea flower seeds. .[23 24].The protein

International Journal of Pharmaceutical Research and Applications
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content of the leaves is 21.5-29% while the fiber content is 21.5%.

Fig.3 Roots of Clitoria ternatea

β-sitosterol and aparajitin are also present. The blue-colored blossoms include cynidin chloride, kaemferol L, malvidin, 3β-glucosides, An aparajitin lactone derived from leaves.

Flower

Instead of an alteration as part of chemical structure delphinidin, researchers discovered. This constitute due to a fact that the Compound makeup the various anthocyanins found in the flower is largely what gives the petals their diverse colors. For instance, it was discovered blue' line flowerflower. [25,26].

Discovered lipophilic substances. In the meantime, Zakaria et al. 31 demonstrated the presence of additional substances in addition to anthocyanins. Escher and associates.

The protein content of the leaves is 21.5-29% while the fiber content is 21.5%. β-sitosterol and aparajitin are also present. The blue-colored blossoms include cynidin chloride, kaemfero L, malvidin, 3β-glucosides, An aparajitin lactone derived from leaves

Fig.4 flower of clitoria ternatea

- **Chemical Composition Of butterfly pea flower:**

Additionally, the flower was discovered to contain significant levels of magnesium zinc, sodium and iron .The bioactive substances examined, identified, and isolated in a number of investigations. cyclotides, and flavonol glycosides are all present in the hydrophilicfloral extract. In the meantime, solvent loving contained terpenoids, alkaloids, and fatty acids.

- **Biological Composition butterfly pea flower:**

The flowers are said to include ternatin anthocyanins as well as several flavanol glycosides including myricetin, quercetin, and kaempferol. The pinnate leaves have five to seven leaflets and are eliptic-oblong.

- **Structural features**

It can grow in gardens or in the wild and has noticeable blue or whiteflowers that resemble conch shells. The root system is made up of numerous thin lateral roots and a rather robust taproot with few branches. One to numerous purplish, glaucous, wiry stems are attached to the thick horizontal root, which can reach a length of over two meters. The pinnate leaves have petioles that are linear, and sharp.Stipules filiform; subcoriaceous, 2.5-5 by 2-3.2 cm, elliptic-oblong, obtuse, or caute. The flowers have an orange center, are 4-5 cm long, solitary, deep blue to blue, mauve, or occasionally white, and have a very short pedicellate. With up to ten seeds, the flat, linear, beaked pods are 6–12 cm in length, 0.7–1.2 mm in width, and are somewhat pubescent. The seeds are subglobose or oval in shape, 4.5-7.0 mm long, and 3-4 mm wide. [27, 28,29].wd

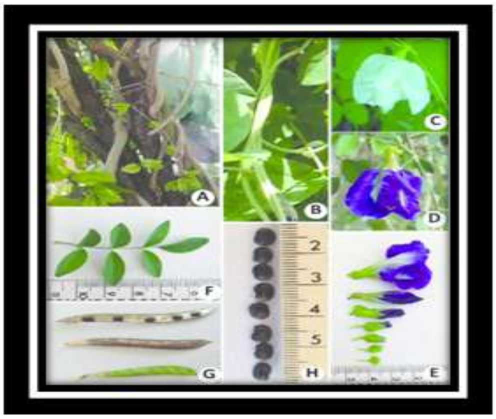

Fig.5 **Morphological Characters**

International Journal of Pharmaceutical Research and Applications
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❖ **Materials and methods:**

- **Design of the Study.**

Since bright blue petals of butterfly pea flower underwent spray drying, the research was performed in two sequential stages.stage I involved the production and characterization of the spray-dried powder, while

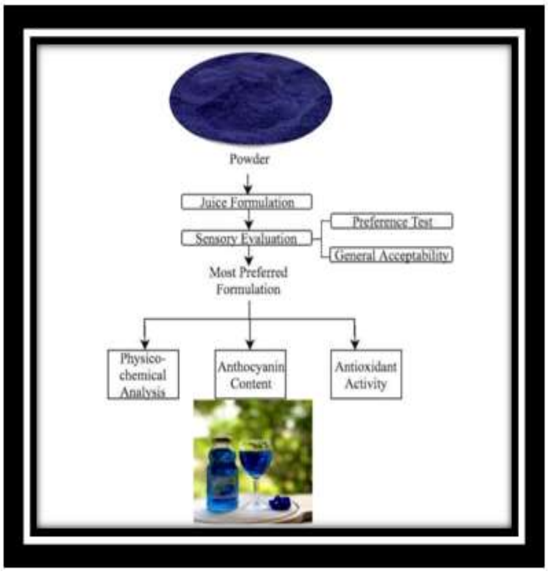

Fig.6formulation of BJP from spray-dried powder

Phase II, which employed a Experimental layout with randomized block **focused on evolution of extract of butterfly pea flower(BPJ)derived from the powder (Figure 2).**

- **Production of Butterfly Pea Powder**

Harvesting of BPF: Locations of —the BPF were gathered at random with regard to date, time, and harvesting technique. The only double petaloid type that was gathered was blue. In order to preserve moisture and keep the temperature low, it was gathered in full bloom in the morning and put in a thermochest right away. Additionally, it keeps the plant fresh, avoids sun exposure, and stops wilting.

- **Collection of BPF:**

Butterfly pea flowers (BPF) were collected randomly from four locations in Iloilo—Oton, Lapaz, Pavia, and City Proper—without consideration of the specific date, time, or harvesting method. Only the double-petaloid blue variety was selected. Flowers were harvested at full bloom in the morning to maintain low temperature and moisture levels, then immediately stored in a thermochest to retain freshness, prevent sunlight exposure, and avoid wilting.

- **Selection of BPF:**

Only high-quality petals—those without cuts, bruises, or discoloration—were processed for drying. According to quality standards, acceptable petals were double-petaloid, uniformly blue, of consistent size, fully bloomed, and free from visible defects. After sorting, the ovules, stamens, and sepals were removed (Figure 3). The anthocyanins used for powder production were primarily extracted from these selected petals.

- **Steam Blanching:**

To preserve the petals' color and deactivate the enzymes, the steam blanching procedure was used. Water was first brought to a boil in a kettle, floral segment were put inside set two to three inches over the boiling water. The steam blanching process lasted four to six minutes.

- **Packaging and Storage:**

A polypropylene vacuum bag measuring 8 by 13 inches was used to collect the powder. A mechanical sealer was then used to seal it. The powder was wrapped in foil, placed in a sealed vacuum bag, and kept shadowy area.

- **Study of powder quality:**

The BPP's fat content was ascertained using the Soxhlet method of AOAC. Kjeldahl's technique was used to analyze crude protein. A Kjeltec 2100 distilling unit was used for rapid distillation, while a Foss Digestor 2006 digestion unit was employed for the digestion process. The gravimetric method was used to determine the powder's crude fiber content. Crude ash was calculated using the AOAC technique[30].

- **Isolation:**

A butterfly pea petals were homogenized and filtered to produce the extract. The extraction procedure was extremely important since, in order to create powder of the highest quality, maximizing the utilization of anthocyanins in the flower petals was necessary.

- **Filteration:**

The liquid was strained using cheesecloth. The filtrate was run through a 60-mesh sieve to make sure the mixture included no particles that could harm the spray drier.

International Journal of Pharmaceutical Research and Applications
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- **Spray Drying**:

The spray dryer utilized in the study . The butterfly pea powder was collected from the outlet stream of the equipment after the extract was fed into the dryer's input line via an RS232 connection.

Titration was performed with a Eutech Cyberscan pH meter (RS232), and the endpoint was recorded at pH 8.1. Based on procedure outlined by Thao et al., the extraction solvent used for butterfly pea powder (BPP) consisted of 80% ethanol and 20% water. The absorbance of the resulting solutions was analyzed applying Shimadzu UVmini-1240 [31].

- **Using Butterfly pea powder for juice preparation**

A Randomized Complete Block Design (RCBD), where the formulations served as treatments and the runs represented blocks. Butterfly pea juice was prepared using varying concentrations of BPP:
Treatment 1: 0.01 g/mL of BPP in distilled water
Treatment 2: 0.02 g/mL of BPP in distilled water
Treatment 3: 0.03 g/mL of BPP in distilled water

The other ingredients—1000 mL distilled water, 115 g sugar, and 60 mL fresh calamansi juice—remained constant across treatments. These ingredients reflect standard components in Philippine juice formulations.

A preliminary sensory test involving 15 panelists helped refine the formulations. The main sensory evaluation was conducted in three sessions with 20 trained panelists each, who assessed the samples presented in coded cups. Participants were qualified individuals eligible for sensory evaluation training. The overall acceptability and preference ranking of BPJ samples were determined, followed by analyses of the most preferred formulation's physicochemical properties, anthocyanin content, and antioxidant activity.

- **Statistical Analysis**
- Color evaluation:

Twenty panelists carried out a descriptive color assessment of the BPP using a standardized color scale[32].

❖ **Traditional Uses:**

The tea made from butterfly pea flower is caffeine free herbal infusion prepared by decocting moisture reduced lemongrass along with leaves of Butterfly pea. In addition to extracting the plant's characteristic deep blue pigment—historically used as a natural dye—The tea preserves numerous bioactive compound atributed to butterfly pea flower. A distinctive feature regarding this beverage is its ability to change color with variations in Acid base balance; for instance, the addition of lemon juice transforms its hue from blue to purple.

Fig.7 Traditional uses

Traditionally, the rootsstructure utilized in treatment of sore throats, enlarged abdominal organs, and ascites. Although known to cause mild discomfort and gripping sensations, the roots were also utilized as purgatives. A mixture of root and honey has been administered to children as a general tonic believed to enhance memory, muscle development, and skin hydration, while roots were also used in the management of epilepsy[33,34].

The herb is considered non-toxic and free from adverse effects. In fact, it is believed to promote weight gain and improve overall vitality. Within the framework of Ayurvedic medicine, C. ternatea is classified as a medhya rasayana, a rejuvenating formulation that nourishes both the body and mind. Rasayana therapy is said to enhance cognitive capacity, strengthen immunity, delay aging, and promote mental clarity. When used as an astringent, the plant helps balance the Kapha, Vata, and Pitta doshas and alleviates anxiety by modulating the body's secretion of stress-related hormones, particularly cortisol and adrenaline [35].

❖ **Health Benefits of Butterfly Pea:**

➢ **Anti inflammatory, analgesic, and Antipyretic effects:**

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 6 Nov - Dec 2025, pp: 592-601 www.ijprajournal.com ISSN: 2456-4494

Indrayani studied how topically administered Clitoria ternatea L. extract reduced inflammation in female Swiss strain mice with carrageenan-induced skin edema. The findings showed that Clitoria ternatea L. ethanol extract .The corresponding percentages of inflammatory inhibition were 50.75% and 67.28%[36].This result is consistent with prior research showing that ethanol extract from butterfly pea flowers and methanol extract from butterfly pea roots significantly reduce vascular permeability.Devi (2003) showed in another investigation that oral administration of butterfly pea root methanol extract successfully decreased inflammatory edema and had antipyretic qualities. Additionally, 400 mg of butterfly pea flower extract taken orally had an antipyretic effectmatched with sodium.A related study carried out in 2004 demonstrated that oral butterfly pea extract at 200–400 mg/kg doses had an antipyretic effect [37, 38,39].

- **Anti diabetic activity:**

Rats were exposed to test the anti-diabetic effects from ethanolic extracts. Because ethyl alcohol-based floral extracts inhibited the activities of galactosides and glucosides but not fructosidase, rats given these extracts for three weeks dramatically reduced the serum sugar levels of experimentally created diabetic .STZ-induced hyperglycemic rats were utilized to test the blood sugar level lowering effectof methanol, water, extract butterfly pea flower foliage both short term and intermediate term effects. STZ -induced hyperglycemic rats , extracts of butterfly pea (200–400 mg/kg) greatly decreased the hyperglycemic effect, 400 mg/kg had considerable hypoglycemic effects, and 200 milligram /kilogram additionally dropped blood sugar levels, although lower than 400 mg/kg.Initial action of the methanol extract produced effects that were almost same for 200–400 mg/kg; however, 200 mg/kg induced little decrease in blood sugar levels after 30 minutes. Activity that is subacute produced effects when administered at 200 mg/kg of extract is far more effective than administeredat 400 mg/kg at maintaining blood sugar levels over extended periods. Rats treated with leaf extract essentially displayed the same profile as rats treated with floral extracts in every biochemical test. Streptozotocin-induced diabetic rats were used to test of glucose lowering and lipid modulating properties, and its animal models and in-vivo antioxidant activity was correlated. Butterfly pea flower (leguminous) were found to have an anti-hyperlipidemic effect on rats with preliminarily developed hyperlipidemia using a cute hyperlipidemia induced by poloxamer 407 as well as models of hyperlipidemia produced through induction[40].

- **Antidepressant activity:**

During the behavioral despair test, the methanol-based infusion ofbutterfly pea flowerwith doses of 100 , 400 mg/kg, p.o., demonstrated antidepressant effects. 400 mg/kg of C.ternatea reduced the duration of immobility more than 10 mg/kg of fluoxetine administered intraperitoneally. Research has demonstrated that an alcoholic-based infusion of butterfly pea roots had antidepressant effects treatment at 150 .According towards the findings from a prior study, two compounds that were separated from the root of CT,the aldehyde (Z)-9,17-octadecadienal and saturated fatty acid may be used as lead molecules to create noval type Monoamino oxidase inhibitor that can offers botanical remedies used in care regarding mental illnesses like anxiety and depression[41].

- **Anthelmintic activity:**

At doses ethanolic solution 100 mg /ml and water-based extracts from butterfly peafoilage exhibited antiparastic activity. This was carried out involving red wiggler worm in turn distinct dosage (100, 50, and 25 mg/ml) of ethanol-based extracts. Comparing the anthelmintic activity of C.ternatea leaf extracts artificial system using the pair of alcoholic-based and aqueous-based fraction was the main objective of the study.Because of this, the study needed to time the worms' paralysis (P) and demise (D). The onset of paralysis and mortality times were determined to be 18±1.57 and 53.33 ± 0.33, respectively, while the ethanolic extracts' times were 12.33±0.80 and 32.33±0.71[42].

- **Neuro-pharmacological activity :**

Neuro-pharmacological activity: Reports of neuroprotective effects from C.ternatea have been made; these effects could be related to it's inflammation suppressing and free radical neutralizing properties. It has demonstrated potential in improving cognitive function and avoiding neurodegenerative diseases.According to reports, C.ternatea is a good brain tonic medication that is mostly used to treat mental health issues. According to studies, giving rats and mice an alcohol extract of the steam, flower, leaf, and fruit of C. alternatea intraperitoneally (IP) has been shown to have sedative effects and lower alertness. When administered to rat doses of 300–500 miligram/kilogram, the root portions of C.ternatea reduce electroshock-induced amnesia and raise acetylcholinestarase effect in the various brain zones, including the cerebellum, medulla oblongata[43, 44].

- **Anti epileptic activity:**

Neurological episodeswere brought as results of an imbalancebetween stimulating and supression neurotransmitters. In experimental models of seizures, pharmacological compound boost neurotransmitter activity may have anti-convulsant Characteristics. The approved method for assessing antiepilectic medications for generalized tonic-lonic seizures is the maximal electroshock (MES). When administered at 100 milligram/kilogram.The methanol-based isolation of the arial portions of butterfly pea flower demonstrated anticonvulsant efficacy in mice treated with pentylenetertazole (PTZ) and MES, delaying the onset ofseizures and shortening the time needed for prolonged hind limb extension, respectively. Although a extract from the arial portion of butterfly pea flower occurred showed no protective effect against PTZ and MES -induced seizures in rat these results do point to efficacy of butterfly pea flower as a candidate antiepileptic[45].

- **Antioxidant activity:**

Because they function free radical neutralizer and prevent membern lipid degradation processes mediated by radicals, antioxidants shield the body from a number of illnesses linked to radical reactions. Since they Exhibit radical quenching activity proportional to the dose , several phenol-based antioxidants, including tannis are considered promising. The broad and varied class of phytochemicals known as phenolic compounds comprises numerous categories secondary metabolites found withinherb. Strong antioxidant properties both in vitro and in vivo are attributed to phenolic compounds[46].

- **Nootropic activity:**

Based on the findings, it was determined that the ethanol extract of C. pluricaulis, along with its water-based and ethyl acetate components, possesses nootropic properties. In separate groups of rats, ethyl acetate and water-based components are administered in two doses . Rats' memory and learning were found to be improved by both dosages of C. pluricaulis. This exercise evaluated both active and passive avoidance paradigms utilizing the elevated plus-maze as models. An additional investigation was conducted to determine Shankhpushpi's nootropic properties. The nootropic activity of three plants—Shankhapushpi,butterfly pea flower, and Evolvulusalsinoides—was assessed using Porsolt's swim despair, RPM, and actophotometer models.

Whenlaboratory animalsreceived butterfly pea extracts were given to experimental animals, several investigations found that their cognitive function improved. In one study, rats given ethanol isolated from the roots vegetative tissues of butterfly pea flower orally displayed superior depletion of electric shock-induced amnesia compared to controls. In a different study, neonatal rats showed improved spatial learning ability and memory 48 hours and 30 days after being given an oral dosage of water-based C.ternatea root extract.[47, 48].

- **Antimicrobial activity:**

Antimicrobial screening was assessed against ,enteritidis serover of salmonella coliform bacteria and opportunistic pathogen p. aerogunisoa that were collected from patients suffering from acute gastroenteritis disease and that produced b-lactams producing pathogen.The aforementioned the activity of extractswas assessed a antimicrobial disc diffusion assay . Salmonella typhimurium, Klesiella pneumonia, Pseudomonas aureginosa, uropathogenic were all susceptible to the activity of the aqueous extract, methanolic, chloroform infusion of butterfly pea flowers.A C. ternatea methylol fraction shows relatively high levels as opposed to the aqueous chloroform infusion. Hexane and the activity of hydrocarbon solvent,while the zones of inhibition created by chloroform, methanolic fraction[49].

II. CONCLUSION

The butterfly blue pea act as valuable medicinal plant considered to be abundant bioactive substances such as alkaloids, flavonoids, and anthocyanins. It exhibits strong neuroprotective, antimicrobial, antidepressant, antidiabetic, anti-inflammatory, and antioxidant properties. Its inherent blue pigment can also be used as a safe substitute for dye. All things considered, C. ternatea has a lot of possibility for application in the food, pharmaceutical, herbal medicine commercial sectors.however, more clinical research is required to verify its safety and effectiveness.

International Journal of Pharmaceutical Research and Applications
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International Journal of Pharmaceutical Research and Applications
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