

## Review: A relation between ethnobotany and bioprospecting of edible flower Butterfly Pea (*Clitoria ternatea*) in Indonesia

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**Abstract.** Afrianto WF, Tamnge F, Hasanah LN. 2020. Review: A relation between ethnobotany and bioprospecting of edible flower Butterfly Pea (*Clitoria ternatea*) in Indonesia. *Asian J Ethnobiol* 3: 51-61. *Clitoria ternatea* L., known as “bunga telang” in Indonesia, is an important medicinal plant to Fabaceae, an ornamental perennial climber. It has widely distributed throughout Africa, Asia, Australia, North and South America, Pacific (Northwestern, South-Central, and Southwestern). This review aims to study the relation between ethnobotany and bioprospecting of *C. ternatea*. The literature study revealed that Indonesian communities use flowers as part of *C. ternatea* as an eye medicine, boils disease, an ornamental plant, and a symbol in traditional ceremonies. Leaf, flower, seed, and root of this species have bioprospecting for medicine, agriculture, and food and beverage. Ethnobiology exploration of *C. ternatea* in Indonesia is an initial step to observe the bioprospecting potential. Then, further research can continue to produce commercial products that will provide an economic impact and motivate communities to take part in conservation actions. The present study assesses the minor works on bioecology, ethnobotany, bioprospecting, and market potential. We hope that the study's output can spur further research and industry approach.

**Keywords:** Bioprospecting, *Clitoria ternatea*, ethnobotany, Fabaceae, medicinal plant

### INTRODUCTION

*Clitoria ternatea* L. is known as “bunga telang” in Indonesia. This wild plant belongs to the plant of the Fabaceae family (Karel et al. 2018). The origin of *C. ternatea* is still debatable, but some studies mentioned that *C. ternatea* is a native plant of Ternate, Indonesia Archipelago (Jain et al. 2003; Gupta et al. 2010; Oguis et al. 2019). The etymology of this species is postulated to be from the Ternate Island in the Indonesian archipelago. It is based on the specific description of Linnaeus produced (Oguis et al., 2019). Furthermore, according to Staples (1992), *C. ternatea* originated from the Pacific Ocean or the South China Sea, but it is from around the Indian Ocean. Currently, *C. ternatea* has widely distributed throughout Africa, Asia, Australia, North and South America, Pacific (Northwestern, South-Central, and Southwestern) (Al-Snafi 2016).

*Clitoria ternatea* is an ornamental perennial climber in other plants or in-wall of home gardens, which lives in various types of soil and has a pH of 5.5-8.9 (Sutedi 2013; Chen et al. 2018). It can adapt to heavy cracking clay soil areas (Hall 1985). *C. ternatea* is a self-pollination plant, and it spreads through seed (Chen et al. 2018). *C. ternatea* occurs in plentiful sunlight and is partially shaded (Jamil et al., 2018). Dry stressing can inhibit population growth, fresh weight, germination, shoot, and root length (Bharti and Kumari 2017). This medicinal plant can be found in

high rainfall areas and prolonged dry season areas (Gomez and Kalamani 2003). The germination is 1-2 weeks, and the flowering is 3-4 weeks (Jamil et al. 2018).

The height of *C. ternatea* is up to 6 m with soft twigs. The description stem of *C. ternatea* is adpressed pubescent, glabrescent, and slender. *C. ternatea* has imparipinnate leaves consisting of 5-7 elliptic to lanceolate leaflets with a length of 1-6.7 cm and wide of 0.3-4 cm. The petiole length is 1-3 cm; the rachis is 1-6 cm, petiolules 1-3 mm, and leaflets 4-10 mm. The flower characteristics are axillary, paired, or solitary, with pedicels length of 6-9 mm, and striking blue and white color. The color of the seeds is black and brown, with a length of 4.5-7 mm, wide of 3-4 mm, and thick of 2-2.5 mm. The calyx is pubescent with tube 8-12 mm, under one-third of their length with the upper pair, acuminate or acute. The corolla is standard white, often margined with completely blue or blue. The pod is flat with a length of 6-12.5 cm and wide 0.7-1.2 cm; on each pod, there are 6-8 seeds. The color of the seeds is black and brown, with a length of 4.5-7 mm, wide of 3-4 mm, and thick of 2-2.5 mm (Gillett et al. 1971).

Leaves and flowers have flavonols compounds (Kazuma et al. 2003a,b). The other non-proteinaceous components were found in the roots of *C. ternatea*. For instance, taraxerol, novel norneolignans, and clitorienolactones A-C were found in the roots (Vasisht et al., 2016). *C. ternatea* has cyclotides (proteinaceous components) and is the only family member within the

Fabaceae (Gilding et al., 2015). The edible flowers had antioxidant activity and antimicrobial potential as a medicinal plant for several diseases (Petrova et al. 2016; Dhiman et al. 2017; Wang et al. 2017).

Ethnobotany of *C. ternatea* has been documented as the drug "Sankhupushpi" of Ayurveda (Mukherjee et al., 2008). Ayurveda means the science about life; it contains the traditional medicinal knowledge in India from between 2500 and 500 B.C (Mukherjee and Wahile 2006). The seeds and roots are used for alterative, laxative, and a 'tonic of the nerves' (Mukherjee et al., 2008). On the other hand, the data of ethnobotany in Indonesia is still limited. In Indonesia, *C. ternatea* is used as a medicinal plant or for traditional ceremonies and is known locally only.

Bioprospecting is an exploration of new natural resources of economic and social value. The pharmaceutical industry is one of the massive industries conducting it. However, other sectors, such as agriculture, construction, manufacturing, engineering, and others, also explore bioprospecting (Beattie et al., 2005). To find a novel of biological and chemical resources was conducted by exploration in nature or from traditional knowledge. Thus, the ethnobotany of species is crucial as foundation information for bioprospecting. Based on that, benefits from species can be used wider and optimal. This current literature review aims to study the relation between

ethnobotany and bioprospecting of *C. ternatea*. The data documented of ethnobotany and bioprospecting from *C. ternatea* is to develop conservation action and optimize utilization

### ETHNOBOTANY OF *CLITORIA TERNATEA*

Numerous ethnobotany research of *C. ternatea* is preliminary and requires a more thorough investigation. In Indonesia, research areas are still limited, such as East Java, Bali, West Nusa Tenggara, West Kalimantan, and Central Sulawesi. In Java, for instance, the data was only found in Madura. Ethnobotany knowledge of *C. ternatea* was depicted in Table 1.

The exploration of the ethnobotany of *C. ternatea* in Tamao Village did not reveal clear information about the utilization (Haryanti et al., 2015). However, based on literature, Dayak Tamambaloh in Embaloh Hulu is still keeping their local wisdom (Sulistiyowati 2016). In general, the Dayak Tamambaloh Community finds beneficial plants from forests, house yards, gardens, river beaches, hills, and fields (Rike et al., 2018; Supiandi and Leliavia 2019).

**Table 1.** List of ethnobotany research of *Clitoria ternatea* in Indonesia

Location	Part	Utilization	References
Tamao Village, Embaloh Hulu District, West Kalimantan	Flowers	Medicine, traditional ceremony, and ornamental	Haryanti et al. (2015)
Five of <i>Pakraman</i> Villages, Bali ( <i>Pakraman</i> Jatiluwih Tabanan, <i>Pakraman</i> Sukawati Gianyar, <i>Pakraman</i> Penglipuran Bangli, <i>Pakraman</i> Tenganan Karangasem, and <i>Pakraman</i> Banyuning Buleleng)	Flowers	Traditional ceremony ( <i>Panca Yadnya</i> )	Surata et al. (2015)
Lenteng District, Guluk-Guluk District, and Bluto District in Sumenep Regency.	Flowers	Eye disease medicine	Destryana and Ismawati (2019)
The Hindu Community of Jagaraga Village, West Lombok Regency, West Nusa Tenggara	Flowers	Eye disease medicine	Eni et al. (2019)
Togian Tribe, Tojo Una-Una, Central Sulawesi	Flowers and roots	Boils and fever medicine	Tabeo et al. (2019)
The Adjacent Area of Lake Buyan-Tamblingan, Bali	Flowers	Eye disease medicine	Oktavia et al. (2019)
Mincidan Village, Klungkung, Bali	Flowers	Eye disease medicine, 'nunas' tirta ceremony, and ornamental	Defiani and Kriswiyanti (2019)
Madura Sumenep Communities	Flowers	Clean and clear baby's eyes	Ismawati and Destryana (2019)

The ethnobotany from some areas in Indonesia used the flowers for many purposes. Flower of *C. ternatea* is utilized as the medicine for eye diseases by the Sumenep-Madura community (Ismawati and Destryana 2019), the adjacent area of Lake Buyan-Tamblingan, Bali (Oktavia et al. 2019), the community around the area model of KPH Kapuas Upstream (Haryanti et al. 2015), as well as the Hindu Community of Jagaraga Village, West Lombok Regency, West Nusa Tenggara (Eni et al. 2019). Ethnobotany knowledge of *C. ternatea* for eyes medicine has been proven through research. The phenol 0.026% from the extracts of *C. ternatea* flower revealed inhibition of 0.87mm as an antibacterial of *Staphylococcus aureus*, a bacterium that causes eyes diseases (Hutajulu et al. 2008). Through ultrafiltration (UF), the extracts of *C. ternatea* in water extract sterilization can be used to eye drops ingredients (Anthika et al., 2015). Furthermore, the extracts of *C. ternatea* can dissolve Calcium (Ca) and Natrium (Na) compiler cataract model in the concentration of 2.5% (Kusrini et al. 2017).

Togian tribal communities in Malenge Island, Talatoko District, Tojo Una-Una, Central Sulawesi used *C. ternatea* for boils medicine (Tabeo et al. 2019). Boils are also caused by *S. aureus*. The antibiotic of *S. aureus* can be produced from ultrasound-assisted aqueous leaf and petal extract, ethanolic leaf, and callus extract of *C. ternatea* (Shahid et al. 2009; Anthika et al. 2015). In addition, *C. ternatea* also has an antipyretic activity that can reduce fever (Devi et al., 2003).

The various ceremonies which belong to the *Panca Yadnya* ceremony need part of plants for the ceremony, and *C. ternatea* is one of them (Surata et al. 2015; Defiani and Kriswiyanti 2019). Hindu Bali's people use leaves, flowers, and fruits as a medium of offering (*sesajen*) and praying (*persembahyangan*) (Sardiana and Dinata 2010). Furthermore, they classified into several uses such as *canang* (offering to God), *kewangen* (scenting God's name), and *bhasma* (the symbol of Siwa's purity) (Surata et al., 2015).

*C. ternatea* is also used as an ornamental plant. Since *C. ternatea* has an attractive color for making aesthetic scenery to home and garden and ornamental crop adding value (Karel et al. 2018). For example, Mincidan Village in Bali uses plant floral diversity to promote ecotourism (Defiani and Kriswiyanti 2019).

## BIOPROSPECTING

Bioprospecting includes cultural information, biodiversity information, and processing and handling technology. Bioprospecting is the effort to search genes and natural compounds of biodiversity for product development (Pushpangadan et al. 2018). The economic benefits from *C. ternatea* include food and beverage, forage, phytochemicals, biopesticides, bioinsecticides, colorants, and medicines. In this part, we reviewed the evidence, based on scientific and research, the difference with the ethnobotany that only focused on Indonesia's studies. In bioprospecting, we explored the current research

progress of *C. ternatea* from Indonesia. Thus, we can elaborate on evidence-based scientific and ethnobotany from Indonesia.

### Phytochemicals

Leaf of *C. ternatea* contains compounds such as 3-rutinoside, beta-sitosterol, 3 monoglucoside, 3-o-rhamnosyl-glucoside, 3-neohesperidoside, kaempferol-3-o-rhamnosyl essential oils (Tiwari and Gupta 1959; Morita et al. 1977; Mukherjee et al. 2008; Manjula et al. 2013; Thakur et al. 2018). The seed contains oleic, linoleic, stearic, beta-sitosterol, polypeptide, linolenic acids, a water-soluble mucilage, delphinidin 3, 3', 5'-tri-o-glucoside, palmitic, finotin, oligosaccharides, p-hydroxycinnamic acid (4), anthoxanthin glucoside, flavonol-3-glycoside, ethyl  $\alpha$ -d-galactopyranoside, adenosine, 3,5,7,4-tetrahydroxyflavone, 3-rhamnoglucoside, hexacosanol, -sitosterol (5), -sitosterol (Grindley et al. 1954; Kulshrestha and Khare 1967; Kulshrestha and Khare 1968; Joshi et al. 1981; Revilleza et al. 1990; Macedo and Xavier-Filho 1992; Husain and Devi 1998; Kelemu et al. 2004). Root has been reported containing alanine, aminobutyric acid, aspartic acid, arginine, flavonoids, glycine, histidine, leucine, methyleneglutamic acid, ornithine, saponins, phenols, taraxerone, taraxerol, valine (Banerjee and Chakravarti 1964; Rajagopalan 1964; Kumar et al. 2008; Swain et al. 2012; Manjula et al. 2013). The flower has ternatins, flavonoids, alkaloids, tannins, resins. (Kazuma et al. 2003 a,b; Kazuma et al. 2004; Manjula et al. 2013).

### Food and beverage use

The flower of *C. ternatea* is used as a natural coloring for food and beverage. The bright blue color is the advantage characteristic of colors. The color is produced from anthocyanin in ternatins (Srivastava and Pande 1977; Zussiva et al. 2012). It is the pigment of the flavonoid group, which is soluble in water (Zussiva et al., 2012). For a natural dye of food and beverage, *C. ternatea* showed the best result in the anthocyanin with the treatment of the 10% addition maltodextrin concentration (Hariadi et al. 2018). The compound's content is stable and could withstand high temperatures (Azima et al., 2017; Angriani 2019). Coloring extracts flower was used to an ice lolly with the same quality with blue diamonds of CI 42090 (Hartono and Angelia 2013). It can also be coloring for several traditional foods such as *putu*, *onde-onde*, *bandang*, *barangko*, *getuk lindri*, *cendol*, candy, sticky rice *tapai*, and others (Saati et al. 2018; Angriani 2019; Febrianti 2019; Permana 2019; Palimbong and Pariama 2020; Shofi and Putri 2020). The flower extracts with 0.25% and 1% concentration were more stable when used in the paracetamol syrup preparations (Pratimasari and Lindawati 2018). Furthermore, *C. ternatea* was used for coloring goat milk yogurt, and it showed effects on the levels of pressure (color) (Dewi et al. 2019).

Blue tea from *C. ternatea* began to be known in Indonesia. It possesses antioxidant properties for healthy beverages because it reduces oxidative stress (Srichalkul 2018; Lakshan et al. 2019). Moreover, drinking *C. ternatea* can reduce postprandial glucose and insulin concentration

concomitant (Chusak et al. 2018a). Processing of *C. ternatea* is conducted through drying, either using sunlight or an oven. Drying is one of the most critical steps in processing *C. ternatea* tea. The aims are to prolong shelf life, prevent microorganism growth, reduce weight to press storage and transport costs, and minimize enzymatic degradation (Fernandes et al. 2018). Drying is conducted at 08.00-12.00; then, it is continued on the next day. By doing so, the beneficial compounds of *C. ternatea* are not damaged by sunlight (Mulangsari 2019). *C. ternatea* tea is made with five flower petals (1.0 g) dissolved in 250 ml boiling water. Consuming *C. ternatea* tea routinely is good for the thin phlegm in asthmatics (Kusuma 2019) and can improve human health due to its non-caffeinated contents (Panda 2018).

Starch digestibility of cooked rice with a rice cooker was reduced by the incorporation of 1.25% and 2.5% (w/v) of *C. ternatea* flower extracted and 2.5% (w/v) with a microwave oven (Chusak et al. 2019). Flower extracts of *C. ternatea* caused a reduction in hydrolysis index, predicted glycemic index of flour, and glucose released at 0.5%, 1%, and 2% (w/v). In comparison, 5%, 10%, and 20% (w/w) decreased the rate of starch digestion of the wheat bread. The pancreatic  $\alpha$ -amylase activity can be inhibited by 1% and 2% (w/v) by using a substrate of all flours (Chusak et al. 2018b). In addition, flower extracts of *C. ternatea* inhibited the food damage and disease of *Pseudomonas aeruginosa* (the extracted ethanol flower concentration of 10% to 100%) and *Bacillus cereus* (the extracted ethanol flower concentration of 30% to 100%) (Riyanto et al. 2019). These bacteria have been reported as the food poisoning cases in several foods such as rice and noodles in Indonesia's market, particularly in food streets (Ruriani and Nurhayati 2010; Amanati 2014; Ekantini et al. 2017). This makes *C. ternatea* use a bioactive potential for food preservation (Kamila et al., 2009).

## Agricultural applications

### Anthelmintic

*C. ternatea* has Anthelmintic activity reported killing *Meloidogyne incognita* (Hasan and Jain 1985; Kumari and Devi 2013). The high effectivity to inhibition of hatching of the egg can be used to minimize the damage of *M. incognita* to fruits and leaves of mulberry. *M. incognita* has been reported decreasing in pepper production in Bangka and West Kalimantan (Sukanaya 2001). In soybean, *M. incognita* can make lost yield up to 30%-90% (Suryanti et al., 2017). *M. incognita* is also a critical plant disease on *kenaf* (*Hibiscus cannabinus*) production in the nursery and tomato development area (Budi et al. 2006; Pradana et al. 2016; Irmawatie et al. 2019).

### Antibacterial and antifungal

The purification of *C. ternatea* seed produces a small protein called Finotin (Kelemu et al. 2004). Finotin has been reported to significantly kill the bacteria of *Xanthomonas axonopodis*, which attacks beans. *X. axonopodis* is a disease that causes severe damage in soybean crops and economic loss in citrus crops in

Indonesia (Das 2003; Khaeruni et al. 2007; Khaeruni et al. 2008).

As a fungicide, a protein that was designed as a Ct protein from the isolation of *C. ternatea* seed caused the death of some fungus, such as *Alternaria* sp., *Aspergillus flavus*, *Cladosporium* sp., *Curvularia* sp., *Rhizopus* sp., and *Sclerotium* sp. (Ajesh and Sreejith 2014). Finotin from *C. ternatea* seed could inhibit *Bipolaris oryzae*, *Pyricularia grisea* from rice, *Colletotrichum gloeosporioides*, and *Lasiodiplodia theobromae* from *Stylosanthes* spp; *Colletotrichum lindemuthianum*, *Fusarium solani* from common bean, and *Rhizoctonia solani* from *Brachiaria* spp (Kelemu et al. 2004). Furthermore, *Fusarium oxysporum* that causes moler disease on Shallot from Indonesia can be killed by the crude aqueous leaf extracts of 50% (Das and Chatterjee 2014) and flower extracts at 5% concentration (Suganda and Adhi 2017). Research by Suganda and Adhi (2017) is preliminary for plant antifungals since the focus is mainly on human pathogens rather than plant pathogens.

### Insecticidal

Cyclotide sequences have insecticidal activity against *Helicoverpa armigera*, the cotton budworm (Poth et al., 2011). *H. armigera* makes cotton fruit undeveloped and fallen because of broaching buds, flowers, and bolls, especially in central areas of cotton production in Indonesia such as Central Java, East Java, South Sulawesi, Southeast Sulawesi, East Nusa Tenggara, West Nusa Tenggara, and Bali (Diyasti et al. 2016). 1-2% (vol/vol) of the oil-based formulation of the *C. ternatea* mixture was used for integrated pest management (IPM) to control *Helicoverpa* spp in Australian cotton. Furthermore, 1% w/w finotin application to *Zabrotes subfasciatus* and 5% w/w to *Acanthoscelides obtectus* resulted in a maximum level of 100% larva mortality (Mensah et al. 2015).

### Forage for livestock

To obtain high quality and nutrition, *C. ternatea* is harvested at 45 days (Mahala et al., 2012). *C. ternatea* has high productivity up to 17-25 tons/ha (Abdelhamid and Gabr 1993). A high carotenoid content positively impacts bovine livestock fertility and egg yolk color (Barro and Ribeiro 1983). *C. ternatea* also has a better potential nutritive value than alfalfa and clover (Abreu et al., 2014).

*Clitoria ternatea* escalates diets and sound quality for ruminants due to its nutritional contents (Gomez and Kalamani 2003; Avalos et al. 2004; Juma et al. 2006; Shammad 2019). As a forage, *C. ternatea* increases the weight of beef cattle and cows, 0.7 and 0.36 kg/day, respectively (Sutedi 2013). In addition, the weight loss of cows during shipment from Timor to Java can be minimized up to 5-7% when generally it is 12-15% (Nunik 2009).

Barros et al. (1991) discovered a better dietary N of goats given *C. ternatea* as forage. Guinea Grass-*Clitoria* mixed hay can be a potential forage to sheep because it increases digestible dry matter intake up to 61% (Sandoval et al. 2009). Besides that, the use of *C. ternatea* to sheep also provides a positive effect on wool growth and live weight gain (Schlink 1998). The two cuts of *C. ternatea*

have better acid and neutral detergent fiber, acid detergent lignin cellulose, crude protein and fiber, hemicellulose than berseem hay (Abdelhamid and Gabr 1993).

A decrease of 10% of *C. ternatea* for boilers diet showed better growth (Marin et al., 2003). A comparison between *C. ternatea* and *Brachiaria humidicola* showed that *C. ternatea* has higher protein content and metabolizes energy, but the fiber content was lower than *B. Humidicola*. Nevertheless, 15% *C. ternatea* substitution decreased growth and consumption in chicken (Monforte et al. 2002).

Muir and Massaete (1996) found that the crude protein content of dietary components used during experiments in rabbits was 16 %. It is because *C. ternatea* has protein up to 18-25%, which complies with the nutritional needs of rabbits (Sutedi 2013). Nevertheless, Elamin et al. (2011) suggested that sweet potato is better used for rabbits than *C. ternatea* based on performance and blood constituents.

#### Soil fertility

The high nodule maintenance and the non-structural carbohydrate mobilization make *C. ternatea* adapt quickly to stress after the shoot removal (De Souza et al. 1996). *C. ternatea* increases Nitrogen, Phosphor, Potassium, and Magnesium and impacts soil acidification and nutrient solubilization (Njunie et al. 2004; Alderete-Chavez et al. 2011). Environmental conditions affect nodulation growth. The optimum nodulation growth is on moderate temperatures, such as at 06.00 (27-32°C), 14.00 (36-42°C) and 18.00 (27-30°C) and with the light intensity in summer (11.4-17.1 Wm<sup>-2</sup>) and winter (11.4 Wm<sup>-2</sup>), as well as the optimum duration of 11-14 hours (Habish and Mahdi 1979). On the other hand, an optimum soil pH was 6.3 in the four strains of *C. ternatea* (Zoroug and Munns 1980a). Phosphor is an essential nutrient for nodulation growth (Zoroug and Munns 1980b). Unfortunately, we currently do not find the *C. ternatea* to improve soil fertility in Indonesia. This can be an opportunity to discover the utilization of *C. ternatea* to improve soil fertility in Indonesia. It is because *C. ternatea* grows horizontally and makes tightly covered. This growth characteristic brings several benefits, such as preventing erosion, maintaining soil moisture, and improving soil fertility from leaves (Suarna 2005).

### Medicinal properties

#### Antimicrobial

Cliotides T1-T2 in flower, seed, and root of *C. ternatea* can be used as an antimicrobial against *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, and *Escherichia coli* (Nguyen et al. 2011). Fourth, novel cyclotide sequences have been identified, and noted that *C. ternatea* was one of the prosperous cyclotide-producing medicinal plants (Nguyen et al. 2016). Ethanolic and aqueous leaf and callus extracts can inhibit human diseases bacteria, such as *Bacillus cereus*, *B. subtilis*, *Enterococcus faecalis*, *Staphylococcus aureus*, *S. epidermidis*, *Streptococcus pyogenes*, and *S. viridans* (Shahid et al. 2009); *Micrococcus luteus* (Ajesh and Sreejith 2014); *Salmonella typhi* and *Proteus Vulgaris* (Anand et al. 2011). Moreover, as an antifungal, 14.3 kDa seed protein inhibited

*Aspergillus fumigatus*, *A. niger*, *Candida albicans*, *C. parapsilosis*, *Cryptococcus neoformans*, *C. albidus*, and *C. laurentii* (Ajesh and Sreejith 2014). Leaf extracts successfully inhibited *Aspergillus niger* (Kamila et al. 2009). In ethnobotany, communities mostly use *C. ternatea* for diseases caused by microbes, such as eye disease and boils caused by *S. aureus*. There are numerous benefits from *C. ternatea* as an antimicrobial that Indonesian communities have not explored.

#### Antidiabetic

In Indonesia, it has 10,681,400 cases of diabetes in adults (International Diabetes Federation 2020). Currently, *C. ternatea* leaf extracts have shown potential for an antidiabetic medicine (Daisy and Rajathi 2009; Suganya et al. 2014; Talpae et al. 2014; Chusak et al. 2018b; Kavitha 2018). Leaf extracts of *C. ternatea* decrease blood glucose, HbA1c, other biochemical parameters and increase serum insulin level (Kavitha 2018). After five hours of oral administration, the mix of *Punica granatum* and the dried flower powder resulted in an antihyperglycemic effect. This is affected by flavonoids and alkaloids (Borikar et al., 2018). The root extract in experimental rat models, *C. ternatea*, prevented pancreatic tissue in juvenile diabetic and the possible complications related to brain hippocampal area CA3 (Mathada et al. 2012).

#### Anti-inflammatory activity, antipyretic activity, and analgesic

Leaf and flower extracts of *C. ternatea* have been identified as having an inflammatory activity (Devi et al., 2003; Bathia et al., 2013; Suganya et al., 2014; Singh et al., 2018). Petroleum ether extract and ethanol resulted in the analgesic activity that ethanol-treated extract showed up to 2 hours of long-lasting effect (Bathia et al. 2013). Flavonoids were important for anti-inflammatory, analgesic, and antipyretic activities in *C. ternatea* (Devi et al., 2003). The methanol extract of *C. ternatea* root at 200, 300, and 400 mg/kg body weight doses. The yeast-provoked raised the temperature dose-dependent and decreased the temperature body to normal (Parimaladevi et al. 2004). Drugs (narcotics or non-narcotics) treat inflammatory and pain conditions, which are very costly and have adverse effects. Natural drugs, especially from *C. ternatea*, can be an option for providing cheaper and feasible drugs.

#### Antioxidant activity

The root extracts of *C. ternatea* have antioxidant activity based on some research both in white flowers and blue flowers (Patil and Patil 2011; Jadhav et al. 2013). Flower extracts of *C. ternatea* have been reported to have antioxidant activity (Kamkaen and Wilkinson 2009; Jayachitra and Padma 2012; Jadhav et al. 2013; Zingare et al. 2013; Azima et al. 2014; Iamsaard et al. 2014; Phruksanan et al. 2014; Azima et al. 2017; Havananda and Luengwilai 2019; Lakshan et al. 2019). Biological synthesized MgO-NPs of flower extracts of *C. ternatea* showed high antioxidant activity (Sushma et al. 2016). The white flower produces higher enzyme antioxidants than the blue flower (Jayachitra and Padma 2012). Antioxidant

activity in *C. ternatea* prevents lipid peroxidation in erythrocytes, protein oxidation, and free radical-induced hemolysis (Phruksanan et al., 2014). *C. ternatea* has enzyme and non-enzyme antioxidants rather than the other plants, such as *Eclipta prostrata* (Rao et al. 2009), *Syzygium cumini*, and *Ardisia colorata* (Azima et al. 2017). In addition, Antioxidant activity in *C. ternatea* is potent to be cosmetic properties (Kamkaen and Wilkinson 2009). Currently, the need for natural anti-rising is rising since synthetic antioxidants bring side effects such as allergies, asthma, inflammation, headache, loss of consciousness, and disorders of the eyes and stomach (Sharmila et al., 2016). *C. ternatea* has the potential to be used as a natural antioxidant.

#### *Nootropic activity*

Nootropic activity, anxiolytic, anticonvulsant, antistress activity, and antidepressants have been found in the extracts of *C. ternatea* (Jain et al., 2003; Talpate et al. 2014). Root extracts of *C. ternatea* increase acetylcholine in the hippocampus to enhance memory and learning (Rai et al. 2001; Rai et al. 2002). An increase of rat brain acetylcholine and acetylcholinesterase activity was produced from the alcoholic extracts root of *C. ternatea* at 300 mg/kg doses (Taranalli and Cheeramkuzhy 2000). In addition, *C. ternatea* also raises episodic memory and cellularity and declines autophagy. However, several studies have reported only in experimental animals (rats). This progress is proved that *C. ternatea* has the potential for improvement in human cognitive performance.

### AN RELATION BETWEEN ETHNOBOTANY AND BIOPROSPECTING

There are three critical stimuli to interfere with the community's attitudes, i.e. (i) natural stimulus, (ii) helpful stimulus, and (iii) religious stimulus (Zuhud et al. 2007). The stimuli are a powerful driver of the community's attitude and behavior for realizing conservation actions. Firstly, the natural stimulus is a sustainable resource that needs to be based on bioecology characters. This plant is a wildflower. Even though people also cultivate in the home garden (Eni et al. 2019). Farmers can increase their income and conserve agro-biodiversity through their home gardens (Mohri et al., 2013; Sutoro 2017).

Secondly, the valuable stimulus is the values of human-being needs for economic, medicine, biological/ecological, and the other benefits. It can be identified by biological/ecological utilization, medicinal uses, economic sectors, and social culture aspects (Deryanti et al., 2007; Zakiyyah et al., 2016). Exploration knowledge is an initial step to optimize the potential of *C. ternatea*. The study of ethnobotany can be used to analyze the bioprospecting of *C. ternatea*. Then, further research can continue to produce commercial products to increase income for the community. For example, the information from the ethnobotany of *C. ternatea* in Indonesia describes it as a medicinal plant, some processed products such as herbal tea (dried *C. ternatea*), coloring powder, and eye drops.

Species are endangered or rare because people use natural resources to utilize knowledge or exploit. So, when the valuable stimulus can be optimized, it will empower the community to be part of conservation action. Optimizing bioprospecting can generate income and support the conservation project (Skiryycz et al., 2016).

Thirdly, a religious stimulus is noble values, especially the rewards from God, spiritual values, universal religious values, merit, happiness, cultural/traditional wisdom, inner satisfaction, and many more. For instance, a local concept of traditional medicine called "Usada Taru Pramana" in Bali. In the idea, *C. ternatea* is regarded as a medicinal plant for the eye (Cahyaningsih et al. 2019). Bali communities admit *Usada* or *Aushadhi* in Sanskrit as guidance for plant medicine (Sutomo and Iryadi 2019). It is related to the Hindu-Bali's belief, *Tri Hita Karana*. *Tri Hita Karana* is the philosophy of harmony relation between human beings and God (*parhyangan*), harmony with other people (*pawongan*), and connection with nature (*palemahan*) (Wirawan and Pendit 2017) (Figure 2). *Parhyangan* is a value/mindset element that can be described in the existence of the Hindu temple. According to Suarmini (2011), *Parhyangan* associated with social subsystems is realized by conducting ceremonies on certain days. In these ceremonies, *C. ternatea* is usually used as one of the elements. *Pawongan* is associated with a social subsystem, where the community has to maintain harmony and togetherness. *Palemahan* is related to the mindset/value realized in preserving, such as a village, village forest, and nature. Rather than exploiting nature, *Palemahan* intends to think that nature is an equitable partner.

Based on the three critical stimuli to the effect of community's attitudes, the relation between ethnobotany, bioprospecting, society, and conservation was shown in Figure 3. We modified the circle of regard by adding ethnobotany as a part of values. Since Indonesia is rich in ethnobotany knowledge that can be a source of natural products. In exploration (ethnobotany), species are still known locally and limited. Thus, comprehensive research by government research institutes or private industries is needed for scientifically proven. The result of the study is products that can be promoted to more comprehensive customers. The products can be used as commercial products. Finally, the study should provide an economic impact on the communities and motivate communities to conserve them.

### FUTURE OUTLOOK OF MARKET OVERVIEW

According to the Indonesian Agriculture Ministry Decree Number 511/Kpts/PD.310/9/2020, *C. ternatea* on kinds of plant commodities fostered by Directorate General of Plantation, Directorate General of Food Crops, and the Directorate General of Horticulture (Indonesian Agriculture Ministry 2020) However, in the market overview, the production of *C. ternatea* products are still not optimal. However, herbal medicine is rising gradually with the "back to nature" trend worldwide (Fernandes et

al., 2019). In 2019, the traditional medicine industrial sector grew above 6% or above the national economic growth. Industries absorbed herbal medicine of 63% total market, then exports by 14%, and for household consumption 23% in 2007 (Indonesian Agriculture Ministry 2007). In Indonesia, most herbal medicine consumers are economically categorized as the low-middle class (Andriati and Wahjudi 2016).

A qualitative study with descriptive analysis was used to survey the three most significant marketplaces in Indonesia, e.g., Bukalapak (www.bukalapak.com), Tokopedia (www.tokopedia.com), and Shopee (www.shopee.co.id). It aimed to know the diversity of *C. ternatea* in the Indonesian marketplace. We observed the products sold from 100 procedures in each marketplace (Figure 4). Result explicate that *C. ternatea* was mostly sold as a dried flower tea (Tokopedia of 65%, Bukalapak of 53%, and Shopee of 74%) and a commercial seed/seedling (Tokopedia of 22%, Bukalapak 41%, and Shopee 22%). This result is identical with ethnobotany information which said that the flower of *C. ternatea* is used the most. Less than 10% of *C. ternatea* was used for beverages. Also, there was a product of eye drops (1%). The same percentage of 1% was used for fresh leaf, flower, and coloring powder. Thus, according to this data, the utilization of *C. ternatea* has still not developed optimally.

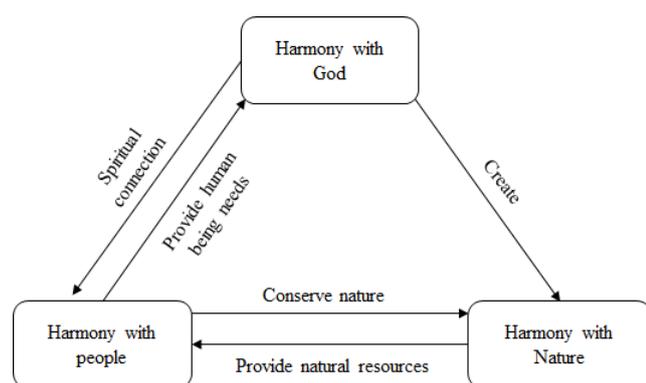
The current development of technology eliminates the gap between producers and consumers. Through e-commerce, for instance, it is easier for the farmers to enlarge their market access, increase the sale, and reduce transaction costs (Chang and Just 2009; Mishra et al. 2009; Zapata et al. 2016; Fecke et al. 2018). In January 2020, the total of internet users in Indonesia reached + 175.4 M, and this number increased by +17% between 2019 and 2020. That makes Indonesia the top five most significant internet

users, with people spending 7 hours 59 minutes longer than globally (Kemp 2020). This condition leads to a shift of consumers' behavior from conventional to digital in their daily activities.

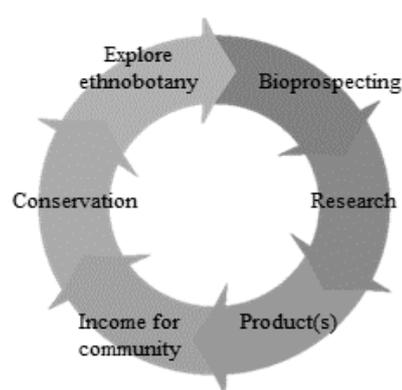
Most producers are small-medium enterprises that use home gardens or limited land and partnership farmers with social enterprises to sell and process their products—for example, empowering farmers through the partnership that Agradaya dan Javara has done. Javara claims to have a partnership with more than 5000 farmers throughout Indonesia and is visioning “to preserve Indonesia’s biodiversity and brings community-based, organic products to broader markets” (Javara 2020). On the other hand, Agradaya has a partnership with more than 300 farmers in Yogyakarta and East Java and brings a mission of “collaboration for sustainable agriculture” (Agradaya 2019).

*C. ternatea* is also grown for urban farming since it can live in various habitat types. For instance, Konekroot is rooftop farming that has hydroponic, aquaponics, and organic agriculture (Konektoot 2019). They sell processing *C. ternatea* for dried tea or seed/seedling. They also use *C. ternatea* for garnish of food. Besides that, Kebun Kumara, a social enterprise located in Jakarta, grows *C. ternatea* in its urban space for agriculture. Like Konekroot, Kebun Kumar also sells seed/seedling of *C. ternatea* (Kebun Kumara 2019).

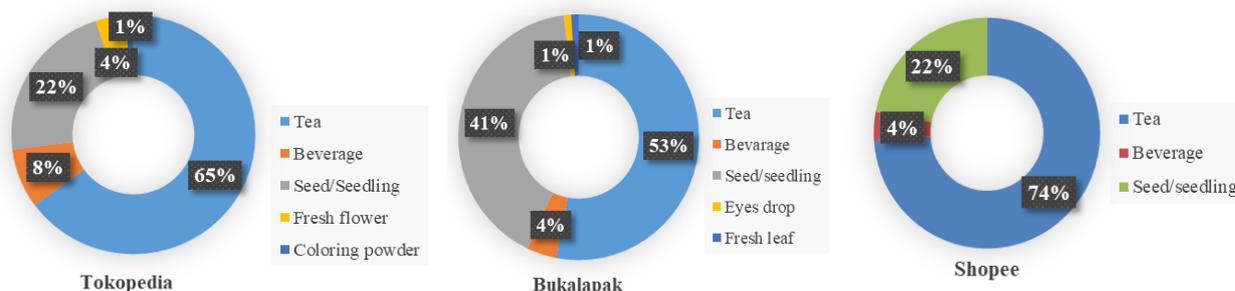
In conclusion, the ethnobotany of *C. ternatea* can be knowledge resources for bioprospecting in several utilizations, such as food and beverage, agriculture, and medicine. Through innovation, technology, and research, the potential of *C. ternatea* can be explored to provide high-quality products under tremendous opportunities. We hope that the study will impact communities' economics and escalate their motivation to conserve *C. ternatea*.



**Figure 2.** The ancient Balinese philosophy of Tri Hita Karana (Nias Press in Zen et al. 2019)



**Figure 3.** Ideal relation between ethnobotany, bioprospecting, community, and conservation



**Figure 4.** The diversity of products of *C. ternatea* in Indonesia's e-commerce; source: Tokopedia (www.tokopedia.com), Bukalapak (www.bukalapak.com), and Shopee (www.shopee.co.id)

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