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Ethnobotanical study of *Gyrinops versteegii* (Gilg.) Domke from Lombok Island, West Nusa Tenggara, Indonesia as an effort in supporting the conservation of agarwood-producing species

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Gyrinops versteegii (Gilg.) Domke is one of the eaglewood species that is distributed especially in the East region of Indonesia, including Lombok Island, West Nusa Tenggara, and it grows in the natural habitat or is cultivated. The aim of this study was to explore different uses of *G. versteegii*, and reveal important ethnobotanical aspects of *G. versteegii* in Lombok Island. Ethnobotanical methods applied in this study included participatory observation, interview, documentation, and verification using herbarium specimens. The total reported use (RU) of *G. versteegii* is 19, where the stem has the highest percentage in the type of utilization. This result means that generally, *G. versteegii* has several potential uses in local communities that could be revealed, developed and conserved. Conservation efforts need to be considered to maintain the availability and diversity of agarwood-producing species, as well as to ensure the preservation of the natural environment where it grows.

Keywords: Agarwood, Ethnobotany, *Gyrinops versteegii*, Lombok Island.

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Introduction

Eaglewood or agarwood-producing tree (*Gaharu* in Indonesian) is one of the high-value woods in the world related to the chemical compound contained in it. Eaglewood species can produce a valuable resin called agarwood that is used in aromatherapy, handicraft, incense, body treatment, etc., especially in East Asia and Middle East countries[1]. Two important agarwood-producing genera with high quality and high economic value in Indonesia are *Aquilaria* and *Gyrinops* (Thymelaeaceae)[2]. One of the important species is *Gyrinops versteegii* (Gilg.) Domke, and Lombok Island is one of the areas that produce good quality agarwood from *G. versteegii*[3], either in their natural habitats or in plantations.

In Indonesia, agarwood is used for fragrances, perfumes, traditional medicines, religious facilities, room ornaments, rigging, and reinforcement needs[4]. It is especially used for religious or ritual purposes, and medicine in Japan. Indonesia and Vietnam are the two largest supplier countries of agarwood[5].

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Scientific information on *G. versteegii* from Indonesia needs to be revealed more through research from various disciplines.The agarwood-producing species of *Gyrinops* are legally protected[6], but sustainability is still threatened due to intensive search related to its high economic value[7]. There are concerns that the species could become extinct while important scientific information regarding *Gyrinops* species has not been properly revealed. Multidisciplinary studies need to be conducted to explore the various potentials of *G. versteegii* so that its utilization and preservation could be followed up wisely. Ethnobiology studies are basically an effort to preserve and document the traditional knowledge of the community, which also plays an important role in reducing genetic and cultural erosion of biological resources and community knowledge systems[8-10].

The aim of the study was to explore different uses of *G. versteegii*, and to reveal ethnobotanical aspects of *G. versteegii* in Lombok Island, Indonesia. The results of this research are expected to be important information that could be a recommendation to develop agarwood research, especially on

G. versteegii, to support the conservation efforts of agarwood-producing species in general.

Materials and Methods

This study was conducted in Lombok Island, Indonesia. The site included several villages that have areas overgrown or cultivated with *G. versteegi* in West Lombok Regency, North Lombok Regency and Ampenan District, either in natural habitat or being cultivated in plantations. Included in these areas were the villages inhabited by communities that recognize the utilization of *G. versteegii* in their daily lives, or used it in economic aspects.

Ethnobotanical approaches were applied in this research. Data was collected through field observation, semi-structured interview (interview using questions outline), in-depth interview and free listing method[11,12]. Informant selection was based on the purposive sampling method, which was directed to people whose any related knowledge on *G. versteegii* in the research areas. A total of 27 informants including farmers, villagers, agarwood buyer, agarwood souvenir collectors, craftsmen, *kepala dusun* or local chief of the village, plantation owners, and any other people who had intense activities related to *G. versteegii* were included. Informants were determined based on snowball sampling, where the next informant was recommended by the previous informant. In snowball sampling, data collection and interviews are stopped when there is no new data that could be added[13].

Qualitative data consisted of several ethnobotanical aspects of *G. versteegii*, i.e, types of utilization, how to utilize and which part of plants is utilized by people, aspects in cultivation, social-culture, social-economic, and also botanical information related to *G. versteegii*. Quantitative data consisted of total reported use (RU) of *G. versteegii* calculated using the index of importance value introduced by Gomez-Beloz[14] in 2003, which were used to reveal the total amount of utilization:

$$RU = \sum_{i}^{n} species_i$$

RU = total reported uses of *G. versteegi* cited by all informants

n = number of uses

i = informant

Qualitative and quantitative data were analyzed descriptively to develop an ethnobotanical profile of *G. versteegii* utilization in Lombok Island.

Results and Discussion

Botanical aspect of *G. versteegii*

G. versteegii categorized in Thymelaeaceae, a family that mostly grows and dominates the structure of forest stands in tropical rain forests, lowlands from dry to swamps with an altitude of 0-1,000 m asl. *Gyrinops* has the highest species diversity with a fairly wide distribution area, This genera consists of seven species of total 26 agarwood-producing species distributed in eastern Indonesia from various generas. *Gyrinops* species are distributed in Papua (4 species), Sulawesi (2 species), Maluku (1 species).) and Nusa Tenggara (1 species)[15].

G. versteegii generally grows in eastern Indonesia, especially Sulawesi, Maluku, Nusa Tenggara, and Papua[3]. In Lombok Island, West Nusa Tenggara, there are several infraspecific variations of *G. versteegii* based on some characters in anatomy, morphology, and aromatic resin[3,16]. Polymorphism in the local population could be a result of gene flow, selection balance, and also geographical and ecological distribution, which could cause a gradual shift in the frequency of polymorphic variants[16]. Taxonomists have used the term “group” in forestry for this variety-level infraspecific category[17]. The speciation of *G. versteegii* in Lombok splits into five infraspecific populations (group) which local hunters call *Ketimunan Beringin, Buaya, Pantai, Madu,* and *Soyun*.

G. versteegii is also found in Sumbawa, Alor, and Flores islands. This species is usually a tree with10-17.5 m height, 25-30 cm stem diameter; chartaceous to subcoriaceous leaves, dull and light green in upper surface, shining and dark green in dorsal surface, with elliptic, ovate or obovate-oblong in shape. Fruits are yellow or orange, slightly obovoid or ellipsoid, with ovoid seed[3].

Cultivation of *G. versteegii* in Lombok island

G. versteegii naturally grow well in secondary forests or forests that have no intensive community intervention. Meanwhile, cultivated *G. versteegii* generally grows in people's yards (Fig. 1), nurseries, or certain land that has been provided for cultivation by local government. The agarwood resin in *G. versteegii* could be produced naturally (Fig. 2) or artificially through cultivation (Fig. 3). Wounds that trigger the production of natural resin could be caused by friction with other nearby trees, fallen trees, or the presence of holes that certain insects could enter (such

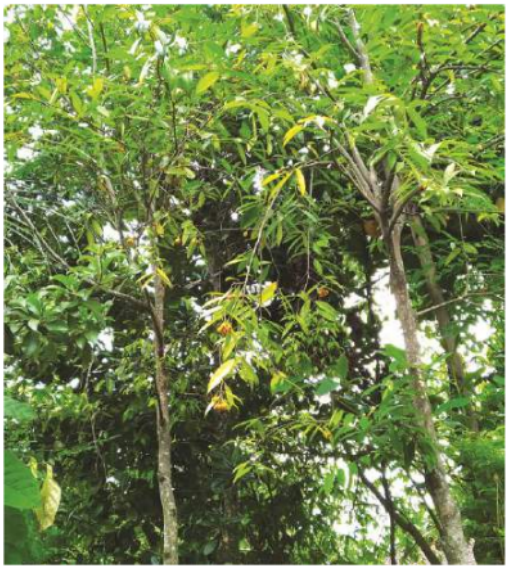

Fig. 1 — Young agarwood tree

Fig. 2 — Natural agarwood

as ants). Meanwhile, the artificial resin could be obtained through fungal inoculation or local formulas (inoculation liquid made from herbs by local people) which are applied using the nailing method (Fig. 4) or zinc-plat method. Fungi that are usually used for

Fig. 3 — Cultivated agarwood

Fig. 4 — Nailing method

inoculation are *Fusarium lateritium* and *Fusarium popullaria*. Harvesting can be done in 6 months after being inoculated using fungal inoculum, but if the harvest is too late the plant will be damaged or fail in producing the resin. Agarwood farmers prefer to use local herbal ingredients they called "vaccine" for inoculation, for safety reasons in harvesting.

In some villages, *G. versteegii* cultivation land was a yard around the house, an area at the edge of a rice field, or land on the hill or mountain owned by the government. Harvesting can be done at least 6-7 years

after cultivation. In nailing method inoculation, agarwood would be produced after 10 months – 2 years after nailing, using nails that could be used twice. The long period of nailing and repeated use of nails should be avoided due to corrosion that could damage the stem tissue.

Distance between trees is quite far apart in agarwood cultivation so that intercropping system using several vegetables or other agricultural crops with a short period of harvesting could be applied to gain optimum benefit. Intercropping system is one of the solutions in dealing with the problem of low growth success rates in cultivating agarwood-producing trees, especially in vacant land or open spaces in semi-arid areas[18]. This is related to the requirement for shade trees to increase humidity and reduce the temperature in the surrounding area. Several crops could be used in intercropping system. *G. versteegii* is usually grown in association with *Albizia chinensis* and this association is beneficial as *A. chinensis* can store water and hence, retain the soil moisture in the surrounding area. Agarwood-producing trees can be found in primary and secondary forests, but their ecological important roles have not been widely known because this species is a minor component of the ecosystem[4]. As a minor component, the effect of this population in biological processes becomes significant when associated with other species in the ecosystem. In addition to contributing to the success of agarwood cultivation, the intercropping system also has an impact on the socio-economic aspect of the surrounding community because it can accommodate the community's food needs. Therefore, there is also a guarantee that the community will take part in preserving the environment in the area.

Agarwood production will generally be optimal if being cultivated in humid areas, but it is also possible for areas with low humidity such as some areas in West Lombok Regency. Clay and rock soil are usually good for its growth. This could be related to moisture factors and soil particles that are not easily eroded during heavy rain and other disturbances.

The cultivation of agarwood-producing trees in monoculture system or outside their natural habitat is generally susceptible to pests and diseases[19]. Authority of Forest Area with Special Purposes in Mataram, Lombok, has a record that centre of agarwood cultivation on Lombok Island is one of the areas that has to overcome pest attacks periodically, especially from *Heortio vitessoides* larvae. Pest or disease in *G. versteegii* includes caterpillars that attack leaves, although they do not affect agarwood production. Mechanical control of caterpillars is handled by removing or picking the affected leaves. Biological control was carried out by applying a mixture of water, chilli (*Capsicum frutescens*), and tobacco (*Nicotiana tabacum)* leaves which are pounded and squeezed, then sprayed to the *G. versteegii* leaves. Biological control can also be carried out using natural predators of the pests and caterpillars, such as *Oecophylla smaradigna*.

Utilization of *G. versteegii* in Lombok Island

Utilization of *G. versteegii*in Lombok Island is divided according to plant parts used, i.e, stem (wood), leave, fruit, and seed.

Stem (wood)

Utilization of *G. versteegii* stem or wood is especially intended for extracting the agarwood resin, which is formed as a result of an immune reaction against incoming or inoculated microorganisms. Agarwood is sold to buyers for further processing such as distillation to obtain agarwood oil which is used in making perfumes, fragrances, cosmetics, aromatherapy, traditional and religious rituals, and others. The distillation process also generates water that can be consumed as a health drink. Some entrepreneurs refer to it as *biosol*, a solution found at the bottom of agarwood oil during the distillation process. The efficacy of this drink is thought to be related to the content of phytochemical compounds in the agarwood plant. Phytochemical analysis showed that leaves and stems contain terpenoids, tannins, flavonoids, and have anti-bacterial activity[20].

G. versteegii stem that produces low-quality agarwood can also be processed into carving and decorating material (Fig. 5), as well as a room deodorizer. One of the agarwood craft centres is located in the Orong Selatan Village, West Lombok Regency. The skills of craftsmen are generally obtained from parents or previous generations that handed down their skills to their children. Types of *G. versteegii* that are commonly used are from Beringin and Madu group. Each group of agarwood has special characteristics in wood anatomy[21], but the group selection for its use as a decoration material is based on community adjustment to the availability of the group in their area.

Another kind of utilization is the use of rods as material for architectural decoration purposes, such as for villas construction. Another use is by filling the

Fig. 5 — Agarwood handcrafts

low-quality agarwood stem with agarwood resin (generally from Pantai group) that has been scented with better resin from another group (such as Kalimantan agarwood). *G. versteegii* Pantai group is a special resin-producing eaglewood that can be inserted into ordinary or low-quality eaglewood stem, after being given a better quality aroma from another agarwood. The aromatic resin of *G. versteegii* Pantai group has a less sharp aroma (maybe due to low oil content) so that the craftsmen usually use the resin to insert into ordinary agarwood stem. A phytochemical test based on the content of lignin, cellulose, hemicellulose, total sugar, total starch and resin, agarwood of Pantai group has a close relationship with the Beringin group[21].

Craft waste as carved remnants (scrapings) is generally collected (Fig. 6.), then sold, refined and extracted to obtain agarwood oil which is then sold as a fragrance. Waste is generally sold to Java or sold to communities (especially Arabian

Fig. 6 — Agarwood craft-waste

communities) that will process it as fragrance or incense. Other products from agarwood waste are shirts buttons and carvings for room deodorizers. Agarwood oil is also used in cosmetics, include ing soap and shampoo products. Agarwood incense is also used as perfume and as an element of important religious occasion in Malaysia, Taiwan and Japa n[22]. The Middle East is Indonesia's main export destination for agarwood, followed by China, Taiwan and Singapore[2]. Agarwood waste can not be used as firewood due to the aroma and bitter taste generated. Another use of agarwood wastes is as a mosquito repellent, which is commonly used by the local people when doing outdoor activities at night. Burned agarwood waste produces smoke with an aroma that is avoided by mosquitoes. This could be related to the phytochemical compounds contained in agarwood.

Leaves

G. versteegii leaves are used by the local community in making agarwood tea, a kind of health drink made from boiled *G. versteegii* leaves (young or old). Small sliced leaves are dried, boiled or brewed with boiled water. The agarwood tea helps treat body fatigue, colds, and cough. Agarwood tea can also be prepared using trees that have been inoculated[23]. The phytochemical screening proved that leaves, stems, and eaglewood extract contain tannins, terpenoids, alkaloids, flavonoids, and a few anti-bacterial compounds[20]. It has been detected that *G. versteegii* leaves in methanol extract contains an anti-free radicals activity[24]. *G. versteegii* leaves can also be used as organic fertilizer, but not as a fodder plant due to the bitter taste.

Fruit

Local people consume raw fruit to avoid mosquito bites. Presumably, the bitter active compound which contained in human blood after consuming the fruit could help human to avoid mosquito bites. In some

areas of Lombok and Sumbawa Island, fever is treated with a mixture of mashed fruit of *G. versteegii* to decrease the body temperature[25] Another use of *G. versteegii* fruit is as an ingredient for weaning babies so they will no longer consume breast milk. The people in Kerujuk hamlet, West Lombok, use mashed *G. versteegii* fruit and then apply it to their breast skin when weaning their babies. Almost all parts of *G. versteegii* can be utilized in people's daily lives. Roots, leaves, fruits, and barks are boiled and consumed as a health drink.

Seed

G. versteegii seeds are generally collected from the forest or other natural habitat by people to be sown, sold, and then will be cultivated until produce agarwood. The use of seeds for sowing is the most common use for people due to the high economic value of *G. versteegii*. The seeds can also be processed into agarwood coffee. Mature seeds are dried, roasted and pounded, then brewed like coffee made from *Coffea* sp. This could be a local beverage that could be introduced as Sasak's functional beverages other than *kupi* (coffee) and *kupi kedele* (soya coffee) known in Lombok[26]. Sasak is the original tribe of Lombok Island.

Ecotourism potential

G. versteegii could also be developed to be an ecotourism project related to cultivation and craft art aspect. In Orong Selatan village, almost all residents realize the important economic value of agarwood, and they generally earn a living as farmers, hunters, craftsmen, injectors and other professions associated with agarwood. This matter should be followed up by the authorities or local government to develop community-based ecotourism. Ecotourism is a type of tourism that is conditioned to support conservation and sustainable development activities, be environmentally responsible, and play a role in efforts to empower local economy aspects. In more detail, ecotourism has local management, good quality tourism program, appreciation of culture, relation with natural and cultural resources, and the existence of integration of development and conservation[27]. The Orong Selatan village has things needed for the establishment of an ecotourism program, such as natural conditions and communities that have activities related to natural and cultural resources in term of agarwood, especially agarwood farmers with all their activities. This capital can be followed up to be handled in professional management. It also needs to design suitable tourism packages that contain education, nature and cultural conservation, as well as programs that have synergies with the community's economic activities.

Socio-cultural and economic aspects of *G. versteegii*

G. versteegii acts as a source of livelihood for local people in agarwood-producing regions, either as a main or side job. Livelihoods related to this are agarwood farming (either their land or work on other people's land), injectors (people who inoculate the agarwood stem with microorganism), agarwood craftsmen, hunters, traders and broker (people who connect traders with prospective buyers). Their expertise related to agarwood cultivation and processing is obtained from the previous generation (parents), and also through assistance carried out by related government institutions. Some residents who previously worked as stone sellers turned to agarwood farming due to their interest in the agarwood trade. In Asian society culture, agarwood-producing species is a very important non-timber forest product related to its use in various religious and cultural activities, and this cause the selling price of agarwood to always increase, which is also determined by the quality and grade of the agarwood[28].

In Lombok Island, sales are carried out directly by farmers, collectors, hunters, craftsmen, internet sites (social media networks, blogs), or sold through brokers of tourism business such as hotels and travel agents. Agarwood consumers also come from other regions throughout Indonesia, even from overseas, such as Middle East, Thailand, Singapore and the USA. The main obstacle is the limited availability of raw materials when there is high demand. A problem that often causes a broken supply chain is harvest failure, which is usually caused due to extreme weather conditions or incompatibility of inoculant given, which causes mass death of agarwood-producing trees[29]. Another obstacle is the legal aspect because not all sellers or farmers have the complete license administered by the Natural Resources Conservation Center (KSDA), where it is determined the amount of agarwood that is allowed to be traded per person, in a year. According to the farmers, another main obstacle in agarwood management is fulfilling administrative requirements, due to the farmers' lack of ability in communicating and understanding the provisions, such as obligations in the notary deed, building use certificate management,

land certificate (land size, number of trees), where this should be initiated at the village and sub-district level. The essence of the problem is that the sellers/farmers have not been organized and understands well in conducting trade legality management procedures. The legal aspect is very important to be fulfilled to avoid various violations in the marketing process, such as shipping agarwood products through being declared as other goods, for example as accessories. Another obstacle in marketing is a misunderstanding in communication between the parties involved, unstandardized price, and high capital that is required.

In agarwood trade trends, legality together with sustainability and quality are three aspects that are expected. Legal and traceability practices should conform with applicable national and international regulations, whereby harvesters, collectors and traders should be register or certified[30]. So far, Indonesia has an activity to develop a registration system for agarwood plantation, and some efforts to ensure traceability in agarwood trade.

Conservation aspects

An important factor in ensuring the availability of agarwood stock is the existence of hunters, the people who seek eaglewood that has produced agarwood. Hunter is usually a local community in a region, looking for agarwood in groups of 4-8 persons, and usually are family members. Hunter is in charge of looking for agarwood producing tree that has produced the agarwood resin, and cooperating with other people who also collect agarwood to sell them to consumers. There is cooperation and profit-sharing system between collectors and hunters in agarwood trading.

The environmental problem that often arises is that hunters only focus on searching for agarwood and ignoring environmental conditions. Logging has been done to the roots of the trees, and there are not any recultivation efforts. Loggers often leave large holes around trees that are felled, which also contributes to the degradation of the forest environment. The next impact is a reduction in springs, erosion and landslides in the forest area. The conservation of primary forests could be initiated by only harvesting parts of the agarwood trees that have produced the agarwood resin, and not cutting down the entire tree[31].

Agarwood hunting is getting more intense in Indonesia and it results a population reduction. This also causes a threat of local extinction for certain varieties or groups. Preservation efforts have been carried out since 1996 by the local government of West Nusa Tenggara Province, by establishing a main plantation for *G. versteegii* in Pusuk Protection Forest, West Lombok. Reforestation of agarwood-producing tree, both by non-governmental and government assistance, is also carried out outside the forest area[21]. To preserve agarwood germplasm, especially from *Gyrinops*, it is necessary to cultivate the whole agarwood groups, especially from the Wallacea region, to conserve the genetic diversity of agarwood.

The low-growth of *G. versteegii* in West Nusa Tenggara is considered due to the arid region which caused the poor shade for the population[29]. Another trigger is the lack of wise exploitation, poor harvesting techniques and the lack of cultivating efforts. The solution offered by the local Forestry Service includes reforestation projects on a provided land. In addition, seedlings are distributed free to surrounding communities to be planted. Meanwhile, local conservation efforts carried out by the community are by collecting agarwood seeds found in the forest, sowing and planting the seedlings on their land. The threat that also deserves caution is the increasing number of agarwood collectors or hunters, where this will cause more intensive harvesting of agarwood which will have an impact on its sustainability[32]. Three basic steps in sustainably managing natural agarwood-producing trees are survey, inventory and monitoring; developing a database; and calculating a sustainable harvest[33].

Development in agarwood management needs to be done to maintain the sustainability of agarwood production and protect the germplasm diversity of agarwood-producing species in Indonesia. This effort requires collaboration with communities around the forest so that activities can run effectively and efficiently. This strategy will also be able to protect biodiversity and forest sustainability because the community will also take benefits from the results of agarwood development, especially the economic benefits. It is an urgent need for the conservation of the genetic diversity of the tree species with special emphasis on anthropogenic activities. This could help in creating mass awareness also in promoting ethnobotany knowledge within a region[34]. From an ecological perspective, agarwood-producing trees will also maintain environmental stability due to the increase of absorption and retention capacity of

groundwater, prevent erosion, absorb CO_2 and produce O_2 needed in life. Agarwood development in the area around the forest will not only strengthen the function of the forest but also empower the surrounding community, which will be is a kind of community-based forest management[35].

Based on RU calculation, the total RU of *G. versteegii* is 19, calculated from the total types of utilization reported by all informants. The stem is the plant-part with the highest utilization rate (42.1%). Other plant parts are fruit, leaves, seeds, roots, and all parts, 21.1, 15.8, 10.5, 5.3, and 5.3%, respectively. This shows that stem is the part that is most often used for several purposes by the community, where the stem is also the main part which is taken from *G. versteegii*, related to the production of agarwood resin. The use of agarwood as a raw material for incense and fragrance has been going on for various cultural backgrounds, and other various purposes[36]. Other uses are minor uses but have the potential to be further developed, such as functional drinks. There should be extended researches on other potentials of different parts of agarwood-producing species and support their future in natural pharmaceutical preparation for many treatments of any other diseases[37].

Agarwood cultivation and processing areas also have the potential to be managed as ecotourism destinations. These potential need to be followed up so that *G. versteegii* is not utilized only for the wood or sap (resin) but also its other plant parts so that it can be more beneficial to the community. Conservation efforts need to be considered to maintain the availability of *G. versteegii*, as well as to ensure the preservation of the natural environment where it grows.

Conclusion

G. versteegii has various potential utilizations that have not been explored and followed up properly. These utilizations involve various plant organs and various aspects of *G. versteegii* that could be potential for further research and development, where so far studies have only focused on the stem and the production of agarwood resin. Related to agarwood hunting and the continuous increase of agarwood demand, it is necessary to design conservation efforts to maintain the sustainability of *G. versteegii* populations in their habitat. Wise collaborations with local communities are needed to ensure the conservation efforts are implemented effectively.

Conflict of interest

The author declares no conflict of interest in this work.

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References

1 Mulyaningsih T, *The traditional use of agarwood in Japan*, Research Report, (Mataram University, Indonesia), 2017.

2 Ministry of Forestry and International Tropical Timber Organization, Completion Report on promoting conservation of plant genetic resources of *Aquilaria* and *Gyrinops* species in Indonesia, 2014.

3 Mulyaningsih T and Yamada I, Notes on some species of agarwood in Nusa Tenggara, Celebes and West Papua, in *Natural resource management and socio-economic transformation under the decentralization in Indonesia: Towards Sulawesi area studies* (CSEAS Kyoto University, Japan), 2008.

4 Puslit Biologi LIPI & Dirjen Perlindungan Hutan dan Konservasi Alam, Report on NDF of agarwood for sustainability harvest in Indonesia, 2010.

5 Compton J and Ishihara A, *The use and trade of garwaood in Japan*, (Traffic Southeast Asia), 2010.

6 Wyn L T and Anak N A, *Wood for the trees: A review of theagarwood (gaharu) trade in Malaysia* (Traffic Southeast Asia, Malaysia), 2010.

7 Susilo A, Kalima T and Santoso E, *Panduan lapangan pengenalan jenis pohon penghasil gaharu Gyrinops* spp. *di Indonesia* (Pusat Penelitian dan Pengembangan Konservasi dan Rehabilitasi – ITTO - CITES Phase II Project, Bogor), 2014.

8 Matthews P J, Genetic diversity in taro, and the preservation of culinary knowledge, *Ethnobot Res Appl*, 2004, **2**, 55-71.

9 Shresta D, Indigenous vegetables of Nepal for biodiversity and food security, *Int J Biodiv Conserv*, 2013, **5**(3) 98-108.

10 Singh R K and Singh A, Biodiversity and recipe contest: Innovative socioecological approaches to capture ecological knowledge and conserve biodiversity in Arunachal Pradesh, *Indian J Tradit Knowl*, 2013, **12**(2), 240-251.

11 Cotton C M, *Ethnobotany: Principles and applications*, (John Wiley & Sons, England), 1996.

12 Martin G J, *Ethnobotany: A methods manual*, (Earthscan, USA), 2007.

13 Endraswara S, *Metodologi penelitian kebudayaan*, (Gadjah Mada University Press, Yogyakarta), 2006.

14 Hoffman B and Gallaher T, Importance indices in ethnobotany, *Ethnobot Res Appl*, 2007, **5**, 201-218.

15 Hou D, Thymelaeaceae, in *Flora Malesiana Series I*, vol VI, edited by C G G J Van Steenis (Wolter-Noordhoff Publishing, Netherlands), 1960, 1-48.

16 Mulyaningsih T, Marsono D, Sumardi and Yamada I, Selection of superior breeding infraspecies gaharu of *Gyrinops versteegii* (Gilg.) Domke, *J Agric Sci Technol B*, 2014, **4**, 485-492.

17 Lester R N, Hakiza J J H, Stavropoulos N and Teixiera M M, Variation patterns in the African starlet eggplant *Solanum aethicum* L., in *Infra-Specific Classification of Wild and Cultivated Plants,* Special vol. 29, edited by B T Styles (Clarendon Press, Oxford), 1986.

18 Surata I K and Soenarno, Penanaman gaharu (*Gyrinops versteegii* (Gilg.) Domke) dengan sistem tumpang sari di Rarung, Provinsi Nusa Tenggara Barat, *Jurnal Penelitian Hutan dan Konservasi Alam*, 2011, **8**(4), 349-361.

19 Irianto R S B, Santoso E, Turjaman M and Sitepu I R, Hama pada tanaman penghasil gaharu, in *Pengembangan Teknologi Produksi Gaharu Berbasis Pemberdayaan Masyarakat Sekitar Hutan*, edited by S A Siran & M Turjaman (Pusat Penelitian dan Pengembangan Hutan dan Konservasi Alam, West Java), 2010.

20 Hadi S, Muliasari H, Sukma N S and Ratnaningsih P E W, Phytochemical screening and antibacterial testing of gaharu trees (Gyrinops versteegii (Gilg.) Domke) from Lombok Island, in *Proc 2nd Int Semin Chem* (Jatinangor, West Java), 2011, 79-82.

21 Mulyaningsih T, Marsono D, Sumardi and Yamada I, Infraspecific diversity of gaharu (*Gyrinops versteegii* (Gilg.) Domke) in Western Lombok Island, *J Penelitian Hutan dan Konservasi Alam*, 2017, **1**, 57-66.

22 Soeharto B, Budidarsono S and van Noordwijk M, *Gaharu (eaglewood) domestication: Biotechnology, markets and agroforestry options*, Working paper no. 247, World Agroforestry Centre (ICRAF) Southeast Asia Regional Program, Bogor, Indonesia, 2016.

23 Samsuri T and Fitriani H, Pembuatan teh dari daun gaharu jenis *Gyrinops versteegii*, *J Ilmiah Pendidikan Biologi Biosaintist*, 2013, **1**(2), 125-132.

24 Mega I M and Swastini D A, Screening fitokimia dan aktivitas anti-radikal bebas ekstrak metanol daun gaharu (*Gyrinops versteegii*), *J Kimia*, 2010, **4**, 187-192.

25 Sukenti K and Mulyaningsih T, Gaharu (*Gyrinops Versteegii* (Gilg.) Domke) di Pulau Sumbawa: sebuah tinjauan etnobotani, *BioWallacea*, 2019, **5**(2), 62-68.

26 Sukenti K, Hakim L, Indriyani S and Purwanto Y, Ethnobotany of sasak traditional beverages as functional food, *Indian J Tradit Knowl*, 2019, **18**(4), 775-780.

27 Hakim L H, *Dasar-dasar Ekowisata*, (Bayumedia Publishing, Malang), 2004.

28 Liu Y Y, Wei J H, Gao Z H and Lyu J C, A Review of quality assessment and grading for agarwood, *Chinese Herb Med*, 2017, **9**(1), 22-30.

29 Herda S and Setyawan A A, Manajemen rantai pasok kayu gaharu di Kalimantan Barat, *Jurnal Ekonomi Manajemen Sumber Daya*, 2017, **18**(2), 92-101.

30 Purwito D, *Current agarwood trade trends*, Report of the Asian Regional Workshop on the Management of Wild and Planted Agarwood Taxa, India, 2015.

31 Kanazawa K, Sustainable harvesting and conservation of agarwood: A case study from the upper Baram River in Sarawak, Malaysia, *Tropics*, 2017, **25**(4), 139-146.

32 Soehartono T and Newton A C, The gaharu trade in Indonesia: is it sustainable?, *Econ Bot*, 2002, **56**(3), 271-284.

33 Prihadi N, *Management and silviculture of natural agarwood*, Report of the Asian Regional Workshop on the Management of Wild and Planted Agarwood Taxa, India, 2015.

34 Wagh V W and Jain A K, Arboreal ethnoflora of Western Madhya Pradesh India, *Indian J Nat Prod Resour*, 2019, **10**(4), 68-80.

35 Mucharromah, Pengembangan gaharu di Sumatera, *Pengembangan teknologi produksi gaharu berbasis pemberdayaan masyarakat sekitar hutan*, edited by S A Siran & M Turjaman (Pusat Penelitian dan Pengembangan Hutan dan Konservasi Alam, West Java), 2010.

36 Sampson A L and Page T, History of Use and Trade of Agarwood, *Econ Bot*, 2018, **20**(10), 1–23.

37 Eissa M A, Yumi Z, Hashim H Y, Salleh H M, Saripah S S, *et al, Aquilaria* species as potential anti-inflammatory agents–A review on *in vitro* and *in vivo* studies, *Indian J Nat Prod Resour*, 2020, **11**(3), 141-154.

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