

# A field survey of agarwood in Indonesia

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Agarwood is one of the most valuable non-timber forest products harvested from the tropical forest in Southeast Asia. We have surveyed agarwood in Indonesia which is performed through interviewed collectors, businessmen, and government officers (Ministry of Forestry, East Kalimantan, Indonesia) and also surveyed the wild agarwood and its cultivation in South Sulawesi and East Kalimantan Provinces. High economic value is one of the reason for collecting agarwood to increase family income of the peoples living near by the forest. Each surveyed area has a different classification and price of each grade, according to their experience by observing the darkness, smell, oily, and density of agarwood. Over exploitation of natural resource of agarwood makes the stock becoming exhausted. It was been an initiative for conservating the plant of source agarwood by cultivation. Fungi, the known stimulators in formation of agarwood, are used in the cultivation of agarwood. *Fusarium laseritum* is the faster fungus infected of *Aquilaria* sp. tree, and can be isolated and inoculated easily into medium. Thus, this fungus is used by inoculate into the holes on the trunk. One year after inoculation obtained agarwood with the lowest grade. This cultivation program was supported by Indonesian government through research and training to the collector who cultivate agarwood.

**Key words** agarwood, gaharu, *Fusarium laseritum*, Indonesia.

## Introduction

Agarwood is the heavily oleoresin impregnated solid chips of wood obtained and processed from the fungus affected part of the trees. Devoid of the fungus, the agarwood tree in it self has no values. It has been traded since biblical times for it use in religious, medicinal, and aromatic preparation. The first historical of agarwood from Assam (India), it was used for fragrance with burning and incense by the Hinduism. It is written also by Bana 652 AD in Sanskrit-the Harsha Charita the chronicle the fact that agarwood was used at this time.<sup>1,2)</sup>

*Aquilaria* spp. are the principal source of agarwood. The genus belongs to the Thymelaeaceae family, consists of 15 species, which occur in tropical forest in Asia. Others families known as the plant sources of agarwood are from families of Leguminosae and Euphorbiaceae with the genus *Dalbergia parvifolia* and *Excoecaria agallocha*, respectively. On these plants, *Aquilaria malaccensis* LAMK is the tree source of agarwood with the high quality.<sup>3,4)</sup>

The density of oleoresin is the most important factor to decide the grade of agarwood. It does not generate obviously fragrance before burning, highly flammable to create black smolder and oil burning while they are burning. Mostly product of agarwood is used for incense, perfume, cosmetics and for traditional medicines.

Agarwood is one of the most valuable non-timber products harvested from tropical forest and locally known as "gaharu" in Indonesia. Six species of *Aquilaria* plants (*A. cumingiana*, *A. malaccensis*, *A. microcarpa*, *A. hirta*, *A. beccariana*, and *A. filaria*) were reported as the sources of agarwood in Indonesia and to be located in Sumatra,

Kalimantan, and Irian Jaya.<sup>4)</sup> Trades of agarwood in Indonesia are the wood with a variable grades, agarwood powder, agarwood oil, cosmetics, medicines, and aroma therapy.

In our interest to investigate agarwood in Indonesia, we have surveyed the wild and cultivation of agarwood and interviewed the collectors, businessmen, and the local government officers (Ministry of Forestry). The locations of our investigation are Luwu Utara (South Sulawesi Province), Tarakan and Samarinda (East Kalimantan Province) (Fig. 1). This project was supported by Ministry of Education, Culture, Sports, Science and Technology (Monbukagakusho), Japan.

## Survey area

### Luwu Utara (South Sulawesi)

Luwu Utara is one of the districts in South Sulawesi Province which has a total forest area of 1,058,349 ha. In Indonesia, this area is not popular as the area of source agarwood. Presence of agarwood was known from the local people who harvest agarwood from the forest. According to the collectors who we interviewed, the people in this area know about agarwood since 1998. They got information about the characteristics of agarwood tree from their family who migrated to Irian Jaya Province (one of the area source of agarwood in Indonesia). Nowadays, the businessman came to this area and bought agarwood from the collectors. Because of uncontinuity supply from the collectors, business agarwood in this area is not favorable.

Agarwood is harvested from the forest in groups, one group of 10 people with at least one professional collector. They carry with them food, knife, and other necessary kitch-

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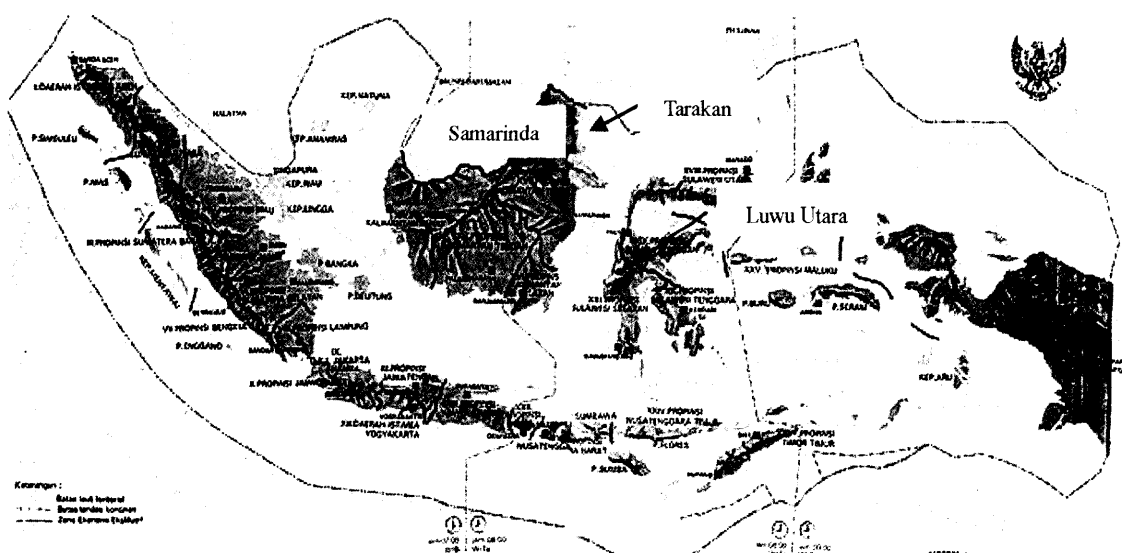


Fig. 1 Map of the study area in Indonesia

enware for two or three weeks trip. During their trip, after one agarwood tree is found, they stay in that area for search other ones, because they believe that if they found one tree means there are other ones near from that tree.

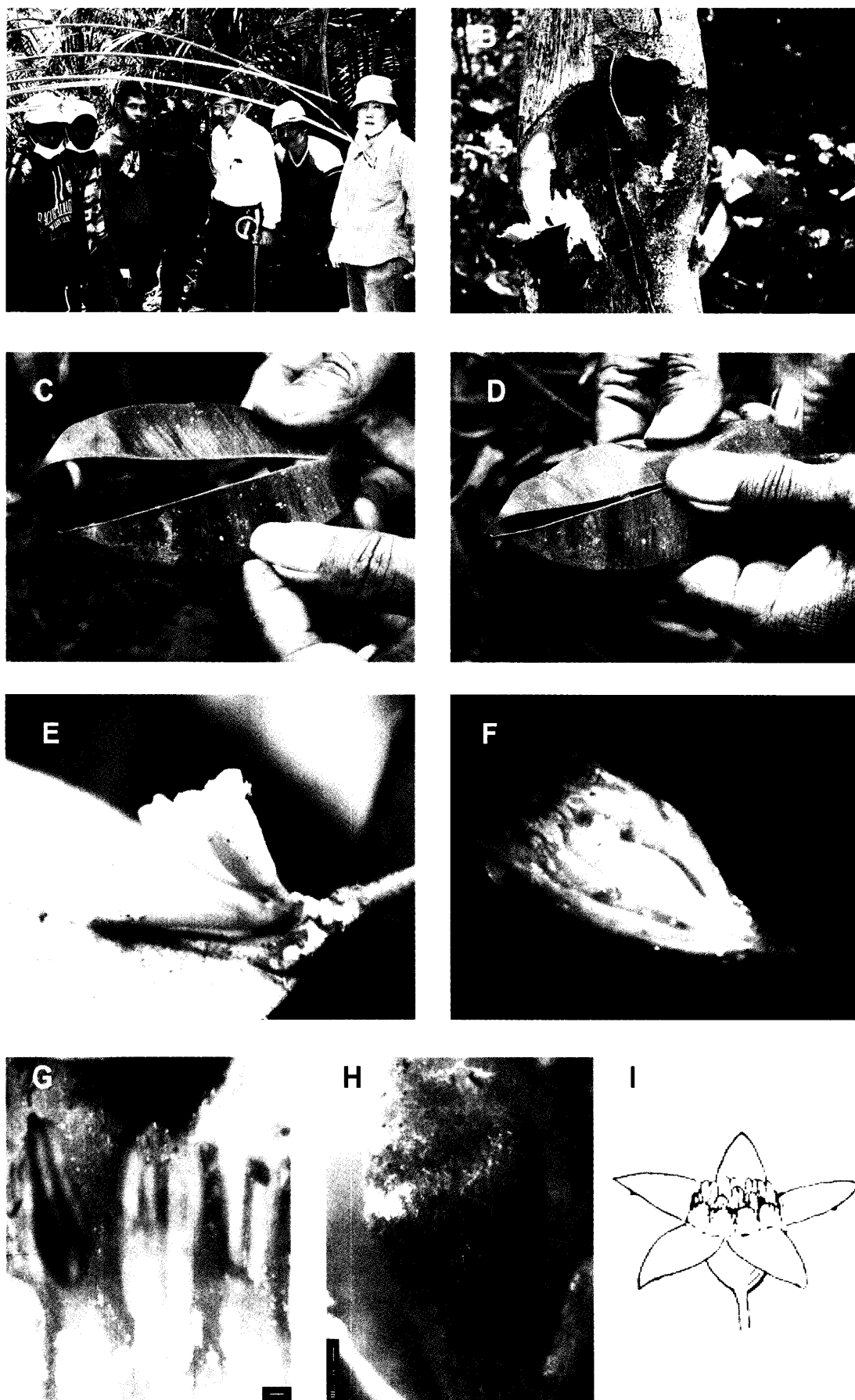
Not all the agarwood tree can produce agarwood, they select the trees with the leaf showed yellow color or not fresh, the trees with the broken branch or occupied by ants. They believe that the tree in those conditions is containing agarwood. Size of the tree is not an indicator of presence agarwood, sometimes the small tree with the diameter trunk of 5 cm contains agarwood. On the selected trees, they slice the suspected part and the wood with the brown or black color with aroma when it burning were taken and polished during their trip. The collectors harvest agarwood from the forest in any season according to the ordering of the businessman. The native peoples in this study area do not use agarwood in their life and agarwood was collected only for its economic value.

Under guidance of the professional collectors in this area, we surveyed the wild agarwood in the Salutodan Forest (Fig. 2. (A)). In the altitude of 825 m after walking into forest for two hours, we found the flowering agarwood tree with the diameter trunk of 15 cm and other young trees (Fig. 2 (B)). A simple traditional method to distinguish with other tree is from the leaf which can be divided vertically into two equal parts from tip to the edge of the leaf (at the central vein) (Fig. 2. (C)), but difficult to divide or break from other side, vertically (Fig. 2. (D)). The tree had been wounded on its trunk and had produced agarwood with the lowest grade, when a small piece of the wood taken from the wound, was burned, the smoke had the lowest-grade agarwood smell. The flower, leaf, and trunk were collected for further investigation on the species of this plant.

In our investigation on the morphology of the agarwood found in this area, we observed the trunk with the bark is ashen, lenticel is nearly longitudinal, and the wood is whitish. Leaf apex is acute angled, and the length and width of leaf are about 10-12 and 5.5 cm, respectively, and the

petiole with the length of 5 mm. Surface of blade exposed to the sun is coriaceous, bright green, and semilustrous with a few hairs. While, another surface, especially at around main vein, is grown a few appressed hairs. On the young petiole and branch are densely grown appressed hairs which are white and deciduous. The flower is tubulose and elongated with 6-7 mm in length and around 2 mm width (Fig. 2. (E)). The lobe is curl to outside at one-fifth from the top, and pubescence is growth on outside and inside (Fig. 2. (F)). Peduncule is short with 2-3 mm in length with rare of hair. The numbers of stamen are twofold of calyx lobes with length about 1 mm, almost sessile, attached inside of the flower. The petaloid appendage between them is very short (Fig. 2. (G)) and the ovary is grown with hyploid hairs downward at the bottom, and upward at the top (Fig. 2. (H)). Length of stigma is about 1 mm, and the style is very short.

In our effort to determine the species of this agarwood, it was compared with the morphology of six species of agarwood reported to occur in Indonesia.<sup>5)</sup> The leaf morphology of these species are relative similar to each others, thus difficult to identify only with leaf feature. The flower shapes of three species, *A. cumingiana*, *A. malaccensis*, and *A. microcarpa* which are copulate or companiform (Fig. 2. (I))<sup>6)</sup> was different with the flower of this agarwood with tubulose form (Fig. 2. (F)), and their filaments are same or longer than anther, so the agarwood tree was through to be neither *A. cumingiana*, *A. malaccensis*, nor *A. microcarpa*. The agarwood tree was suggested to be different species from *A. filaria* whose flower was written to be infundibular, worn rich cilia, and have half length of calyx lobes with 1 mm length of petaloid appendage. The petiole appendage was very small (Fig. 2. (I)) compared to that of *A. beccariana* which is equal to the length of stamen and pubescent which was indicated that the tree was not *A. beccariana*. These evidences supposed that the indigenous agarwood tree found in South Sulawesi might be *A. hirta* RIDL. or other species from the 6 species, through certain evidence such as feature of fruits was not enough.



**Fig. 2** (A) We surveyed wild agarwood in Salutodan Forest together with the professional collectors. (B) Wounded trunk of the agarwood tree. (C) Leaf of agarwood can be divided into two equal parts at the central vein, but (D) difficult from other side, vertically. (E) Flowers, (F) opened flower, (G) stamens, and (H) ovary of the *Aquilaria* sp. (I) Flower with a copulate or companiform.

The grade or quality of agarwood was classified base on the darkness (black color is the best quality), the presence of oil with the strong smell, the shape which the horn form is the best, and the density which they identify by put into water with the sink agarwood is the best quality. The final grading of their agarwood is decided depend on their negotiation with the businessman. Sometime, agarwood with the best quality according to the collector, but for the businessman is the middle quality and they decide as the middle quality with the special price (more than normal price for the middle quality). They classify the agarwood into four classes. The highest quality is called "super" with the price of Rp. 7 million/kg, followed by class of "medang" Rp. 1.8 million/kg, "kacang-kacangan A" Rp. 200,000/kg, and "kacang-kacang B" with the price of Rp. 100,000/Kg (US\$ 1  $\approx$  Rp. 9000, November 2004).

High economic value and difficulty to find the tree source of agarwood in the forest to make the collectors also brought the young tree of agarwood from the forest and planted in their garden. We interviewed Mr. W. Damiri (50

who tried to cultivate agarwood in his garden, with the experience of 3 months training on cultivation of agarwood in Bogor (Java). He had cultivated four species of *Aquilaria* plants with about one year old. Among them, *A. beccariana*, *A. microcarpa* and *A. filaria* were collected from Bogor (Java) as a cuttage and *A. malaccensis* from this area as a seed (Fig. 3. (A), (B), (C), and (D)). The species from this area was determined as *A. malaccensis* according to his experience about this plant. It is different from our investigation on the wild agarwood which we found in the Salutodan Forest. Due to the small size without flowers or fruits on his plantation, we could not determine the species of his agarwoods. When becoming 4 years old, *Fusarium* sp. will be injected to the holes in the trunk with 1.5 cm-diameter of hole and the depth of one-third of the diameter trunk at 50 cm high. In his garden, he planted the agarwood tree together with vanilla, as the host tree of vanilla to give economic values during the growing time until 4 years old (Fig. 3. (E)).



Fig. 3 (A) *A. beccariana*, (B) *A. malaccensis*, (C) *A. microcarpa*, and (D) *A. filaria* were cultivated in Luwu Utara, South Sulawesi Province, and (E) *Aquilaria* spp was planted together with vanilla.

### Tarakan and Samarinda (East Kalimantan)

In our continued interest to this study, we also surveyed agarwood in East Kalimantan as an area source of agarwood in Indonesia. East Kalimantan is the second widest province in Indonesia with 11% of totally Indonesia area, after Irian Jaya. More than 80% of the area or over 17 million hectares is covered by forest. The harvesting of non-timber forest products represent as the important source of additional income for many inhabitants of this province, the main of that are gaharu (agarwood). Agarwood in this area is also called "sekau" from Dayak language, the native tribe in Kalimantan. *A. malaccensis*, *A. microcarpa*, and *A. beccariana* are the species occurring in East Kalimantan. Among them, *A. malaccensis* is the popular species with the high population than other species source of agarwood.<sup>4)</sup>

In this area, we interviewed Mr. C. Lesmana (53), a busi-

nessman of agarwood in Tarakan with the experience of more than 20 years on this business. His agarwoods are bought from districts Apukaya (Bulung), Malinau, and Berau. He classifies agarwood into 5 grades according to the smell, density, and the color of the agarwood. The special grade is called "double super" with the price of Rp. 15-20 million/kg, indicated by black color, heavy (high density), and has strong smell when burned. The second one is called "super" with the price of Rp. 10-12 million/kg, the third is "AB" with Rp. 5-6 million/kg, the fourth is "kacang-kacangan" with the price of Rp. 2.5-3 million/kg, and the lowest is "teri" with the price of Rp. 1-1.5 million/kg (Fig. 4). The higher grades are exported to Singapore and Saudi Arabia, and the lowest grade to Taiwan. Other businessman who we interviewed in Samarinda classifies agarwood into 5 grades with the subclass. The first grade is "super" with

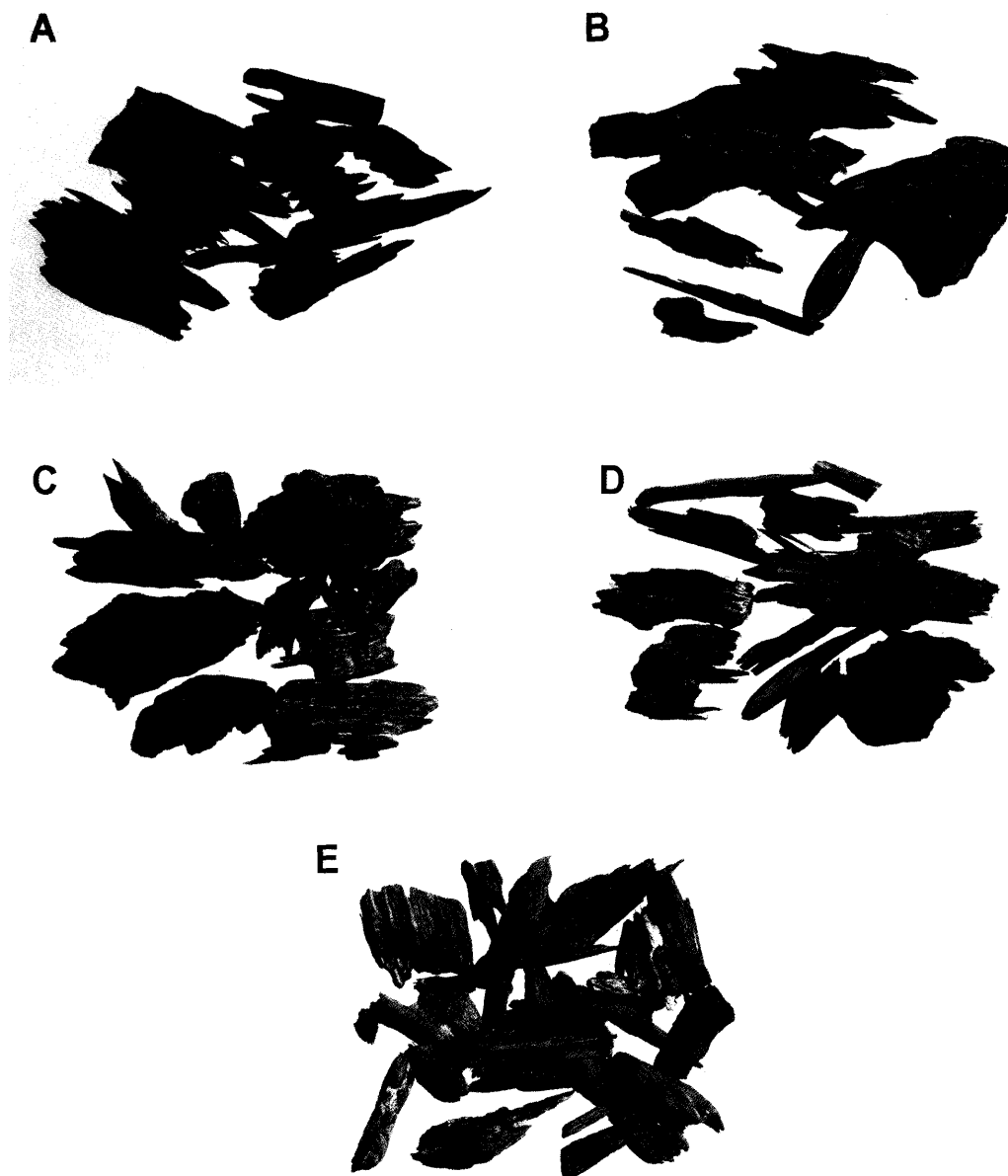
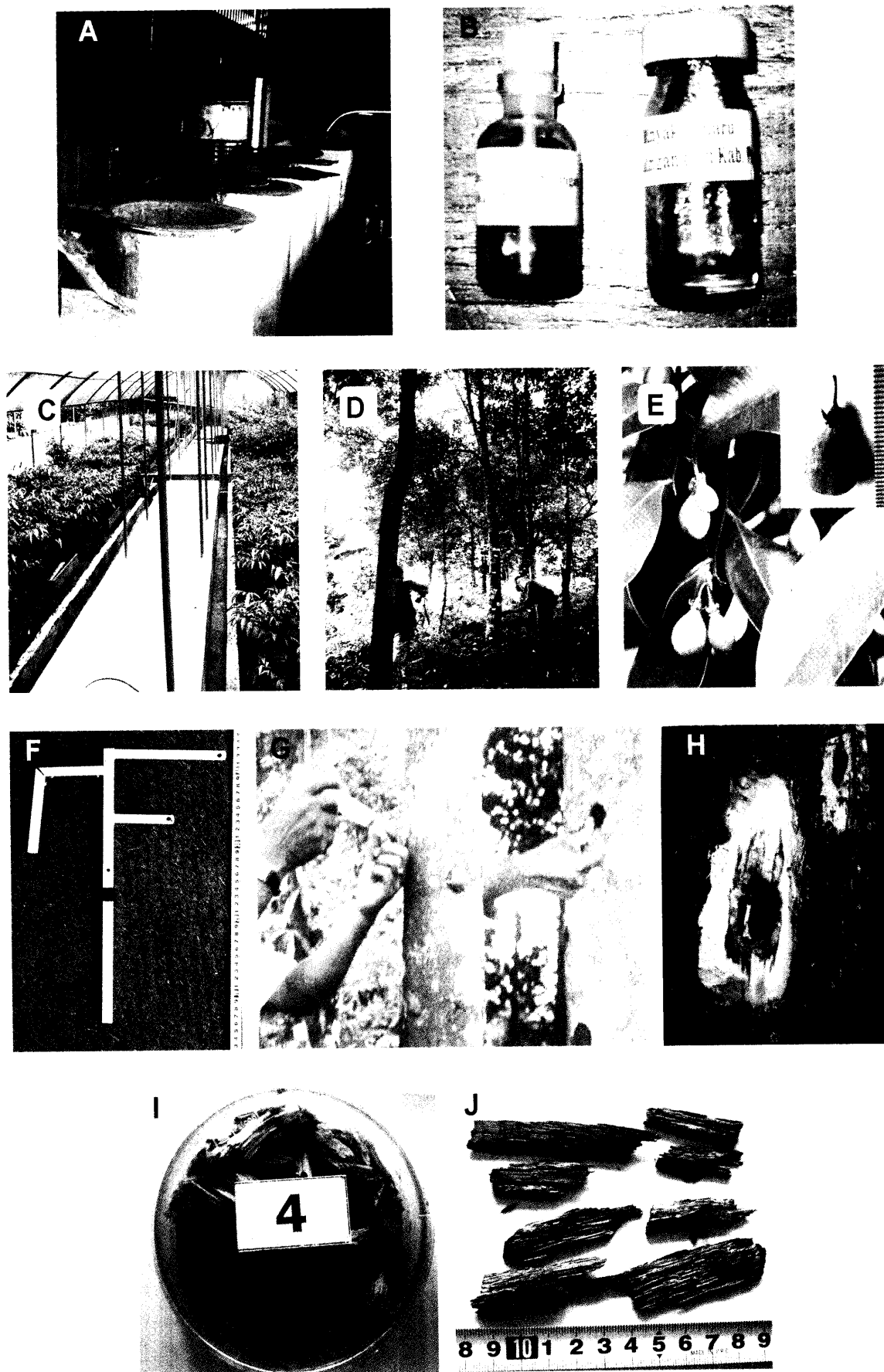


Fig. 4 Commercial grade of agarwood in district Tarakan (East Kalimantan), "double-super" grade (A), "super" grade (B), "AB" grade (C), "kacang-kacangan" (D), and "teri" (E).



**Fig. 5** (A) Distillation of Agarwood (home industry) in Samarinda (East Kalimantan). (B) Agarwood oil. (C) Plantation. (D) *Aquilaria* sp. tree in the arboretum. (E) Fruits of *Aquilaria* sp. (F) Hole measurement. (G) Inoculation of *Fusarium* sp. (H) Infected tree. (I) Agarwood produced after 4 months and (J) 1 year inoculated by *Fusarium* sp.

divided to 3 subclasses (double king, king and super), followed by "tanggung" (A and B), "kacangan" (A and B), "teri" (A and B) and "kemedangan." It was indicated that each area of source of agarwood have a different standardization of grade.

The traditional uses of agarwood in this area are for incense in their traditional ceremonies, flavoring agent in the rice, sometime also they keep in their smoke to give a good smell when smoking and as a traditional medicine for diarrhea and impotence.

In this time, we also visited the home industry of distillation agarwood in Samarinda (East Kalimantan). The lowest grade and the wood remaining after polish of agarwood are collected and distilled with steam for two or three days to give agarwood oil. From one kilogram of sample is obtained 2 ml of oil (Fig. 5. (A) and (B)).

### Program cultivation of agarwood in Indonesia

Evidence that agarwood are declining in availability in Indonesia was obtained from the personal experience of agarwood collectors. They reported<sup>4)</sup> that agarwood is becoming more difficult to find, indicates that stock are becoming exhausted. The regional trade data also indicate a recent decline in the volume of agarwood traded from Indonesia.

Cultivation is one of the solutions to dissolve this problem. The collectors have self-initiation to cultivate this plant by plantation the young tree that they found in the forest to their garden. The big trees without agarwood that found in the forest were stimulated by strike the bark of trunk with a hammer. They believe that from this wound part of tree, agarwood will be form. Other traditional methods are by making hole on the trunk and put a mixture of oil and brown sugar into hole or with a small piece of agarwood.

We visited the Ministry of Forestry East Kalimantan, Division of Research and Development who have program of cultivation of agarwood since 2 years ago. They planted the young agarwood trees or seeds which were brought from the forest and the collector's garden. At this time (November 2004), in their arboretum, agarwood had fruit and would ripe after one month later (Fig. 5. (C), (D), and (E)).

A fungus as the stimulator formation of agarwood was inoculated to the trunk at 4 years old of the tree. There are five species of fungi which can infect the tree and stimulate formation of agarwood. They are *Botryodipodia* sp., *Phytium* sp., *Fusarium oxysporium*, *F. bulbigenum*, and *F. laseritum*. In their investigation, *Fusarium* spp. were the faster fungi infected the *Aquilaria* spp. tree than others. From these species, *F. laseritum* was the fungus which could be isolated and inoculated easily in the media of Potato Dextrose Agar (PDA).

Fungus was inoculated by injection into the hole in trunk. Hole was made with diameter of 0.8-1cm and depth of hole is one-third of the diameter of trunk. The holes were made at 20 cm from the land (high) and the next hole was 20 cm from the previous hole with the spiral position on the trunk by using hole measurement (Fig. 5. (F) and (G)). Fungus was prepared in liquid or solid inoculants. Liquid inoculants

were made from suspension of the *F. laseritum* in the liquid medium and solid inoculants were made from inoculation of *F. laseritum* in the powder of *Aquilaria* spp. wood. After inoculation, the holes were closed with wax to avoid contamination by others fungi. Formation of agarwood was ascertained after three months inoculation by holing the trunk or slicing the bark near from inoculation hole (Fig. 5. (H)). A slice wood from this site was burned and presence of the aroma agarwood indicates the tree was infected. On their observation, after one year of inoculation gave agarwood with the "teri" grade, the lowest grade (Fig. 5(I) and (J)).

The government, Division of National Standardization standardizes the grade of agarwood according to the color, size, contamination of wood, density and the smell when burning. It is classified into three classes and each class with subclasses (Table 1). According to their definition, the grade "gubal" is the wood from the tree or part of the tree source of agarwood with the strong aroma and black or dark brown color. The grade "kemedangan" is wood from the tree or part of tree source of agarwood contains less amount of resin which is indicated by weak aroma, gray or brown color, and rough fibers with the soft wood. The grade "abu gaharu" is chips residue of slicing agarwood from the wood. However, this classification also depends on the personal experience.

Commercial grade is more popular than national standard grade. The businessmen like to use commercial grade because they can make a trick business to the collectors from the different standardization of grade in each area. On the other hand, the collectors only familiar with the grade from the businessmen and they are worry if the businessmen are not interest to their agarwoods which are collected with difficult from the forest.

**Table 1** National Standard Grade of Agarwood and commercial grade in Samarinda

No.	National Standard Grade SNI 01-5009.1-1999	Commercial Grade in Samarinda
<b>A</b>	<b>Gubal</b>	
1	Mutu utama	Super
2	Mutu I	Super AB
3	Mutu II	Sabah super
<b>B</b>	<b>Kemedangan</b>	
1	Mutu I	Tanggung A
2	Mutu II	Sabah I
3	Mutu III	Tanggung AB
4	Mutu IV	Tanggung C
5	Mutu V	Kemedangan I
6	Mutu VI	Kemedangan II
7	Mutu VII	Kemedangan III
<b>C</b>	<b>Abu gaharu</b>	Cincangan
1	Mutu utama	
2	Mutu I	
3	Mutu II	

This problem should get attention and support from the government to do more research about standardization of agarwood with using experimental test, without only to the personal experience. From this national standardization will give more economic value also to the collectors.

### Conclusion

Agarwood is highly valuable resinous fragrant heartwood produced principally from tropical trees. In Indonesia, it has been harvested from the forest since ancient time. It is used as incense in the traditional ceremony or as a traditional medicine for diarrhea and aphrodisiac. Nowadays, it was harvested for its economic values for source family income of the people who living near from the forest. Grade of agarwood was classified according to the color, smell, density, and oily of agarwood. However, each surveyed area has a different classification of grade and price. Increasing global demand of agarwood makes over exploitation of the trees source agarwood and becoming exhausted. Cultivation program is one way for conserving this endangered. The collectors cultivate agarwood in their garden by planted young agarwood trees which were brought from the forest. Fungi are used for stimulate formation of agarwood. On their observation (Ministry of Forestry, East Kalimantan, Indonesia), *Fusarium laseritum* is the faster fungus infects the agarwood tree and can be isolated and inoculated easily in the medium. This cultivation program was supported by government (Ministry of Forestry, Indonesia) through research and training to the collectors about cultivation of agarwood.

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### Japanese abstract

沈香は東南アジアの熱帯雨林で採集される樹脂を多く含む心材で、伝統的・宗教的儀式などの香料として珍重されている。我々は、インドネシアの南スラウェシ州と東カリマンタン州における沈香の採集、評価・分類や取引、栽培等の現状について、これらの仕事に携わっている採集者、商人、政府の役所（林業省）を対象に現地調査した。沈香は非常に高価であることから、森林の傍に居住する人々は生活のための収入源の一つとして沈香を採集している。また、地域ごとに沈香の品質に関して異なる等級分類と価格相場があり、それらは外観的な色、臭覚、比重によって経験的に行われていた。世界的な需要増加にともない、沈香資源は乱獲による枯渇が危惧されている。基原植物である *Aquilaria* 属植物の資源保護のため、沈香原木の栽培が実施されている。また、栽培された沈香原木に種々の菌類を植菌し感染させることによって樹脂を含む香木へと人工的に誘導することも試みられており、その一部が成功している。この計画はインドネシア政府の研究によって支援されており、沈香を栽培している採集者を対象にトレーニングが行われている。

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