New insights into Sumatran camphor (Dryobalanops aromatica Gaertn) management and conservation in western coast Sumatra, Indonesia

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Abstract. Camphor resin has been harvested since the seventh century on western coast of Sumatra, Indonesia. Oils or crystals containing borneol collected from Sumatran camphor tree (Dryobalanops aromatica) for anti-inflammatory, analgesic, and fragrances. However, illegal logging and land conversion put the vulnerable species threatened. Based on exploration, remaining camphor trees were found growing in small-inaccessible clusters on lowlands to hills in Aceh and North Sumatra. The population declining has a direct impact on camphor productivity. Camphor crystals have been harvested by cutting and splitting stems into logs and 1.5–2.5 kg of crystals were gathered, conventionally. Camphor extraction also conducted by applying a notch on trunk of standing trees and harvesting liquid resin that exudate from wounded resin channel. Branches and leaves biomass also contain camphor oil, especially young fresh leaves (25.6%). The volatile aromatic compound in this section reveals some opportunities for camphor provision through leaves distillation (yield 0.46–0.73%), a value-added from more sustainable scheme. High beneficial compound contained, 1.8 cineole reveals the opportunities for oil utilization as anti-viral, expectorant, and respiratory and blood vessels blockage treatments. Furthermore, tree improvement strategy initiated by collecting genetic material from various remaining provenances to support species conservation and breeding populations.

1. Introduction

Indonesia is one of mega diversity countries with the largest tropical forest ecosystem in the world. Since the beginning of independence, timber exploitation has become an important sector as a source national development capital. However, direct economic benefits of the forest resources come at expense their sustainability. An area of 9.5 million ha of primary tropical forest has been lost at a significant deforestation rate [1].

The forest disturbances disrupt the ecosystem function as a supply of both timber and non-timber forest products, as well as valuable environmental services. Losing the renewable resources directly or indirectly impoverishes the communities who depend and live in and around the forest. Considering important role of forests as life support and national interests, the Indonesian government launched programs to combat forest degradation. One of them is forest management schemes which optimizing community involvement with non-timber forest products (NTFPs) as the main commodity.

The NTFPs management schemes have a long history as the main source of community livelihood in Indonesia. One of them is harvesting of camphor resin on the western coast of Sumatra. Resins are collected from Dryobalanops aromatica trees which have grown in natural forests since the seventh
century and have become an international trade icon at that time. Oil or crystals containing borneol have used for manufacture of fragrances or various medicinal agents including anti-septic, anti-inflammatory and analgesic properties.

Over the last decade, increasing global awareness on utilization of organic products contributed to high demand for this commodity. Various efforts have been conducted to explore local wisdoms in the application of natural ingredients as a source of herbal medicine and organic preservation [2][3]; including borneol from Sumatran camphor trees. The application of organic compounds for treatment is also triggered by similar concerns over synthetic drug ingredients that have been consumed.

The global market for borneol is influenced by essential oil industry growth, which various products contain this compound. The global essential oil market reached a volume of 177 thousand metric tons in 2019 and expected to grow by around 8% in 2020-2025. The pharmaceutical and perfume sectors contribute significantly for this demand [4]. The advancement in pharmaceutical industry has contributed to borneol industry growth in recent years. An increase of people’s income and followed by a level up the living standard of middle class, as well as the growth of perfume industry, encourage the borneol’s market development. In addition, an increase in demand for exotic and floral consumer products is projected to encourage the camphor industry growth [4].

The high demand for this commodity is mismatch with their supply. Currently, most of world's borneol production comes from China [4]. Meanwhile, Indonesia, which has a significant population of borneol-producing trees, hardly delivered a domestic camphor production report. The logging operations for timber and forest conversion cause the natural population to decline. Currently, there are limited people who harvest camphor resins due to the trees are increasingly rare in their natural forest.

The objectives of this research are to describe the current condition of Sumatran camphor (Dryobalanops aromatica) utilization in which includes efforts to increase the productivity through improving harvesting and processing techniques, to increase the added value through products innovation, as well as efforts to improve and conserve this vulnerable species.

2. Materials and Methods

2.1. Materials
The main materials used include camphor stands in their natural habitat on western coast of Sumatra. Various other essential oils are also required, such as benzoin oil, alcohol, plastic packaging bags for collecting leaves, and seeds. The equipment used is a steam distillatory, chisels and drills, greenhouses and nurseries, compass, hygrometer, GPS receiver, and other forest investment equipment.

2.2. Methods
The scope of the study included identification of current problems and condition in Sumatran camphor management; development of resin harvesting techniques; distillation trials to produce essential oils and hydrosol; phytochemical content identification; personal care product innovation in the form of camphor-based aromatherapy products; calculation the value-added; and formulation of genetic conservation strategies. The research series was started through some field surveys that conducted on natural distribution in Aceh Singkil and Subulussalam in Aceh, and Central Tapanuli in North Sumatra province in period 2015 to 2019. The morphological and phenology observations, seed collection and construction of permanent plots for monitoring growth and yields were carried out.

Identification of current conditions and problems in this NTFP management is carried out through focus group discussions and in-depth interviews with the stakeholders involved, such as forest management units, forestry services, local governments, research institutions, non-governmental organizations and communities. The root of the problem was identified using a problem tree analysis. Next, the identified problems were verified based on facts gathered during exploration in the remaining natural Sumatran camphor forests. These activities conducted in 2016-2017.

The measurement of camphor oil productivity was carried out by making a notch on the stem of standing tree with three relative depth levels. Measurements were applied on three trees which selected purposively in each permanent plot. The oil productivity was identified by the presence of liquid
seepage that appears on the notch surface. The equation function obtained was based on discriminant analysis of the factors which affect the productivity.

Moreover, the productivity of essential oil content was measured by distilling the fresh and dried young and old leaves. Each leaves were harvested weighing 3 kg and repeated three times. Completely randomized design operated with SPSS 14 for window was applied to determine the difference in essential oil content of the two levels of leaves conditions.

Ethnomedicinal application information was collected through in-depth interviews with ten local camphor resin collectors and five herbal practitioners in Aceh Singkil and Central Tapanuli. Meanwhile, the phytochemical content was identified and traced based on various published primary literature. Local wisdom on camphor application as an herbal medicinal ingredient was verified by referring to various pharmacological activities that identified.

The aromatherapy products developed using camphor essential oil combined with benzoin oil as base-note. The added-value calculated for processing resins into essential oils and perfume products. Furthermore, an alternative farmers' income were calculated and compared with current conditions.

Genetic conservation is carried out by collecting seeds from various provenances, germinating and planting for pruning gardens in the arboretum of research institutes. There were five provenances collected in 2015 to 2016 from Aceh and North Sumatra. The growth of five provenances have been observed and measured annually from 2017 to 2020.

3. Results and Discussion

3.1. Historical utilization

Sumatran camphor is one of historic endemic trees which spread its fragrance to various parts of the world. The precious camphor crystals and oils, including other spices such as Sumatran benzoin, have become a magnet for foreign nations to the Nusantara, designation of nations in Indonesia before independence. These commodities were in great demand by international market at that time [5].

Since long ago, various utilization of camphor oil for human purposes have been identified, including Chinese people using this oil as a tonic, aphrodisiac, and for eye inflammation [6]. The Egyptians used camphor resin as a preservative for human remains by smearing it with a balm (a mixture of camphor and ophir spices). In Middle East, camphor essential oils were also used as raw material for making medicines and perfumes [5].

The terminology of camphor was first used in the western world by Amida (502–578 AD), a Greek doctor who lived in Mesopotamia. However, Guilhot explains that the oldest writings on camphor date from the early 4th century AD, written by a merchant named Sogdian while tracing the silk route with Chinese spelling term, "kprwh"[5].

During colonial era, William Marsden, an employee of British colonial government in Bengkulu, wrote in his book History of Sumatra (1783) that camphor had an important role in trade in Sumatra. Marsden explained that camphor price was around 6 Spanish dollars per pound (0.5 kg), equivalent to gold price in Sumatra at that time. Even in China market, the price is more expensive, which is 9-12 Spanish dollars per pound [6]. The higher price was allegedly due to high demand, especially from Arab healers who used camphor as a medicine for several diseases. It also emphasized that in 1907 the selling price of camphor in Singkil area of Sumatra reached 40 dollars, this price exceeded the silver price in the same weight [6].

3.2. Source of problems

Currently, high demand for camphor resin continues, especially from pharmaceutical and perfume sectors. The global essential oil market reaches a volume of 177 thousand metric tons in 2019 with a predicted growth rate of around 8% in 2020-2025 [4]. However, high global demand was mismatched by domestic supply. Currently, most of the world's borneol demands are met from China as the largest producer. Meanwhile, Indonesia, the owner of huge camphor-producing endemic trees, does not have production information. This is identified to be impact of decreasing camphor productivity. The felling
trees for timber and forest conversion resulted in population decline. Therefore, currently it is very rare for local people to harvest camphor resin due to decreasing population in their natural habitat.

Based on problem tree analysis, the decline in NTFP productivity is identified as impact of over-exploitation and forest disturbance in form of illegal logging and forest conversion; and lack of intensive cultivation. In summary, some of root problems identified shown in Figure 1.

![Problem tree of decreased productivity and population abundance of Sumatran camphor](image)

**Figure 1.** Problem tree of decreased productivity and population abundance of Sumatran camphor

Currently, information about Sumatran camphor productivity as a precious NTFP is unknown. In fact, camphor trees are increasingly difficult to find in their natural habitat. Since 2018, the IUCN Redlist categorizes *Dryobalanops aromatica* species in a vulnerable status even though it was previously classified as critically endangered [7]. The threatness is also caused by practice of felling carelessly to get camphor crystals. Other threats include forest degradation, fires and land conversion.

The advanced technology to increase the value added is very limited. There are hardly any domestic innovative products that are developed from camphor resin. Conventionally, camphor collection damages the trees because it is harvested by felling operation, while essential oil production from leaves undeveloped. This condition causes this resource to be under-valued, thus being valued at less than direct economic value of oil palm plantations, the main driver of forest conversion.

The intensive silviculture is limited and undeveloped, these is a symptom of uninitiated tree improvement and superior seed sources, and lack of cultivation techniques to increase the productivity. Until now, there has been no designated seed source due to limited information about source of mother tree or the best provenance, lack of information on viability and phenology. Cultivation techniques, such as appropriate spacing, stands management; growth and productivity estimation; and vegetative propagation have not been well mastered. With limited seed availability due to lack of phenology and superior mother trees information, generative propagation cannot be completely relied on.

### 3.3. Where remaining?

*Sumatrana camohor tree (Dryobalanops aromatica Gaertn)* is a member of Dipterocarpaceae which produces a various high economic value commodities, both timber and non-timber. This dominant species is synonymous with *D. camphora* Colebr., *D. sumatrensis* (J.F. Gmel.) Kosterm, and *Shorea camphorifera* Roxb. [8]. The endemic species in west coast of Sumatran also being known as Kapur, Kapur Barus or Kapur Singkel, in Borneo region tree has names Kapur, Kapur bukit, Kapur peringii, Kapur anggi, or Keladan. In international trading, this NTFP is also known as Indonesian kapur (UK, US), capur d’Indonesia (Fr), capur indonesiano (Sp, It), and Oost-Borneo kamfer, kapaer (NI) [8].

The species name comes from Latin (*aromaticus* = like spices) and refers to resin smell, one of main sources of camphor or borneol. The tree grows to diameter of 150 cm and height of 60 m. The bark is brown or reddish brown with a rough surface, shallow grooved and cracked. The camphor scent will be smelled if stems are felled or leaves are crushed. Leave is single and alternate with glossy
surface. Flowers are of medium size, petals are same size, have elliptical petals, bloom, waxy white, and have 30 stamens. Fruit is large, shiny and winged as many as 4-5 pieces.

The habitat of camphor tree is mixed Dipterocarp forest, on hillside and mountains. The species distribute naturally from Malay peninsula, Sumatra island, to Borneo island. Some of natural habitats are peat forests, beaches, heat forest, fresh water swamps, river banks, and lowland forest. In Sumatra, natural distribution included the western of Singkil, Natal river, along Sibolga and Padang Sidempuan to Airbangis (West Sumatra) and throughout of Rokan river to north of Batanghari river in eastern Sumatra. This species found in Riau islands including Bengkalis and Malacca, off west coast of Sumatra. It is found in Morsala island [6].

Based on exploration in Subulussalam, Aceh Singkil and Tapanuli Tengah in 2015 - 2017, the remaining camphor trees were found grow in small clusters in lowlands to hills at an altitude of 700 masl. After forest exploitation era ended, natural camphor stands were only found in separate small spots that were not covered by logging operations in Kadabuhan, Jongkong and Sultan Daulat in Subulussalam district, Singkohor and Danau Paris in Aceh Singkil district, as well as Strandonrung and Manduamas, north of Barus, Central Tapanuli district. During exploration in 2018-2019, this species was also found in swamp peat forest in Singkil, Aceh [9].

Natural populations of camphor trees in Subulussalam region found in Kadabuhan, Pulau Penyengat, Laot Bangko, Singgersing and Babaluhung. The populations grow in remaining forest spots, while surrounding areas converted into oil palm plantations. The trees in Kadabuhan have large height and diameter up to 85 cm - 180 cm and height of 20 - 25 m. The population in Laot Bangko is a relatively uniform diameter of 15 - 35 cm and height of 8 - 12 m. Mother trees with large diameter are not found due to forest were logged and shows the character as secondary forest in this area.

In Aceh Singkil, natural stands are found in Lae Sipola, Singkohor, Aceh Singkil district. The population grows around oil palm plantations, mixed with shrubs and pioneer tree species. Camphor trees have a diameter of 20 - 50 cm and a height of above 25 m [9]. In the last, the population of Sirandorung has a wider diameter distribution from 10 to 50 cm up. Of the 28 sample trees measured, half were in 40 - 49 cm diameter. There are four trees with diameter above 50 cm. Compared to Singkohor’s population, the population in Sirandorung are bigger and taller [9].

3.4. From timber to healthy products

Camphor tree was once an important timber trade species in Indonesia. The camphor wood trade - combined with keruing (Dipterocarpus spp.), reached an export value up to US $ 100 million in 1989. The golden period for camphor wood production lasted until the mid-90s.

Camphor wood is preferred because it durability (categorized class II –III), it can be shaved well, but the results tend hairy if the knife is blunt. The timber is used in various constructions such as beams, poles and boards in residential buildings and bridges, used for shipping, caskets and coffins. Camphor timber is also used for plywood, heavy construction, shipboard flooring, sawed shingles, truck body and packing crates for heavy goods.

After millennial, camphor timber production decreased dramatically. The Central Bureau of Statistics (BPS) reports that total log production by forest concession companies during 2004-2011 reached 2.5 million m³ or around 400 thousand m³ per year. However, after this period production trend continued to decline, around 209,287m³ in 2011 [10]. During period 2016-2017, camphor wood production only reached 35-56 thousand m³ [10]. This shows that camphor tree population is decline significantly in their natural population.

On the west coast of Sumatra, this timber was a primadonna. Many timber exploitation companies operating in Natal areas of South Tapanuli, Sibolga of Central Tapanuli and Aceh Singkil produce this commercial wood which are sent abroad in the form of logs and plywood. At that time many plywood industries operated in the Barus from the early 70's to the late 90's. However, the decline in population resulted in current timber decline drastically and timber companies closed. Since the beginning of millennial, thousands hectares of forest concessions area were converted into oil palm plantations. This condition displaces the camphor population that grows in the forest area.
Sumatran camphor is a camphor producer species besides *Cinnamomum camphora*. This crystalline oil compound is a secondary metabolic product found in the axial parenkin channel of the stem [11], so the most common way to harvest the resin is by cutting and splitting the stems. Crystals can also exudates on injured stem bark.

Traditionally, camphor crystal extraction involves several steps, from selecting and cutting the tree, and splitting the stems into 1.5 - 2 m blocks. Not all of the trees that were cut down contain camphor crystals. Therefore, the felling was carried out carelessly by a logger until a tree that was filled with camphor crystals was found. If it is considered sufficient, the crystal collection process is continued. In this way about 1.5–2.5 kg of camphor crystals of various qualities are obtained.

Camphor extraction is also carried out by applying some notches on trunk of standing tree, followed by gathering liquid resin that exudate from wounded resin channel (Figure 2). The notch is a 4 inch deep hole at base of tree (6 feet above ground). The hole is made from bark to woody part. The notch will slowly drain liquid exudates. The technique produces about 80-100 ml of liquid camphor for six hours.

![Figure 2. Camphor resin in various forms](image)

The productivity of this liquid camphor is influenced by tree size and the wounding technique. Based on the discriminant analysis, the oil productivity is influenced by the stem diameter with an effect value of 64%, while 36% remain by tapping holes depth [9]. This shows that the larger tree diameter, the greater the oil production. Wound renewal is necessary to avoid the clotting the resin fluid flow. From the experiments conducted, no oil and resin was produced on smaller trees with diameters below 20 cm. This shows that in young trees, secondary metabolic has not appeared, while most of the photosynthesis products are used to build biomass.

Twigs and leaves were also identified containing camphor. Lacerated young leaves will release visible oil. If the leaves are squeezed, it will produce a distinctive camphor aroma. The aromatic content in these parts open the opportunities for provision camphor through the distillation process. The essential oil content obtained using the steam distillation of young and old leaves.

The distillation process begins with loading 20 kg of water and 3 kg of leaves into the boiler. Thirty minutes after the distillation started, distillate produced by all leaves condition. Distillates consist of both essential oils and distillate water (as hydrosols) [12]. The essential oils were detected significantly at sixty minutes. The accumulation of essential oils increases until termination of distillation. At the termination of distillation (300 minutes), fresh shoot-young produced the highest concentration of essential oil as shown in Table 1.
The highest yield of essential oil was obtained from distillation of fresh shoot-young leaves with a yield of 0.603%. This concentration level is quite high, even without distillation the high oil content is evident when leaves are plucked or torn apart. Older fresh leaves have lower yields (0.223%). Unlike other essential oil-producing plants, drying the leaves before distillation produces lower yields. Dried young leaves contain 0.187% essential oil, while dried old leaves contain 0.083%. The decrease in oil concentration was identified due to the volatile compounds contained in the leaves lost when drying.

Similar results were shown by hydrosol production from distillation different leaves condition. The fresh shoot-young leaves produce about 2,523 ml of hydrosol, the highest compared to other leaves. The amount of hydrosol produced from dried mature leaves is 2,304 ml. Despite the weight of the hydrosol produced did not differ significantly, each hydrosol has a different distillate aroma. This was identified due to the different content and concentration of camphor compounds dissolved in the water.

Despite both essential oils and hydrosols are produced by steam distillation process, they have very different in their utilization. Traditionally, local community use camphor oil as well as eucalyptus oil for toothache medicine, redened eye inflammation, rubbing oil and for external wounds infected with germs. The oil is also used in traditional medicine to treat colds and dyspepsia symptoms such as nausea, bloating, ulcers and other symptoms of stomach problems. In topical applications, oil is applied to treat wounds, burns, rheumatic, muscles and joints pain, as well as to relieve itching due to insect bites, sprains, rashes, and other skin diseases.

Leaves and fruits are also utilized by the community. Camphor leaves are dried into a nutritious tea to relieve colds and increase the appetite. In addition, the fruit of the camphor tree can be made sweets that can be eaten immediately. Fruit that is cooked on the fire can also produce edible oil [6]. Local wisdom also reveals the potential of this oil to extend the expired date of of processed foods.

Borneol is an alcohol terpene that resembles a white powder or crystal (C\textsubscript{10}H\textsubscript{18}O), which is widely utilized as fragrances, antiseptics and others [13]. In China, it applied as anti-inflammatory and analgesic. This compound also utilized as additional ingredient in sanitary napkins (bio panty) which is useful for reducing pain and pressure during menstruation, reducing muscle and joint pain [14][15]. Recently, demand for borneol from Dryobalanops is high because it identified as effective for thawing clots in cases of blockage of blood vessels in the human heart and brain [14][15].

Several studies denoted the high potential of Sumatran camphor as raw material for herbal medicines [14][15][16]. The organic compounds in essential oil include camphene, limonene, 1,8-cineole, a-pinene, p-cymene, etc. In aromatherapy utilization, camphor aroma has relaxing and refreshing effects. The 1.8 cineole identified potential as anti-viral, anti-bacterial and anti-fungal, expectorant, and blood flow. Recently, this compound applied for respiratory tract and blood vessels treatment and to improve immune system [3]. Moreover, p-cymene proven to reduce anxiety, refresh and calm the mind and increase libido. Bioactivity test results indicate that organic content in camphor oil can rectify the nervous system [2][17]. In daily application, camphor oil can relieve inflammation, insect bites, itching, irritation, rashes, sprains, and muscle and joint pain.

In this study, aromatherapy products developed utilizing camphor essential oil combined with benzoin oil as a base-note. The combination of same active compound harmonizes the aroma with minimal contraindications, so that resulting aroma have refreshing, relaxing and calming effects.

Hydrosol has lower safety concerns, although there are some important points in application safely. Generally, hydrosol can be applied for cuts and scrapes, base for lotions, or consumed as a flavoring for drinks or therapeutic use, and perfume. Meanwhile essential oil is much stronger than hydrosol and
can be applied with diffuse into air, and helps relieve colds, however, internal consumption for acute health conditions should be carried out under supervision of a qualified practitioner.

Hydrosol contains a higher concentration of volatile substances than herbal teas and has therapeutic benefits when consumed \([12],[18]\). Some of hydrosol benefits when taken internally include helping to relieve rheumatic pain; relieves headaches; and calm nerves. Furthermore, hydrosol used to remove make-up; face toner; facial lotions; and application as a pleasant and relaxing perfume (cologne).

Basically, hydrosol is a byproduct of essential oil distillation. Therefore, the production costs are closely integrated with essential oil distilling costs, so that no special cost allocation is required. Production costs come from leaves provision, installation of distillation equipment and energy to produce water vapor (steam). However, leaves provision cost is assumed to be zero, or at least only daily wage, considering that camphor leaves are not used so far.

Based on ongoing research, it is estimated that production cost in form of energy for distillation each kilogram of hydrosol is around IDR 18,000. If hydrosol price in online market reaches at least IDR 500,000/kg, an increase in added value of IDR 282,000/kg will be obtained from distilling leaves, resources unutilized, but fell and decay on forest floor. Even if collecting leaves cost is IDR 50,000 daily for 100 kg of leaves (average IDR 500/kg), the added value of this innovation product is high and significant for the community's alternative source of income.

The results indicate that leaves distilling process can be a prospective scheme in increasing the added value of Sumatran camphor. Recently, organic and green products have become fashionable, but quality goods are generally produced with selected raw materials, and are therefore expensive. On the other hand, this research shows that by utilizing the relatively abundant leaves waste, high quality and healthy hydrosol can be produced cheaply.

3.5. Tree Improvement and Conservation

Not all camphor trees produce camphor oil and crystal and there are individuals with superior growth performance indicating breeding efforts are a necessity. Extracting information on distribution, increasing the population’s abundance and productivity through quality seed sources and appropriate silviculture techniques are expected to increase camphor productivity.

Based on phenology observations on permanent plots during the period 2015 - 2018, it is known that the flowering period of the Sumatran camphor trees starts in December - January with ripe fruit and falls in February - March. It was observed that mass flowering and fruiting occurs once every four years. These seeds are recalcitrant so it must be germinated immediately and cannot be stored for long time without water content regulation.

Tree breeding initiatives have been initiated by collecting seeds from five provenances from Aceh Singkil and Barus [9]. The seeds were germinated and then planted in the research center arboretum which is at an altitude of 1200 m asl, a higher elevation than the provenance. The results of preliminary growth observations since 2018 have shown excellent performance for all provenances growth. The average height reached 2.5 cm with diameter 3 – 4 cm at the base of stem. The adaptability at higher elevations as well as on opened sites or logged scrub and frequent fires in critical lands dominated by imperata allow this camphor tree as a rehabilitation species.

In order to monitor the growth and conserve the genetic diversity, a permanent plot of 0.25 ha (50 mx 50 m) was built since 2015 in each provenance [9]. All tree species above 10 cm diameter in the plots were measured. These trees are measured and recorded in the following years.

Density and species abundance for each permanent plot were different. In the plots built in primary forest conditions, large and old camphor trees dominated. Meanwhile, in logged-over secondary forest, the trees are relatively uniform but smaller in size. The remaining camphor trees in the area are more due to high level logging difficulty due to steep topography. Conversion of forest to oil palm plantations is the biggest threat to continued growth monitoring on the plots.

Based on vegetation analysis in each permanent plot, camphor tree is dominant species with the H’ Index is calculated at 1.41-1.81 which indicates that tree species diversity is moderate. The density of camphor tree species reaches 36-104 trees/ha with a total density of all species 200-340 trees/ha.
In each permanent plot, some plus trees were also selected. The selection was made by taking into account the stands diversity. The position of selected tree is the initial key in the construction of stands or mother trees as source of quality seeds. The mother or plus tree selected is the best tree among three surrounding trees based on criteria for resin quantity. Selection of prospective plus trees aims to collect as much as possible genetic diversity in the stand.

The criteria for evaluating the selection of mother (plus) trees include: (a) relatively high resin production; (b) produce abundant fruit and viable seeds; (c) healthy trees (not attacked by pests and diseases); and (d) compared to average height and diameter of the surrounding trees, the height and diameter of the parent tree should be at least 5% larger [9].

Vegetative propagation technique is required to overcome the limited of good seeds availability [9][19]. The tree improvement strategy for this vulnerable species began by collecting genetic material from various remaining provenances. Furthermore, this genetic diversity will promoted to support the provision of basic, breeding, reproduction and production population for wide plantation development.

4. Conclusions
This paper describes a new insight into the management of Sumatran camphor as a potential non-timber forest product from the west coast of Sumatra. Research revealed new findings which some the improved harvesting techniques increase the camphor resin productivity. Camphor extraction can be conducted by applying some notches on the trunk of a standing trees and gathering the liquid resin or exudate oils from the wounded resin channel. Young fresh leaves contain camphor significantly. The volatile aromatic compound in this biomass reveals some opportunities for provision of camphor through the distillation process, an added-value from more sustainable utilization scheme.

Aromatherapy product innovations were identified to increase the total economic value of this resource. High beneficial compound contained reveals the opportunities for camphor essential oil utilization as an anti-viral, expectorant and relaxing of mind. Furthermore, vegetative propagation technique is required to overcome the limited seeds availability for widely plantations. The breeding strategy began by collecting genetic material from various remaining provenances to support the species conservation and breeding populations.

The information is expected to become a basis for policy makers to conserve the remaining camphor stands. Without sufficient attention, it is feared that in the next few years Sumatran camphor tree will be increasingly threatened. Based on the aspect of biodiversity conservation, this research supports the genetic conservation of Sumatran camphor species by adding and enriching existing populations both in-situ and ex-situ.

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