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 belongs Fabaceae, which is 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 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, as well as food and beverage. Ethnobotany exploration of C. ternatea in Indonesia is an initial step to observe the bioprospecting potential. Then, it can be continued to further research to produce commercial products where these products will provide an economic impact and motivate communities to take a part of conservation actions. The present study assesses the limited works that have been carried out 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 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 found from the location of Linnaeus produced (Oguis et al. 2019). Furthermore, according to Staples (1992), C. ternatea originated is not 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 with 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, but it also occurs in partially shaded (Jamil et al. 2018). Dry stress can be an inhibiting factor of the population growth, fresh weight, germination, shoot, and root length (Bharti and Kumari 2017). This medicinal plant can be found in high rainfall areas, as well as in long 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 stamn of C. ternatea are 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 length of the petiole 1-3 cm, rachis 1-6 cm, petiolules 1-3 mm, and leaflets 4-10 mm. The flower characteristics are axillary, paired or solitary, with pedicels length up to 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 flavonoids compound (Kazuma et al. 2003a,b). The other non-proteinaceous components were found in the roots of C. ternatea. For instance, taxerol, novel norneolignans, clitoriolenolactones A-C that were found in the roots (Vasisht et al. 2016). C. ternatea has cyclotides (proteinaceous components), and the only family member within the Fabaceae (Gilding et al. 2015).
The edible flowers had antioxidant activity and antimicrobial which is 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 since 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 known locally only.

Bioprospecting is an exploration to find new natural resources of economic and social value. The pharmaceutical industry is one of the massive industries conducting it. However, other industries, 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, ethnobotany of species is crucial as foundation information for bioprospecting. Based on that, benefits from species can be used wider and optimal. This present 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 C. TERNATEA**

Numerous ethnobotany research of *C. ternatea* are preliminary studies and require 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 Tamambahlo in Embaloh Hulu is still keeping their local wisdom (Sulistiyowati 2016). In general, the Dayak Tamambahlo Community finds beneficial plants from forests, yard houses, gardens, river beaches, hills, and fields (Rike et al. 2018; Supiandi and Leliavia 2019).

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Part</th>
<th>Utilization</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tamao Village, Embaloh Hulu District, West Kalimantan</td>
<td>Flowers</td>
<td>Medicine, traditional ceremony, and ornamental</td>
<td>Haryanti et al. (2015)</td>
</tr>
<tr>
<td>Lenteng District, Guluk-Guluk District, and Bluto District in Sumenep Regency.</td>
<td>Flowers</td>
<td>Eye disease medicine</td>
<td>Destryana and Ismawati (2019)</td>
</tr>
<tr>
<td>The Hindu Community of Jagaraga Village, West Lombok Regency, West Nusa Tenggara</td>
<td>Flowers</td>
<td>Eye disease medicine</td>
<td>Eni et al. (2019)</td>
</tr>
<tr>
<td>Togian Tribe, Tojo Una-Una, Central Sulawesi</td>
<td>Flowers and roots</td>
<td>Boils and fever medicine</td>
<td>Tabeo et al. (2019)</td>
</tr>
<tr>
<td>The Adjacent Area of Lake Buyan-Tambilingan, Bali</td>
<td>Flowers</td>
<td>Eye disease medicine</td>
<td>Oktavia et al. (2019)</td>
</tr>
<tr>
<td>Mincidan Village, Klungkung, Bali</td>
<td>Flowers</td>
<td>Eye disease medicine, 'nunas' tirta ceremony, and ornamental</td>
<td>Defiani and Krisiwyanti (2019)</td>
</tr>
<tr>
<td>Madura Sumenep Communities</td>
<td>Flowers</td>
<td>Clean and clear baby’s eyes</td>
<td>Ismawati and Destryana (2019)</td>
</tr>
</tbody>
</table>
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 Sumenep-Madura community (Ismawati and Destryana 2019), the adjacent area of Lake Buyan-Tamblingan, Bali (Oktavia et al. 2019), community around the area model of KPH Kapuas Upstream (Haryanti et al. 2015), as well as the Hindu Community of Jagaraja 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 0.87% as antioxidant 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 ingredient (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% (Kusri et al. 2017).

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

The Various ceremonies which belong to 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 media 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 as well as ornamental crop adding value (Karel et al. 2018). For example, Mincidan Village in Bali uses the plant floral diversity to promote the ecotourism sector (Defiani and Kriswiyanti 2019).

**BIOPROSPECTING**

Bioprospecting that includes the multidiscipline fields, such as cultural information, biodiversity information, and technology of processing and handling. 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 was only focusing on Indonesia's studies. In bioprospecting, we explored from in current research progress of *C.ternatea* was not only from Indonesia. Thus, we can elaborate on evidence-based on 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-neohesperidose, 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). Seed contains oleic, linoleic, stearic, beta-sitosterol, polyepptide, 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 α-galactopyranoside, adenosine, 3, 5,7,4-tetrahydroxyflavone, 3-mangroglucoside, hexacosanol, -sitosterol (5), -sitosterol (Grindley et al. 1954; Kulshrestha and Khare 1967; Kulshrestha and Khare 1968; Joshi et al. 1981; Revillez 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, methylene glutamic 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 tertamins, flavonoids, alkaloids, tannins, resins. (Kazuma et al. 2003a,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 coloring. The color is produced from anthocyanin, which is 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). It is because the compound’s content is stable and that able to withstand high temperatures (Azima et al. 2017; Angriani 2019). Coloring of extracts flower was used to an ice lolly where it has the same advantage characteristic (Dewi et al. 2019).

Blue tea from *C. ternatea* begins to be known in Indonesia. It possesses antioxidants properties for healthy beverages because it reduces oxidative stress (Srichalkul 2018; Lakshan et al. 2019). Moreover, drinking routinely...
of C. ternatea can also 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 important steps in the processing of 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) that are 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-cafeinated 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 of glycemic index, predicted glycemic index of flour, and glucose released at 0.5%, 1%, and 2% (w/v), while at 5%, 10%, and 20% (w/v) decreased the rate of starch digestion of the wheat bread. The pancreatic α-amylase activity can be inhibited 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 kinds of 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 can use a bioactive potential for food preservation (Kamila et al. 2009).

Agricultural applications

Antihelmintic

C. ternatea has Anthelmintic activity that has been reported killing Meloidogyne incognita (Hasan and Jain 1985; Kumari and Devi 2013). The high effectiveness 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 an important plant disease on kenaf (Hibiscus cannabinus) production in the nursery and the development area and tomato (Budi et al. 2006; Pradana et al 2016; Irrawatie et al. 2019).

Antibacterial and antifungal

The purification of C. ternatea seed produces a highly basic small protein called Finotin (Kelemu et al. 2004). Finotin has been reported to significantly killed bacteria of Xanthomonas axonopodis, which attacks bean. X. axonopodis is a disease that causes severe damage in soybean crop 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 of Bipolaris oryzae, Pyricularia oryzae from rice; Colletotrichum gloeosporioides, and Lasiodiplodia theobromae from Ficus carica, and Fusarium oxysporum that causes molder disease on Shallot from Indonesia, it 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 Sugand and Adhi (2017) is a preliminary for antifungal of plant since the focus research mostly on human pathogen rather than plant pathogen.

Insecticidal

Cyclotide sequences have insecticidal activity against Helicoverpa armigera, which is 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 has also better potential nutritive value than alfalfa and clover (Abreu et al. 2014).

Clitoria ternatea escalates diets and rational 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 weight beef cattle and cows, 0.7 and 0.36 kg/day, respectively (Sutedi 2013). In addition, 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 that were 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* has 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 a better growth (Marin et al. 2003). A comparison between *C. ternatea* and *Brachiaria humidicola* showed *C. ternatea* has higher protein content and metabolizes energy, but the fiber content was lower rather than *B. Humidicola*. Nevertheless, 15% *C. ternatea* substitution decreased growth and consumption in chicken (Monforte et al. 2002).

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

### Soil fertility

The high nodule maintenance and the non-structural carbohydrate mobilization make *C. ternatea* adapting easily to stress after the shoot removal (De Souza et al. 1996). *C. ternatea* increases Nitrogen, Phosphor, Potassium, and Magnesium, as well as impacts soil acidification and nutrient solubilization (Njinnie 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-2) and winter (11.4 Wm-2), as well as the optimum duration of 11-14 hours (Habish and Mahdi 1979). On the other hand, an optimum soil pH 6.3 in the four strains of *C. ternatea* (Zorouq and Munns 1980a). Phosphor is an essential nutrient for nodulation growth (Zorouq and Munns 1980b). Unfortunately, until currently, we do not find utilization of *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 (Suanna 2005).

### Medicinal properties

#### Antimicrobial

Cliotides T1-T2 in flower, seed, and root of *C. ternatea* can be utilized as an antimicrobial substance against *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, and *Escherichia coli* (Nguyen et al. 2011). Fourth one 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. albidos*, and *C. laurentii* (Ajesh and Sreejith 2014). Using another part which was leaf extracts, it 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 have not been explored by Indonesian communities.

#### 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 anti diabetic 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). The mix of *Punica granatum* and the dried flower powder resulted in an antihyperglycemic effect after five hours of oral administration. This is affected by flavonoids and alkaloids (Borikar et al. 2018). The root extract in experimental rat models, *C. ternatea* exhibited a prevention 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 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 indicated to have important roles for anti-inflammatory, analgesic, and antipyretic activities in *C. ternatea* (Devi et al. 2003). The methanol extract of *C. ternatea* root at doses of 200, 300, and 400 mg/kg body weight., yeast-provoked raised the temperature in a dose-dependent manner and decreased the temperature body to be normal (Parimaladevi et al. 2004). Drugs (narcotics or non-narcotics) are used for the treatment of inflammatory and pain conditions, which are very costly and have negative 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 flower or blue flower (Patil and Patil 2011; Jadhav et al. 2013). Flower extracts of *C. ternatea* have been reported having an 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;
Phrueksanan et al. 2014; Azima et al. 2017; Havenanda 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 (Phrueksanan et al. 2014). *C. ternatea* has enzyme and non-enzyme antioxidant 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 the potential to be cosmetic properties (Kamkaen and Wilkinson 2009). Currently, the needs for natural antioxidants is raising, since the use of synthetic antioxidants brings 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, antidepressant 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 that it enhances 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 andcellularity and decline 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 key stimuli to interfere with community's attitudes, i.e. (i) natural stimulus, (ii) useful stimulus, and (iii) religious stimulus (Zuhud et al. 2007). The stimuli are a powerful driver of the community's attitude and behavior for the realization of conservation actions. Firstly, the natural stimulus is the natural resources sustainable needs based on biocology characters. This plant is a wildflower. Even though, people also cultivate in the home garden (Eni et al. 2019). Through the home garden, farmers can increase their income and also conserve agro-biodiversity (Mohri et al. 2013; Sutoro 2017).

Secondly, the useful 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, medicine uses, economic sectors, as well 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, it can be continued to further research to produce commercial products where these products will increase income for the community. For example, information from ethnobotany of *C. ternatea* in Indonesia that describes as a medicinal plant, some products that are processed such as herbal tea (dried *C. ternatea*), coloring powder, and eye drops. Species are being endangered or rare in nature because people have a lack of natural resource utilization knowledge or do exploitation. So, when the useful stimulus can be optimized, it will empower the community to be part of conservation action. Optimizing bioprospecting can be a source of income and support the conservation project (Skirycz 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, in Bali, there is a local concept of traditional medicine called “Usada Taru Pramanam”. In the concept, *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, that is *Tri Hita Karana*. *Tri Hita Karana* is the philosophy of harmony relation between human beings and God (parhyangan), harmony with other people (pawongan), and harmony with nature (palemahan) (Wirawan and Pendit 2017) (Figure 2). *Parhyangan* is 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 associated with subsystems the mindset/value that is realized in the form of preserving, such as a village, village forest, and related to nature. Rather than exploiting nature, *Palemahan* intends to think that nature is an equitable partner.

Based on the three key stimuli to the effect of community’s attitudes, the relation between ethnobotany, bioprospecting, community, and conservation was shown in Figure 3. We modified the circle of relation 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, for scientifically proven, comprehensive research by government’s research institutes or private industries is needed. The result of the research is products that can be promoted for wider customers. The products can be used commercial products. Finally, the research should provide an economic impact on the communities and motivate communities to take part to conserve it.
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 Crop 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. Despite this, herbal medicine is rising gradually in line with the trend “back to nature” globally (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, the majority of 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 greatest 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 products of *C. ternatea* in the Indonesian marketplace. We observed the products sold from 100 procedures in each of marketplaces (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 same with ethnobotany information which said that 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 be top five biggest of the internet users’ number, with people spending 7 hours 59 minutes longer than globally (Kemp 2020). This condition leads to a shift of consumers’ behavior from conventional into digital in their daily activities.

Most producers are small-medium enterprises that use home gardens or limited land, as well as the partnership farmers with social enterprises to sell and process their products. For example, empowering farmers through the partnership that has been done by Agradaya dan Javara. Javara claims to have a partnership with more than 5000 farmers throughout Indonesia and visioning “to preserve Indonesia’s biodiversity and brings community-based, organic products to broader markets” (Javara 2020). On the other hand, Agrada has a partnership with more than 300 farmers in Yogyakarta and East Java and brings 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 farming (Konkoot 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 also grows *C. ternatea* in its urban space for agriculture. Same to Konekroot, Kebun Kumar also sell seed/seedling of *C. ternatea* (Kebun Kumara 2019).

In conclusion, 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
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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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