Professorial Lecture

ENHANCING THE WORLD OF FRAGRANCE THROUGH MALAYSIAN BIO-GAHARU

KU HALIM KU HAMID
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All Praise to Allah SWT whose help and guidance has sustained me to bring this book to completion. Gaharu Industry had caught the public interest in which can be seen in the drastic public involvement in this industry. Therefore, the idea of publishing this book came when thinking about problems and challenges faced by the entrepreneurs of gaharu.

Hope that this book is able to provide a clear explanation to overcome all the problems related with gaharu. This can be used as a guide to all operators gaharu in Malaysia. Gaharu industry is also expected to increase the economy of Malaysia. Its high commercial value can be seen in the increasing demand by the Middle East particularly. Improvement made in the research of gaharu plantations is one of the stepping-stones for the development of this industry.

My deepest gratitude to the Faculty of Chemical Engineering and Southern Farm Valley Company who have enriched me not only in technical aspects but also for unreserved encouragement and support. I also would like to take this opportunity to thanks UPENA for publishing this book. My sincere thanks also goes to every individual, including my colleagues and families, who had help me in one way or another in making this book a reality.
I begin in the name of Allah, the Kind, the Great, the Merciful, the Beneficent, the Trustworthy, the Creator of all, the Giver of life, and the Taker of life, the One who has no children, nor was He born of anyone and there is no other besides Him. Peace and salutations upon our master, perfect example, Prophetic light and beloved, the Prophet Muhammad SAW and upon his noble family, his righteous companions and all those who follow him.

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Gaharu is scientifically known as *Aquilaria* and well known as Agarwood. Sometime it is called as **Wood of the Gods**. It is used as a raw material for incense, perfumes or fragrant and even alternative medicine. It is believe that the aromatic product of the tree is one of the most expensive in the World. There are few hadith that encourage Muslim to use Gaharu products in certain cases, including medicinal practices; and most of religions in the world are using Gaharu in their ceremony. Wild *Aquilaria* trees normally found in Malaysia and grow randomly and scatter in forest through natural seeding process. *Aquilaria malaccensis* is one the species that produce high quality of products, grow in various habitats, including those that are rocky, sandy or calcareous, well-drained slopes ridges and near swamps. Since wild Gaharu trees have been chopped for the resinous stems, there are efforts have been carried out to develop Gaharu farm in Southeast Asia countries and India. Integrated farming normally practices by combining with many types of commercial plants, where Gaharu seeding by tissue culture technique is getting popular in order to quicken the plantation activities. Gaharu product from plantation is harvested by using inoculation or inducement process, it is an artificial technique in producing of agar or resin in Gaharu trees. The method is accomplished by developing of wound, chemically, biologically or physically into xylem part of the trees stem. In Malaysia, most of inoculation process is performed by
using imported inoculants from neighbor countries and mainly are chemical based, usually require 8 to 12 months to produce quality agar or resin in the trees. However, there are disappointment parts of the inoculation process faced by Gaharu planters, the death of the trees as initially shown by extra ordinary dropped of leaves after the process taking place or unsuccessful to produce resin after certain period of the process. An innovative effort was established to overcome the problem by producing bio-based inoculant, called 4 MOONS BOOSTER. It was developed as a result of smart partnership between Southern Farm Valley Sdn Bhd and Faculty of Chemical Engineering, UiTM. Several trials of inoculation to Gaharu trees were carried in various parts of the country by using this inoculant and produced remarkable results with shorter period in producing of resinous wood for essential oil production. Several important steps from Gaharu seeding to processing technologies are laid in this book as a guide for Malaysian planters in establishing of Bio-Gaharu. Being a harmony of multi racial country, fertile land, natural cultivation skill of the society, strategic location and good trade facilities and infrastructures which have been putting in the right place would bring Malaysia as the world leader of Bio-Gaharu production and trading. It is important to the whole of Gaharu players to struggle collectively to materialize the aspiration and endlessly innovate the industry as a package to compete globally. Gaharu products would become an important export commodity and the related Gaharu activities are able to create new job opportunities to this country.
INTRODUCTION

Gaharu, well known as Agar wood, is also known as Woods of the God. Since recent years Gaharu plantation has become an excitable issue among few Malaysians. Hence, some state governments through their agencies, private companies and individuals have been seriously involved in the plantation. This might be due to the concern for rapid depletion rate of wild agar wood trees in Malaysia and the enormous market demand. Agar wood is also well known as a raw material for incense, perfumes or fragrance and even alternative medicine. It is believed that the aromatic product of the tree is one of the most expensive in the world. It is known by many names in different areas such as Chen-xiang, Jin-koh, Oud, Aloes wood, Ogoru, Ghara, Tram Huong, Agar, Mai Ketsana and many more. In Malaysia it is also known by several names such as depu, karas, candan, and cendana among others. Agar wood remains today the world's most expensive incense. Amazingly, the value of agar wood shipped out of Singapore alone each year has been estimated to exceed $1.2 billion (Hansen, 2000). However, trading of Gaharu by Singaporean traders is not known by most of Malaysians, even though this country is blessed by fertile and suitable land for Gaharu.
Gaharu or scientifically known as *Aquilaria* is the resinous heartwood native to South East Asia. There are fifteen *Aquilaria* species in the tropical Asia. Natural distributions occur widely in South and Southeast Asia, namely, south of China, Pakistan, India, Nepal, Bhutan, Bangladesh, Sri Lanka, and the Southeast Asia such as Cambodia, Vietnam, Laos, Malaysia and Thailand. The 15 species of *Aquilaria* are: *A. apiculata, A. baillonii, A. banaense, A. beccariana, A. brachyantha, A. cumingiana, A. filaria, A. hirta, A. khasiana, A. malaccensis, A. microcarpa, A. rostrata, A. sinensis, A. subintegra, and A. crassna* (CITES, 2001 and CITES, 2004). Figure 1 shows the World Map of Gaharu, mainly located in South East Asia region (royaloudh.com, October 2010).

Aquilaria is a genus of eight species of trees in the *Thymelaeaceae Aetoxylon sympetalum* native to Southeast Asia. The genus is best known as the principal producer of the resin-impregnated agar wood, especially *Aquilaria malaccensis*. The depletion of wild trees from indiscriminate cutting for agar wood has resulted in the trees being listed and protected as an endangered species (CITES, 2004). Therefore, some countries in Southeast Asia aggressively are cultivating Aquilaria trees to produce Gaharu in a sustainable manner.

**GAHARU IN RELIGIOUS AND CULTURAL ASPECTS**

**Gaharu in Islam**

Hadith is the words and actions relating to Prophet Muhammad (pbuh). Related hadiths are stated below as directly quoted from the Books of Sahih Muslim and Sahih Bukhari.
Book 10 of Sahih Muslim, #3831

Rumaid reported that Anas b. Malik (Allah be pleased with him) has asked about the earnings of a cupper. Then (the above-mentioned Hadith was reported but with this addition) that he said: The best treatment which you get is cupping or aloeswood and do not torture your children by pressing their uvula.

Book 26 of Sahih Muslim, #5487

Umm Qais, daughter of Mihsan, the sister of ‘Ukasha b. Mihsan said: I visited Allah’s Messenger (pbourh) along with my son who had not, by that time, been weaned and he pissed over his (clothes). He ordered water to be brought and sprinkled (it) over them. She (further) said: I visited him (Allah’s Apostle) along with my son and I had squeezed the swelling in the uvula, whereupon he said: Why do you afflict your children by compressing like this? Use this Indian aloeswood, for it contains seven types of remedies,
one among them being a remedy for pleurisy. It is applied through the nose for a swelling of the uvula and poured into the side of the mouth for pleurisy.

**Book 26 of Sahih Muslim, #5488**

Umm Qais, daughter of Mihsan, was one of the earlier female emigrants who had pledged allegiance to Allah's Messenger (pbuh). She was the sister of Ukisha b. Mihsan, one of the posterity of Asad b. Khuzaima. She reported that she came to Allah's messenger (pbuh) along with her son who had not attained the age of weaning and she had compressed the swelling of his uvula. (Yunus said: She compressed the uvula because she was afraid that there might be swelling of uvula.) Thereupon Allah's Messenger (pbuh) said: Why do you afflict your children by compressing in this way? You should use Indian aloeswood, for it has seven remedies in it, one of them being the remedy for pleurisy. Ubaidullah reported that she had told that that was the child who pissed in the lap of Allah's Messenger (pbuh), and Allah's Messenger (pbuh) called for water and sprinkled it on his imrine, but he did not wash it well.

**Book 27 of Sahih Muslim, #5601**

Nafi reported that when Ibn Umar wanted fumigation he got it from aloeswood without mixing anything with it, or he put camphor along with aloeswood and then said: This is how Allah's Messenger (pbuh) fumigated.

**Book 54 of Sahih Bukhari, #469**

Narrated Abu Huraira: Allah's Apostle said, "The first batch (of people) who will enter Paradise will be (glittering) like a full moon; and those who will enter next will be (glittering) like the brightest star. Their hearts will be as if the heart of a single man, for they will have no enmity amongst themselves, and every one of them shall have two wives, each of whom will be so beautiful, pure and transparent that the marrow of the bones of their legs will be
seen through the flesh. They will be glorifying Allah in the morning and evening, and will never fall ill, and they will neither blow their noses, nor spit. Their utensils will be of gold and silver, and their combs will be of gold, and the fuel used in their centers will be the aloeswood, and their sweat will smell like musk.”

**Book 55 of Sahih Bukhari, #544**

Narrated Abu Huraira: Allah’s Apostle (pbuh) said, “The first group of people who will enter Paradise, will be glittering like the full moon and those who will follow them, will glitter like the most brilliant star in the sky. They will not urinate, relieve nature, spit, or have any nasal secretions. Their combs will be of gold, and their sweat will smell like musk. The aloeswood will be used in their centers. Their wives will be houris. All of them will look alike and will resemble their father Adam (in statute), sixty cubits tall.”

**Book 71 of Sahih Bukhari, #596**

Narrated Urn Qais bint Mihsan: I heard the Prophet saying, “Treat with the Indian incense (Ud Al-Hindi), for it has healing for seven diseases; it is to be sniffed by one having throat trouble, and to be put into one side of the mouth of one suffering from pleurisy.” Once I went to Allah’s Apostle with a son of mine who would not eat any food, and the boy passed urine on him whereupon he asked for some water and sprinkled it over the place of urine.”

**Book 71 of Sahih Bukhari, #611**

Narrated Urn Qais: I went to Allah’s Apostle along with a son of mine, whose palate and tonsils I had pressed with my finger, as a treatment for a (throat and tonsil) disease. The Prophet said, “Why do you pain your children by pressing their throats! Use Ud Al-Hindi (certain Indian incense) for it cures seven diseases, one of which is pleurisy. It is used as a snuff for treating throat and tonsil disease and it is inserted into one side of the mouth of one suffering from pleurisy.”
Enhancing the World of Fragrance Through Malaysian Bio-Gaharu

**Book 71 of Sahih Bukhari, #613**

Narrated Um Qais: that she took to Allah’s Apostle one of her sons whose palate and tonsils she had pressed because he had throat trouble. The Prophet said, “Why do you pain your children by getting the palate pressed like that? Use the Ud Al-Hindi (certain Indian incense) for it cures seven diseases one of which is pleurisy.”

**Book 71 of Sahih Bukhari, #616**

Narrated Um Oais: that she took to Allah’s Apostle one of her sons whose palate and tonsils she had pressed to treat a throat trouble. The Prophet said, “Be afraid of Allah! Why do you pain your children by having their tonsils pressed like that? Use the Ud Al-Hindi certain Indian incense) for it cures seven diseases, one of which is pleurisy.”

**Gaharu and the Bible**

There are 5 separate places in the Bible where aloeswood is mentioned. In older oral traditions, aloeswood is sometimes referred to simply as aloes (not to be confused with aloe vera).

1. Like valleys that stretch out, Like gardens beside the river, Like *aloes* planted by the LORD, Like cedars beside the waters. (Numbers 24:6)

2. Nicodemus, who had first come to Him by night, also came, bringing a mixture of myrrh and *aloes*, about a hundred pounds weight. (John 19:39)

3. I have sprinkled my bed with myrrh, *aloes* and cinnamon. (Proverbs 7:17)

4. All thy garments smell of myrrh, and *aloes*, and cassia, out of the ivory palaces, whereby they have made thee glad. (Psalms 45:8)
5. Spikenard and saffron; calamus and cinnamon, with all trees of frankincense; myrrh and aloes, with all the chief spices. (Solomon 4:14)

Gaharu in Buddhism

In Buddhist worship, the highest quality offering a devotee can make is to burn agar wood, called *jin-koh* in the form of wood chips or incense. Incense is believed to have been used in Japan from the time of Buddhism around 1500 years ago. In Buddhism, the offering of incense is a purification ritual in which the incense is burned in order to purify the space surrounding statues of the Buddha. In the *Nihon Shoki* (Chronicles of Japan), it is written that incense was burnt when monks read the Buddhist sutras. In the Heian Period, exchanges with China deepened, and perfume was imported under the Japanese trade with Sung Dynasty China (12th Century). At that time, the burning of incense increased with the popularity of Buddhism and spread throughout Japan. In modern Japan, incense is also burned at funerals and on visits to graves.

It has also been a Japanese custom to enjoy incense burning outside of a Buddhist or religious context. In the world of fragrance, *jin-koh* is the ‘supreme fragrance’ in combination with selected blends of other natural products (including sandalwood, spikenard, patchouli, camphor, and benzoin) to create various forms of pure incense, that is, containing no artificial ingredients (TRAFFIC Southeast Asia, 2004).

GAHARU TREE

Gaharu trees are commonly found in 6-20 m height. The leaves are alternate, 5-11 cm long and 2-4 cm broad, with a short acuminate apex and an entire margin. The flowers are yellowish-green, produced in an umbel; the fruit is a woody capsule 2.5-3 cm long.
Wild Aquilaria trees, normally found in Malaysia is shown in Plate 1, grow randomly and scattered in the forest through natural seeding process, usually in difficult to reach areas. A. malaccensis have adapted to grow in various habitats, including those that are rocky, sandy or calcareous, well-drained slopes ridges and near swamps. They typically grow between altitudes of 0-850 m, and up to 1,000 m in locations with average daily temperatures of 20-22° C (CITES, 2004) as shown in Table 1. These conditions are almost well-matched with Malaysian climate.
Table 1: Environmental Factors Suit for A. Malaccensis (Green, 1999)

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th>Attributes Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitudinal range</td>
<td>29 – 1,000 m</td>
</tr>
<tr>
<td>Mean annual rainfall</td>
<td>1,500 – 6,500 mm</td>
</tr>
<tr>
<td>Dry season duration</td>
<td>0 – 4 months</td>
</tr>
<tr>
<td>Mean annual temperature</td>
<td>22–28 °C</td>
</tr>
<tr>
<td>Mean maximum temperature of hottest month</td>
<td>22 – 40 °C</td>
</tr>
<tr>
<td>Mean minimum temperature of coldest month</td>
<td>14 – 22 °C</td>
</tr>
<tr>
<td>Absolute minimum temperature</td>
<td>5 °C</td>
</tr>
<tr>
<td>Soil texture light</td>
<td>medium</td>
</tr>
<tr>
<td>Soil drainage</td>
<td>free</td>
</tr>
<tr>
<td>Soil reaction acid</td>
<td>neutral</td>
</tr>
<tr>
<td>Special soil tolerances</td>
<td>shallow</td>
</tr>
</tbody>
</table>

Plates 2, 3, 4 and 5 respectively show the chronology of agar wood fruit development. Seeds of matured agar wood fruit would create new trees if they were laid in conducive environment to grow as shown in Plate 6.
Plate 3: Agar Wood Fruits

Plate 4: Mature Agar Wood Fruits with Seed
Plate 5: Husk of Agar Wood Fruits

Plate 6: Natural Seeding of Gaharu


Integrated Plantation

Since Gaharu wild trees have been chopped for the resinous stems, there are efforts carried out to develop Gaharu farm in Southeast Asian countries and India. Integrated farming normally practices by combining with many types of commercial plants. By doing this, the plantation owner would achieve the largest potential returns over the long term. In Malaysia, Kebun Rimau Sdn. Bhd. has proven that Gaharu trees seeded from tissue culture have been growing very well in their plantation in Tawau, Sabah (Plates 7 and 8). Besides that, combinations with multi commercial crops are also expected to be resulted with an extremely promising outcome. There are few integrated plantations scattered all over Malaysia where agar wood trees clearly observed as shown in Plates 9 and 10 respectively.

Plate 7: Integrated Gaharu and Teak Trees
(Courtesy: Kebun Rimau Sdn Bhd)
Plate 8: Gaharu Planted in Lemon Grass Farm
(Courtesy: Kebun Rimau Sdn Bhd)

Plate 9: Gaharu Planted in Dragon Fruit Farm in Malacca
Thailand is believed to be one of the most advanced countries in agar wood industry in the world, where the trees have been combined with teak and utilising the latest inter-planting husbandry methods. It was claimed that returns would be obtained in Year 6 of the investment, with further returns in Years 9 and 15. There is also a practical physical benefit to inter-planting teak with agar wood. The teak grows quicker, providing valuable cover for the agar wood tree. Young agar wood flourishes when planted in the shade, and in particular under a forest canopy which the teak provides. (http://www.forestryinvestment.org, August 2010). Plate 11 shows the teak-agar wood integrated plantation.

**Tissue Culture as Gaharu Seeding**

Agar wood seeding by tissue culture technique is considered as important tools in quickening the plantation activities. Thailand might be the leading country in propagating this method throughout its country as well as exporting the seeds to the neighbouring countries. Plant tissue culture is a novel and innovative technique to grow high quality plant, able to produce in large quantity by culturing and maintaining plant cells or organs like leaves, stem, root, branch shoot tip, petals, anther and pollen in sterile, nutritionally
and environmentally supportive conditions in vitro. The technology has enormous potential for meeting the demands of domestic seeding of Gaharu in Malaysia. However, it is a great challenge to produce Gaharu seeds with respect to the various nature of soil in this country.

Plate 11: Integrated Plantation in Thailand: Teak and Agar Wood

GAHARU INOCULATION

Inoculation or inducement is an artificial technique in producing of agar or resin in Gaharu trees. The method is accomplished by developing of wound, chemically, biologically or physically into xylem part of the trees stem. Universally, trees use two different systems of transportation, firstly xylem where water and solutes from
the roots to the leaves; secondly, phloem where the food substances from leaves to the rest of the plant. Both of these systems are rows of cells that make continuous tubes running the full length of the plant as shown in Figure 2.

There are few methods developed by researchers and planters of Gaharu, such as drilling, cutting, chopping or inserting nails into the trees, most of the methods are kept secret to protect their interest. In some cases, Gaharu inoculation is coupled with special recitation (*mentera*) and certain spiritual rule to be abided by. Normally this practice is handed down from one generation to another generation or to their trusted people.

In Malaysia, most inoculation process is performed by using imported inoculants from Thailand and in small amount from Indonesia. The inoculants are mainly chemical based and normally require 8 to 12 months to produce quality agar or resin (darker color) in the infected trees. However, there are disappointment parts of inoculation process faced by Gaharu planters, the death of the trees due to the chemicals as initially shown by extra ordinary drop of leaves after the process has taken place or has been unsuccessful to produce resin after certain period of the process. Plate 12 shows a failure of resin formation by using chemical-based inoculants at young gaharu tree. Result of chemical based inoculation is shown in Plate 13, where the density is much lower than good quality Gaharu and lacking of resin.
Figures 2: Stem — The Xylem and Phloem are Arranged in Bundles Near the Edge of the Stem to Resist Compression and Bending Forces

Plate 12: Failure of Resin Formation of Gaharu Tree
The process of agar or resin deposits is not fully understood. A Dutch paper (Schuitemaker, 1933) reported the occurrence of agar wood in Borneo and discussed many different types of resin produced in trees. Most of the local people at the time believed that resin was formed from mysterious ways and associated with the spirit world. The author stated that “the mysterious occurrence of the 'holy' wood is connected to supernatural powers” and that agar wood was referred to as “wood of the gods.” The author also noted that “we cannot exclude the possibility of a pathological occurrence of which the cause was unknown,” that “perfect trees never have resin,” and that resin “is formed around wounded or rotting parts of the trunk.” The author also suggested that salt put into holes in trees might promote resin. Also, as it was mentioned that being infectious may be possible to induce resin.
Mechanical Method

Pojanagaroon (2002) had tried various mechanical injury methods to induce formation of aloes wood in a 4-year-old *Aquilaria crassna* during February 2001 to October 2002. An observation shows that a sequential change in the wood coloration was observed around injury sites. One month after wounding a pale discoloration occurred, followed by a darker yellow-brown discoloration after 3 months, becoming dark brown within 8-10 months and changing to black within 20 months, accompanied by burning scent. Wood block samples collected from live tree at 10, 15 and 20 months after wounding were compared among the different mechanical treatments. The results indicated that holes made with screws, wounds inflicted with chisels and bark removal with hatchets on the trunk gave dark yellow-brown to dark discoloration near injury (5-10 mm from the cut end), while nails hammered into the trunk gave dark brown to black occurring by the interaction between ferric oxide and fibers, whereas hammers hit on the trunk gave only little discoloration. The larger the objects used to wound the trunk of kritsana trees, the wider the width of the discoloration ring. The rate of the formation of the discoloration ring around the wound in the rainy season (16-20 months after wounding) was 3 times higher than in the dry season (11-15 months after wounding), influenced by seasonal factors. Most treatments gave no specific aromatic kritsana scent by burning the wood samples, except only 4 treatments gave pale scent which was the holes made with screws (1.27 cm and 1.11 cm in diameter) and wounds inflicted with narrow (1 cm) and wide (2.54 cm) chisels. Moreover, the wood samples gave very low percentage yields of essential oil using a hydro-distillation method. In conclusion, mechanical injury can be used for the formation of aloes wood in kritsana trees, and the most suitable method was the holes made with screws (1.27 cm in diameter) which gave the widest discoloration ring and pale specific aromatic kritsana scent by burning.
Various fungi are associated with Gaharu formation although it is still not absolutely clear which are important or even necessary. Infection and Gaharu formation appear to be a slow process and Hooper (1904) noted that trees that were at least 50 years old yielded the largest amounts of oleoresin. Bose (1934) isolated a member of the fungi imperfecti from the diseased wood of A. agallocha. Sadgopal (1959) comments that a Torula sp. isolated by Bose inoculated into A. agallocha trees successfully produced agar formation, but the experiments were abandoned in 1931 because of contamination of the inoculum stock. Further work by Bose involved the successful use of a Cladosporium sp. but the trees were subsequently destroyed. A later repeat of the work yielded no positive results.

Battcacharrya (1952) isolated Epicoccum granulatum from infected wood, and together with Sadgopal (1960) and Verma (1977) further investigated the possibility that agar formation was due to fungal activity, and the prospect of deliberately infecting trees with the causative agents became a popular goal, but the literature often showed conflicting results. One serious contender for the infectious agent was the pathogenic fungus, Philophora parasitica, identified by Gibson (1977) and earlier by Hawksworth et al. (1976), who ascribed spiral cavitation of the tracheid walls of the wood of A. agallocha to this organism. Gibson indicated that the most frequently isolated fungi from infected wood also include Pencillium citrinum, Aspergillus tamarii, and other Aspergillus spp., Fusarium solani, Botryodiplodia theobromae and others. But there were several reports that Philophora parasitica was frequently associated with better quality portions of agaru. It emerged however (Gibson 1977; Rahman and Basak, 1980) that gaharu formation rarely occurred in trees under 25 years old and formation probably followed injury to the tree, for example following wind or storm damage. Yu Chenhung and Liang Yuanui (1980)
working independently in the South China Institute of Botany in Guangzhou with *A. sinensis*, note that no scented oleoresin or secretory tissues were found, but when traditional drug-gatherers cut notches in the trunk, oleoresin was formed after mycelia had been observed leading to infection of the cells containing starch cells.

Jalaluddin (1977) isolated the fungus *Cytosphaera mangiferae* which died from the diseased wood of standing trees, indicating this to be the causative infective agent for standing trees. Tamuli *et al.* (1999) were able to identify four fungal species associated with *A. agallocha* seeds (*Aspergillus* sp., *Fusarium* sp., *Penicillium* sp. & *Epicoccum* sp.). The authors subsequently turning their attention to the *A. agallocha* rhizosphere (Tamuli *et al.* 2000a). Moreover, Tamuli *et al.* (2000) identified two fungal cultures from the diseased wood: *Fusarium oxysporum* Schlect. and *Chaetum globosum* Kunze, and succeeded in inoculating healthy wooden blocks so that colony growth occurred.

Tabata *et al.* (2003) expressed that the artificial induction of five seven years old *Gyrinops versteegii* trees in Matram on Lombok Island and twelve *Aquilaria* spp. in Pekanbaru, Sumatra by drilling eight 10cm deep by 1cm wide holes and inoculating with five *Fusarium* spp. including *Fusarium trifosfrium*. Agar wood formation was observed around the drilled sites in inoculated trees but also in control trees.

Nobuchi and Siripatanadilok (1991) experimented the mechanism of agar wood formation. They investigated that parenchyma cells are the only cells that are able to form agar wood. Kwangtung Institute of Botany (1976) and Prachakul (1989) investigated that wood or xylem of Aquilaria trees presented included phloem that differed from the wood of general dicotyledonous species. The agar oil was found deposited in the included-phloem tissue and also in xylem parenchyma and ray cells which caused the wood to become darker in color. The included-phloem is called concentric, when it appears in layers alternating with xylem layers,
foraminate when it appears in strands surrounded by xylem tissue (Esau, 1965). It scattered or isolated phloem strands within the secondary xylem of certain dicotyledonous (Dickinson, 2000).

Agar wood formation was not caused by fungal activities alone, but it was the result of the interaction of wounding followed by the invasion of pioneer fungi (Nabuchi and Siripatanadilok, 1991). Bose (1983) investigated that on the section cut from diseased wood of *A. malaccensis* collected from many places and found yellowish-brown gum almost in every cell together with fungus-hyphae, he could grow fungus in an artificial medium. Three species of fungi belonging to the genera of *Penicillium spp.*, *Aspergillus spp.*, and *Fusarium spp.* were reported to infect *A. agallocha* and agar wood was formed (Jalaladdin, 1970). Besides that, Bhattacharyya (1952) reported that *Epicoccum granulatum* had been isolated from the infected agar wood to show that fungi has important role in the formation of resin.

**Inoculant Injection**

Injection of inoculants firstly started with preparation of notches or small hollow to the Gaharu trees, where liquid form of inoculants is to be pasted or infused. The trees might be barked in certain manner, based on respective practice of planters or Gaharu inoculation specialist as shown by Plates 14, 15, 16, 17 and 18 respectively. Plates 19 to 22 show resinous wood of Gaharu tree and results of its harvesting after 4 months inoculation process. Inoculant used was **4 MOONS BOOSTER**, a bio-based product developed as a result of smart partnership between Southern Farm Valley Sdn Bhd and Faculty of Chemical Engineering, UiTM. Dark brown in color of resinous wood is suitable to be used for essential oil production. Meanwhile, high quality Gaharu is shown in Plates 23 and 24 respectively, where the resin is intense and the wood resembles black stone, normally longer period is required, typically about 2 years.
A Malaysian company, Agarwood AgroTech Sdn Bhd uses an in-house researched and developed inoculation method and technology. 'The Spiral' method has shown effective results and begins showing in a short period. The inoculant can be used with different types of artificial wounding technique of Gaharu. The methods are, Spin Complex for outer layer and formation of heartwood, Molecular Orbital for formation of heartwood only and Molecular Geometry for outer layer only. (http://www.AgarwoodAgroTech.Com, September 2010). The bark of Gaharu tree is removed in spiral manner, and the technology used by the company is shown in Plate 25. Inoculation is then followed to produce resinous material; the result is shown in Plate 26.
Plate 15: Drilling of Gaharu Tree

Plate 16: Inoculant is Gently Pasted on the Barked Gaharu Tree
Enhancing the World of Fragrance Through Malaysian Bio-Gaharu

Plate 17: Infusion of Inoculant into Drilled Hole

Plate 18: Barked Gaharu Tree and Holes of Inoculation Spot
Plate 19: Resinous Wood of Gaharu Tree After 4 Months Inoculation Process by Using 4 MOONS BOOSTER

Plate 20: Harvesting Resinous Wood of Gaharu Tree
Enhancing the World of Fragrance Through Malaysian Bio-Gaharu

Plate 21: Harvested Resinous Wood of Gaharu Tree (Dark Brown)

Plate 22: Gaharu Tree After Resinous Part was Removed
Plate 23: Formation of High Quality Gaharu: A Cross-Section of Gaharu Stem
Plate 24: High Quality Gaharu

Plate 25: Gaharu Bark was Removed in Spiral up Manner and Stem was Drilled
GAHARU GRADING

Gaharu Cleaning

Gaharu cleaning is purposely done to get rid of non-resin wood from resinous wood and requires dedicated and skilled personnel. Sharp and special set of knives are used in this task. The remaining resinous wood would be getting a better price and easier to be marketed. This is done manually and it could take a long time to complete the task.

Gaharu Grading

Grading and pricing of Gaharu found to be slightly different among traders from various countries. However, basic quality totally depends on content of resin in the Gaharu wood. There are five major criteria to grade the gaharu which are the buoyancy, fragrance and medicinal property, colour and historical background of resin formation (http://www.jdcorp.com).

The most important and objective criterion to grade the genuine Aquilaria is to measure its buoyancy. Materia Medica and Description of the Plants in Southern China stated that there are
three grades for *A. agallocha* according to its buoyancy, whether they are complete sinking, half sinking (floating under the surface of water), and floating kinds.

The density of *Aquilaria* tree without oleoresin is a mere 0.4. However, when the percentage of containing oleoresin is over 25%, gaharu in any forms (chips, powders, or larger pieces) will sink into water. The Chinese name of gaharu is originated from this characteristic. In Japan and Korea, only *Aquilaria* that contains more than 25% of the oleoresin can be used as medicine. This regulation is based on the fact that the only sinking *Aquilaria* can be used as medicine. In China, 15% is the minimum requirement.

The most valuable agar wood is normally considered as Grade I: The impregnation of the resin is intense and the wood resembles black stone. It is heavy and the content is extremely high and difficult to distill. It is mainly exported to the Middle East countries where it is used as incense. Meanwhile, Grade II is brown in color without any black tone. It was also brown in color but interspersed with 50 percent or more of yellow-colored wood. This is also usually used in incense. Grade III is normally used to extract essential oil and superior from the agar wood of Grade IV in terms of resin content. The agar wood of Grade IV is the lowest grade which is mostly yellow with scattered streaks of brown or black resin. This grade is purely used for the essential oil. (http://www.jdcorp.com).

**GAHARU PROCESSING**

**Hydro Distillation**

This method involves submerging the desired raw material (gaharu chips or powders) in water in the still and brought to boil, the oil that evaporates is lost in the water in the still as well as in the aqueous phase of the distillate. The heat and steam cause the cell structure of the plant material to burst and break down, thus freeing the essential oils. The essential oil molecules and steam are carried
along a pipe and channeled through a cooling tank, where they return to the liquid form and are collected in a vat. The emerging liquid is a mixture of oil and water, and since essential oils are not water soluble they can be easily separated from the water and siphoned off. Gaharu essential oils which are lighter than water will float on the surface. Schematic diagram of hydro distillation is shown in Figure 3. Commonly practiced is that the agar wood is firstly chipped into smaller size and followed by sun drying, as shown in Plate 27. The dried gaharu chips will undergo soaking process in water as shown in Plate 28 for one to two weeks, purposely to increase the essential oil yield. Plate 29 shows a common hydro distillation facility by Gaharu producers in Thailand, considered as a traditional technique of essential production. The remaining water, a by-product of distillation, is called floral water, distillate, or hydrosol as shown in Plate 30. It was found that it retains many therapeutic properties of the Gaharu. However, fully research hasn’t been done in Malaysia to explore the potential of this by product, such as its content or for making precious skin care or cosmeceutical products. Essential oils of Gaharu is shown in Plate 31.

Figure 3: Schematic Diagram of Hydro Distillation

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Plate 27: Sun Drying of Gaharu Chips

Plate 28: Soaking of Gaharu Chips
Plate 29: Hydro Distillation of Gaharu in Thailand. Wood Fuel is Used.

Plate 30: Floral Water or Distillate of Gaharu Produced by Hydro Distillation.
Steam Distillation

Steam distillation is the most common method of extracting essential oils of Gaharu. In fact, many old-time distillers favor this method for most of essential oils, and claim that none of the newer methods produces better quality oils. Actually, soaking time varies among the distillers and is practiced based on their standard operating procedures. Soaked Gaharu is then placed into distiller chamber of still exactly above the water level and the distillate, mixture water and essential is collected. Schematic diagram is shown in Figure 4. Gas is the most common fuel used in steam distillation; however skill and experience are needed especially in heat controlling to avoid deterioration of oil quality. Low grade of resinous wood is used for oil production and that normally requires a minimum 20 kg to produce 12 cm$^3$ of oil, regularly called 1 tola among Gaharu traders.
Gaharu oleoresin presents in several different colors. Examining the color of Gaharu should be done under natural sunlight. There were various researches conducted on the color of Gaharu. There are five colors grading for Gaharu. The highest grade is Green; Dark Green comes second, and then Golden (light yellow), Yellow and Black. It's generally believed that the color Gaharu oleoresin is black. In reality, Gaharu containing higher percentage of oleoresin usually shows green or dark green luster. (http://www.jdcorp.com).

In steam distillation, the heat of the steam forces the tiny intercellular pockets that hold the essential oils to open and release them. The temperature of the steam must be high enough to open the pouches, yet not so high that it destroys the essential oils. As they are released, the tiny droplets of essential oils evaporate and, together with the steam molecules, it travels through a tube into the still’s condensation chamber. As the steam cools, it condenses into water. The essential oils form a film on the surface of the water. To separate the essential oils from the water, the film is then decanted or skimmed off the top.

Figure 4: Schematic Diagram of Steam Distillation
Carbon Dioxide Extraction

It is proven that supercritical extraction is able to increase compounds extracted from agar wood (Wetwitayaklung et al., 2009). The technology uses carbon dioxide under extremely high pressure to extract essential oils. Gaharu chips are placed in a stainless steel column and, as carbon dioxide is injected, the pressure inside the column builds. Under high pressure, the carbon dioxide turns into liquid and acts as a solvent to extract the essential oils from the Gaharu chips. When the pressure is decreased, the carbon dioxide returns to a gaseous state, leaving no residues behind. Scientific studies show that carbon dioxide extraction produces essential oils that are very potent and have great therapeutic benefits. This extraction method uses lower temperatures than steam distillation, thus avoiding smoke scent on the Gaharu essential oils as normally occurred when overheating of kettle by using gas or wood fuel in steam distillation process. The supercritical fluid carbon dioxide
Enhancing the World of Fragrance Through Malaysian Bio-Gaharu extraction is an economic and fast technique for Agar wood Extraction. It took only 4 hours for extraction compared to 3 to 7 days for the steam distillation or water boiling methods.

Although the supercritical fluid carbon dioxide extraction has good extraction efficiency, it is a low selectivity method since both the super critical extraction and super critical extraction + co methods could extract high-boiling point constituents, with high molecular weights, from the agar wood. (Giovanni and Angelo, 2002). The Oud CO₂ extract was found to be very viscous, dark brown oil. It is non-sticky and can be applied directly to the skin (in minute amounts) or can be thinned in jojoba oil or other carrier oil. Agar wood may also be mixed into another essential oils (http://www.ouddh.com, October 2010). Schematic diagram of super critical extraction is shown in Figure 5. High investment of this system is a major problem for cottage producer of essential oils from Gaharu. Normally, the system is fabricated from high quality stainless steel as shown in Plate 33.
Table 2 depicts the comparison of extraction methods for Gaharu oil done by selected researchers. The comparisons are based on plant species, types of organic solvent used, soaking time of wood sample, time consumed for the extraction, percentage by weight of yield obtained and finally chemical components extracted. It is very clear that time required in the extraction process is varied, the longest is hydro-distillation method and the shortest is CO$_2$ supercritical extraction. Furthermore, more chemical can be extracted via supercritical fluid extraction process.
<table>
<thead>
<tr>
<th>Extraction Method</th>
<th>Plant Species</th>
<th>Organic Solvent</th>
<th>Soaking Time</th>
<th>Time of Extraction</th>
<th>Yield</th>
<th>Components Extracted</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-distillation</td>
<td><em>Aquilaria malaccensis</em></td>
<td>-</td>
<td>7 days</td>
<td>16 hrs</td>
<td>-</td>
<td>3-phenyl-2-butanone, α-guaiene, β-agarofuran, α-agarofuran, nor-ketoagarofuran,</td>
<td>Nor Azah et al, 2008</td>
</tr>
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<td></td>
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<td>10-epi-γ-eudesmol, agarospirol, β-eudesmol, jinkoh eremol, kusunol, jinkohol II</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Aquilaria crassna</em></td>
<td>-</td>
<td>10 days</td>
<td>7 days</td>
<td>0.2%</td>
<td>γ-selinene, 10-epi-γ-eudesmol, selina-3,11-dien-9-one, tetradecanal, γ-eudesmol,</td>
<td>Wetwitayaklung et al, 2009</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>epoxybulnesene, valerianol, selina-3,11-dien-14-al, β-agarofuran, α-selinene,</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>nor-ketoagarofuran, selina-4,11-dien-14-oic acid, 9,11-eremophiladien-8-one</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Aquilaria subintegra</em></td>
<td>-</td>
<td>-</td>
<td>10 hrs</td>
<td>0.23%</td>
<td>-</td>
<td>Rompoei et al</td>
</tr>
<tr>
<td>Extraction Method</td>
<td>Plant Species</td>
<td>Organic Solvent</td>
<td>Soaking Time</td>
<td>Time of Extraction</td>
<td>Yield</td>
<td>Components Extracted</td>
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<td>-------------------------------------------------------------------------------------</td>
<td></td>
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<tr>
<td>Steam distillation</td>
<td><em>Kamedangan</em></td>
<td>-</td>
<td>-</td>
<td>48 hrs</td>
<td>0.03%</td>
<td>Carvacrol or vulgarone, elemol or cubitene, Caryophyllene or alloromadendrene, Thuj-2,4(10)-dienen, menthathrene and coumarine or dihydro agafuran</td>
<td></td>
</tr>
<tr>
<td>Supercritical fluid extraction</td>
<td><em>Aquilaria crassna</em></td>
<td>-</td>
<td>10 days</td>
<td>4 hrs</td>
<td>0.06%</td>
<td>Selina-4,11-dien-14-al, octadecanoic acid, Campesterol, Oxo-agarospirol, y-sitosterol, hexadecanol, valerianol, Selina-3,11-dien-9-one and Selina-3,11-dien-14-al, p-vinylphenol, Benzylacetone, p-vinylguaiacol, 3,4-dimethoxyphenol, Vanillin, Guai-1(10), 11-dien-15-oic acid, Pentadecanoic acid, Hexadecanol, 1,5-diphenyl-2-pentene, Oleic acid, Octadecanoic acid,</td>
<td></td>
</tr>
</tbody>
</table>

References

Winarni et al, 2009
Wetwityaklung et al, 2009
<table>
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<tr>
<th>Supercritical fluid extraction + co-solvent</th>
<th>Aquilaria subintegra</th>
<th>Ethanol</th>
<th>10 days</th>
<th>4 hrs</th>
<th>4.43%</th>
<th>Aquilaria crassna</th>
<th>6-methoxy-2-(2-(4-methoxyphenyl)ethyl)chromone, 6-methoxy-2-(2-(4-methoxyphenyl)ethyl)chromone, campesterol, stigmasta-5,22-dien-3ol, g-sitosterol and stigmasta-7,22-dien-3-one</th>
</tr>
</thead>
</table>
GAHARU APPLICATION

Gaharu products can be mainly based on two categories, that is, resinous wood and Gaharu leaves. It clearly understood that resinous wood produces Gaharu for essential oils and Gaharu incense as high grade quality woody resin.

Medicinal Application

Medicinal uses of the heartwood, bark, resinous stem, resinous wood and oleoresin, prepared from *Aquilaria*, have been recorded in traditional medical systems including Islam, traditional Chinese medicine, Tibetan, Ayurvedic and Unani. External and Internal preparations have been used citing a variety of *Aquilaria* species. These traditional medical systems have been used for indigenous health-care for thousands of years and have been in practice until today. However, most of traditional practices are associated with scientific facts.

Islamic Medicine

From Hadith of Imam Bukhari and Muslim, Prophet Muhammad (pbuh) mentioned that there are healing properties in Gaharu. In Hadith of Imam Bukhari, Prophet Muhammad (pbuh) said: “Treat with Indian incense (‘oud al-Hindi), for it has healing for seven diseases; it is to be sniffed by one having throat problems, and to be put into one side of the mouth by one suffering from pleurisy.” This prescription was given more than fourteen hundred years ago before aromatherapy was even considered an area of alternative medicine. It is proven that aromatherapy is not new in Islamic practice for mankind medicinal treatment.

Although Gaharu oil is extremely rare and costly, it can also be extremely beneficial. Traditional medical uses for Gaharu include: asthma, chest congestion, colic, diarrhea, diuretic, kidney problems, nausea, thyroid cancer, lung tumors and as a general tonic in China. For these reasons, further research is required into the possible
healing properties of this unique oil and to determine its uses in the “seven diseases” mentioned by the Prophet (pbuh). Thus, for Muslims, this is an obligation to follow the teachings of the Prophet (pbuh) and his Sunnah. (http://www.muslimbase.com/prophetic-medicine-qayyim-jawziyya, August 2010, http://Abdurrahman.org/health/index.html, August 2010).

**Traditional Chinese Medicine**

Traditional Chinese Medicine (TCM) herbs are classified by the way that they reorganise the body constituents to a state of balance (Qi, moisture and blood) and classified into five tastes (closely linked to smell) not dissimilar from the five basic odour classifications of agar wood incense listed in the previous section, of sour, bitter, sweet, spicy and salty. TCM recognises primal forces which govern the body of which fire is the force that has an eliminative action which discharges Qi downwards.

Likewise, Tibetan medicine recognises similar primal forces that govern the body but has six tastes sour, bitter, sweet, salty, hot and astringent. Selections of herbs are made based on their taste and potency with regard to the primal forces for re-balancing and restoring health – fire being the force that transforms.

Shizen Li notes that agar wood *Aquilaria sinensis* is mentioned in ancient Chinese Herbals in 1596 (Li, 1596), being sought after for its physical, therapeutic and energetic applications. Hsu (1996) notes that Aquilariae Lignum (aloeswood) in his *Chinese Materia Medica* consists of the heartwood containing the dark-brown resin which is derived from:

1. *Aquilaria sinensis* (Lour.) Gilg. in Kuanung Province and Hainan Island.

3. *Excoecaria agollocha* L. in India – this Indian mangrove tree although susceptible to soft rot, is not usually associated with Gaharu formation.

Its use was first recorded in *Ming pih lu*, Agar wood, being the heartwood, emits fragrance and sinks in water, from which the drug gets its name and it has slight warming properties, to lower energy (activity), reinforce the kidneys, to regulate the central organs and to alleviate pain. The authors recommend use in abdominal pain, tightness of the chest, vomiting and regurgitation, diarrhoea and asthma. It has been noted that the statement ‘lower energy’ above is a poor translation, rather: ‘to move energy down towards the kidneys where it can continue to be utilised efficiently by the body’.

**Ayurveda**

In Ayurveda, there are five primary categories of matter (which combine to create 3 doshas or forces), five attributes and five elements. Fire is the element that transforms. Ayurveda recognises six tastes - sour, bitter, sweet, salty, pungent and astringent.

Unani medicine recognises the four humors which have elements, body substances, blood, phlegm, yellow bile and black bile and qualities ascribed to each humor. These classifications are based on temperament both of people and the humors themselves. Temperaments of humors and person need to be diagnosed so that humors of plants can be prescribed to bring the body back to a state of balance.

Ayurveda aromatherapy is an ancient medical technique employing the use of scent to bring about good health. Indian physicians have been treating patients with the use of ayurvedic aromatherapy for centuries, using the medicinal properties of dried and fresh herbs in a variety of ways. Ayurvedic healing techniques lean on aromatherapy as a supplemental therapy. Ayurvedic herbs are infused into essential oils for use in baths or massage or formed into incense cones for burning or moxibustion; the herbs are also
used in candles or scented waters used for perfuming the air with the intent of supplementing healing. Aromatherapy is used to bolster the body’s natural vital energy, or prana, to stimulate proper digestion and elimination and to boost immunity. It is also used to calm the body, spirit and mind, helping one to rest sufficiently, so the body can heal itself (Rachel Mork, http://www.lifel23.com, October 2010).

In Ayurvedic healing system, the burning of agar wood has a warming and centering effect on the chakras and promotes a deep meditational state. Agar wood heartwood is used in various Ayurvedic formulas including Chyavanprasha, Arimedadi Taila and Mahanarin Taila (Anon 1978), The Ayurvedic Aquilaria-derived formulations in general seem to relieve spasms and other forms of stagnant or stuck energy particularly in the digestive (stomach, kidneys, liver, bowel) and respiratory systems. This kind treatment is also practiced in TCM, Tibetan and Unani medicine.

Gaharu has also been described as a cardiac tonic, carminative and refrigerant (Natarajan & Purushothaman, 1991). In the Unani herbal medicine it is used as a stimulant, stomachic, laxative (purgative in large doses) and as an aphrodisiac. It is also used in the Ayurvedic system against skin diseases (Anon, 1985), and powdered heartwood is given for treatment of diarhoea, dysentery, vomiting and anorexia (Anon, 1969). Agar wood oil, mixed with essential oils from Piper betel is used against bronchial asthma (Indian Medicinal & Aromatic Plants Facing Genetic, 1978). It is also reported as being used by the traditional vaidyas as a contraceptive and the leaves boiled in oil used to remove fish bones stuck in the throat (Bull. Bot. Surv, India (1980) 22,161).

Miller and Miller (1995) in their book Ayurveda Aromatherapy mentioned the energetic warming, balancing effects of oud and its energy purifying and balancing, relaxant, rejuvenative, transformative, clairvoyant and transcending actions. In Indian Ayurvedic medicine has indicated that Gaharu has been used as
a cardiac tonic and carminative (relieves gas from the intestines). There is some belief that Gaharu or ‘oud oil may be useful in treating lymph system disorders, high blood pressure and as an anti-malarial treatment due to its chemical composition and components.

**Tibetan Medicine and Ethnic Psychiatry**

Oleoresin, wood and oil are used in Tibetan medicine and incense, especially prized as “black aloeswood”, (*Aquilaria agallocha*) which Clifford (1984) states as being relied on by contemporary Tibetan doctors for treatment of a whole range of nervous and emotional disorders. Clifford further describes black aloeswood as the most commonly used minor tranquiliser.

**Aromatherapy**

Aromatherapy is the fragrant or essential oils that are taken from plants and used in homeopathic treatments for pain and stress relieve, as well as relaxation. The word aromatherapy when broken down is aroma which is fragrance or smell, and therapy means treatment. The art of aromatherapy is mostly based on the human scent. Through the scent human body is believed to be able to be protected from poisons and toxic substances, but it is also able to heal the body and mind when using aromatherapy oils. Essential oils in aromatherapy play a crucial role in healing various health problems as normally practiced as shown in Figure 6. An aromatherapy oil burner is a dispenser with which one uses to dispense essential oils into a room or space. Plate 34 shows a decorative electrical oil burner. Aromatherapy oil burning is a great way to enjoy the benefits of essential oils and fill surroundings with the pleasant aromas of aromatherapy. It can be used as a healing tool, room freshener, deodorizer or incense alternative (http://www.aromatherapyhealthbenefits.com, October 2010).
Figure 6: Aromatherapy by Inhalation of Essential Oils

Plate 34: Electrical Aromatherapy Oil Burner
The sense of smell is a very powerful component to human experience. Fragrances are deeply associated with memories, making them very influential on mood. Some scents can evoke very strong memories, almost recreating the initial experience.

The brain naturally experiences chemical changes as a reaction to various fragrances. In some instances, the changes in the brain result in emotional responses, such as disgust, fear, and longing. Other times, the changes result in deep relaxation, invigoration or elation. Each response can have significant influence on a person's health (http://www.methodsofhealing.com, October 2010).

**Limbic System**

The limbic system as shown in Figure 7 is part of the reptilian brain, the older embryological part of brain that is one of the first to form as a fetus. It is the interface between the brain and the outside world. The limbic system is the seat of the emotional center and is partly responsible for our fight or flight response, our emotional reaction to something, our hormonal secretions, motivation, pain reflex and our mood fluctuations. There are three main components to the limbic system: the hypothalamus, the hippocampus and the amygdalae. There are also the pituitary, the cingulate gyrus, the fornicate gyrus, the thalamus, the mammilary body, the nucleus accumbens that help form the system, plus the olfactory bulb that plays such an important part in aromatherapy.

Each of the essential oils has therapeutic properties, in that they are stimulating, calming, sedative, balancing, just to name a few. By inhalation of essential oils molecule, it will travel through the nasal passage to a receptor neuron that transports it up to the limbic brain, especially the hypothalamus. Remember that some of the functions of the hypothalamus are to regulate blood pressure, control heart rate and adjust hunger and thirst. Essential oils that has vibrationally calming effect on the body, the hypothalamus receives the input to relax, then it creates neurochemicals that are sent through the body to relax and calm. Likewise if essential oils as a frequency
known to stimulate the body, then the limbic system will conform by sending the message to energize and become more active. Through this manner of transport, one can understand how aromatherapy oils can increase immunity, balance hormonal secretions, dampen or enliven hunger and thirst, and create sexual desire.

Aromatherapy can play a big part in stress reduction, balanced heart rate, hunger control and sexual desire, all because of its inter-relationship with the limbic system. Whether the oils are rubbed on in massage oil or inhaled through an aroma lamp, the odor molecules will travel to their limbic destination and create the appropriate neurochemicals to affect a physical response (http://www.brighthub.com/health/alternative, October 2010).

Gaharu Leaf Tea

Gaharu tea is traditionally claimed as a very precious medicine, has a very special flavour, can stimulate the brain cell activation in the cerebral cortex, the visceral can run off benign. Agar
wood leaf contains a lot of anti-aging, anti-cancer drug ingredients, and it helps improve one's look (http://www.agarwoodtea.com, October 2010).

Traditionally-claimed benefits of drinking Gaharu tea include:

1. Strengthen the heart
2. Reduce blood sugar
3. Reduce blood pressure
4. Improve sleep
5. Beauty
6. Eliminate constipation
7. Degreasing
8. Good aphrodisiac
9. Eliminate flatulence
10. Eliminate state of being drunk
11. Eliminate asthma
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Normally, as recommended by Gaharu planters, suitable leaves used in Gaharu tea is shown in Plate 36.

Plate 36: Gaharu Leaves for Tea Production

**Cosmeceutical**

Cosmeceutical represents a marriage between cosmetics and pharmaceuticals. Like cosmetics, cosmeceuticals are topically applied, but they contain ingredients that influence the biological function of the skin. Cosmeceuticals improve appearance, but they do so by delivering nutrients necessary for healthy skin. Cosmeceuticals typically claim to improve skin tone, texture, and radiance, while reducing wrinkling. Cosmeceuticals are the fastest-growing segment of the natural personal care industry. Consumers are always interested in maintaining a youthful appearance, and as the global population’s median age increases, this market is

The virtue of essential oils, incense and leaves of Gaharu are already established and widely accepted internationally. Traditionally, the use of the products has been in practice more than 3000 years ago in perfumery products and medicine. This opportunity and wide acceptance should be exploited in making Gaharu creation as a wide range of cosmeceutical products. Increasing consumer concerns about health would trigger growing demand for Gaharu based cosmeceutical emergence. As Gaharu international market trend, large demand for this kind of products might come from the Middle East. One of the products developed is shown in Plate 37, that is, facial cream.

Plate 37: Facial Cream of Gaharu (Agar Wood) Based Perfumery

Yves Saint Laurent was amongst the first European design houses to tap into the appeal of Agar wood for use in the mainstream market with their men’s fragrance M7 as shown in Plate 38. However, from another point of view is that the introduction of Gaharu (Oudh) to the mainstream market might somehow depreciate
its value. Perhaps the heavyweight design houses like Tom Ford are exploiting this rare resource purely with profit margins in mind (http://www.sorceryofscent.blogspot.com, October 2010).

Gaharu is also found to be a growing trend in European niche perfume lines and lots of US consumers are getting exposed to these types of fragrances. Both Ormonde Jayne (London-based niche brand) and Montale (Paris-based niche line) have great oud based fragrances. Montale specifically carries a great starter oud perfume called White Aoud. In US, the most popular woody men’s cologne that features agar wood (or oud) is M7 by Yves Saint Laurent, Plate 39. This cologne opens with a fresh bergamot note and settles into an ambery warm oud note (http://www.hubpages.com, October 2010).
Gaharu in the form of perfume is highly demanded in the Middle East. There are hundreds of Gaharu essential oils or well-known among Arabic countries as Oudh or Oud brands in the Middle East market. Typical products of Oudh or Oud are shown in Plates 40 and 41 respectively. It is reported that in the year 2006, Saudis spent SR600 million on Oud products during Ramadan and Eid (Arab News, 19 October 2006). The Gulf market is considered the biggest oud importer, according to a business report released in 2008. People in the Gulf use two-thirds of oud produced in the world. Saudi Arabia alone consumes 60 percent of what is produced for the Gulf market. Oud is used as part of celebrations following Ramadan and Haj as well as on weddings and on Fridays (Arab News, 26 March 2009).
Incense of Gaharu

The incense of Gaharu is used for burning around the house. Agar Oud has a unique woody smell. Many people believe that it calms anxiety, opens the mind and increases the feeling of love. The pleasant smell of the Agar Oud is also very good for relaxation. Arabian women burn Agar Oud around them to give them a long
lasting divine smell. Besides direct usage of essential oils, burning incense is also a common practice among Arabic people. Normally, chips of higher grade of Gaharu are used in this event, Plate 42. Plate 43 shows a happening of incense burning of Arabic community, while a product of China, called Long Incense Stick of agar wood is shown in Plate 44. High quality of Gaharu incense, called Raw Green Kyara Aloeswood is traded in Japan with the price of US$495.0 per gram as depicted in Plate 45 (http://www.equitech.biz, October 2010).

Plate 42: Gaharu Incense (www.arabperfumes.com)
Plate 43: Incense Being Burned at Arabic Gathering

Plate 44: Long Incense Stick of Gaharu
(Made-in-China.com/Showroom, October 2010)
GAHARU MARKET

The consumer market for Gaharu is well developed in the Middle East and Northeast Asia. Meanwhile, Gaharu has been used for over one thousand years in the prophetic era of Muhammad (pbuh), Japan and China, including Taiwan. Nowadays, Taiwan, Singapore, Hong Kong and Bangkok are major traders of Gaharu in the world. The increasing scarcity of illegal forest Gaharu makes the plantation grown much sought after to meet global demand.

Taiwan

Taiwan has long been a major trader in agar wood for both medicinal and cultural uses. According to official records, 6,843 tonnes of unprocessed agar wood was imported to Taiwan in the ten years to 2003. Prices of agar wood for medicinal use vary between US$ 3,000 to US$ 30,000 per kilogram and processed oils
between US$ 7,000 to US$ 61,000 a litre. Large high quality pieces suitable for ornamental sculptures can sell for up to US$ 100,000 per kilogram (http://www.touchwood.com, October 2010).

Japan

In Osaka, Japan, a shop known as *Jinkoh-ya* (literally, "Agar wood Store") has been trading agar wood products for over 350 years. During the period 1991-1998, according to official Customs figures, 277,396 kilograms of unprocessed agar wood was imported into Japan, or an average of over 34 tonnes a year. A 2004 price survey of unprocessed agar wood pieces found prices ranging from US$ 320 to US$ 22,700 per kilogram with the highest grades selling for between US$ 9,000 to US$ 272,000 per kilogram (http://www.touchwood.com, October 2010).

Middle East

Demand for agar wood products in the Middle East significantly exceeds Eastern Asia. One well-known Saudi Arabian retailer specializing in *oud* (agar oil) has over 550 retail outlets across 17 countries with over 600,000 customers and is one of the world’s largest perfume retailers in the market worth US$ 3.3 billion a year. The company imports 45 tonnes of unprocessed agar wood yearly to produce 400 different fragrances with *oud* as the basic ingredient and has a production capacity of 30 million bottles of perfume a year (http://www.touchwood.com, October 2010).

Yamada (1995) estimated that 2000 tonnes/year of agar wood pass through the principal agar wood trading centre, Singapore, 70% coming from Indonesia and 30% from other South East Asian countries. Of this, 70% is exported to Arab countries and 30% to China, Hong Kong & Taiwan. Japanese merchants go on to trade in agar wood largely via Hong Kong.
METHODS OF CHEATING GAHARU

An important factor that would damage Gaharu market is the counterfeit activities by the traders, mostly involve in quality of the resinous wood and essential oil. For new comers of Gaharu players and customers, knowledge and competency have to be developed in order to identify good and appropriate incenses of Gaharu products. There are many techniques that people might be compromised with and exploited during the Gaharu dealing. A very useful website has layout several techniques used by the cheaters (http://www.vip4arab.com, October 2010).

Polish and Industrial Color

Some merchants resorted to give glint to Gaharu or oud pieces, it gives a good image of the buyer when they glimpse the product. It reflects the cleanliness of the Oud, this trick will be shown when the buyer rubs the Oud pieces, and sometimes to cast it in black or dark brown.

Stuffing Spare Lute and the Use of Adhesives to Increase Weight

Some people stuffing the Gaharu with heavy pieces. Theoretically, heavy Gaharu resembles the content of resinous material. The trick used is to stick adhesive materials such as wax and glue, so it seems that the real weight of Gaharu pieces, this method is used in high Gaharu prices. Due to this method, density of Gaharu might increase and would sink in water. Sinked Gaharu will be sold at high price.

Humidity

One of the characteristics of Oud trees is to absorb a large quantity of water; some traders sprayed the Oud woods with water to gain more weight, thus raising its price. There are types of Oud with significantly stronger absorption for
water and buyers would not feel the moisture, even though the moisture may sometimes reach 40% of weight.

According to experience this method is common and widespread in Indonesia, Thailand and the Mountain State of Cambodia, Burma, Malaysia and the State of Klaus. This method is also claimed being practiced in the Gulf states, especially if the Gaharu is newly imported, which is bagged in plastic bags before submitting for sale, so that it will not lose its weight and consequently drop in the price.

**Industrialized Oud**

It is a claim that this kind of Gaharu is manufactured in Indonesia and made of ordinary wood trees near the island of Kalimantan, which is not normal oud or Gaharu. It was colored in black by furnace and hot sands, and then impaired by oud. Ignition of this kind of Gaharu would give a light smell. However, its heavy parts are difficult to break or bent. The price in The Kingdom of Saudi Arabia is estimated to range between SR 1200-1400 per kg. (SR 1 = RM 0.85, October 2010).

**Mixing**

Mix fine species with poor quality, but both with the same colors. The mixing activities might be originated from the location where raw Gaharu was harvested and difficult to differentiate. Igniting several pieces of Gaharu might help if the color can be used to distinguish the good quality Gaharu.

**CHALLENGE OF BIO-GAHARU**

**Seeding**

Most Gaharu seeding in Malaysia is being practiced by using agar wood or Gaharu matured fruits, that is, the traditional...
method. However, few planters in this country have already embarked aggressively in applying tissue culture seeding but much of them depends on imported technology from Thailand for big scale production (personal communication with Gaharu planters). Therefore, detailed scientific studies should be carried out for popular species among Gaharu players in Malaysia, that is, *A. malaccensis*, *A. subintegra* and *A. crassna* in order to produce high yield and quality. However, there is a hearsay about low class Gaharu trees originated from tissue culture seeding among planters without valid scientific prove. Conversely, Bio-Gaharu plantation of Kebun Rimau Sdn Bhd in Tawau, Sabah has shown a very promising result in terms of tree development, uniformity and fast growing.

**Plantation Method**

Integrated plantation is considered as major rooting for establishment of Gaharu industry in Malaysia. Since quite significant interval required before inoculation of Gaharu trees can be made after seeding, integration with fast income crops could encourage low income groups to participate in this precious opportunity. However, a proper study should be carried out to advise Gaharu lovers to invest and integrate with their existing plantation. Related factors to be inculcated in advising Gaharu planters are related to financially viability, household income, type of soil, Gaharu processing, market and many others. For big or financially sound companies or planters, integration with existing plantation would be benefiting them in many ways especially in long term money-spinning or to be in agenda of corporate planning. They might become main contributors in transformation of World Hub of Bio-Gaharu in this country based on large acreage of plantation and available skilled labors.

**Organic Fertilizer for Bio-Gaharu Plantation**

Originality of Gaharu would be an important element in the future; purposely it is trading and finished products development. This is due to establishment of Gaharu plantation throughout the world to replace wild trees and potential of chemicals used might not
be avoidable, such as inoculants, fertilizer, pesticide and herbicide. A necessary step should be established as a guidance for Malaysian Gaharu planters to emerge bio-Gaharu industry or its trading from the beginning.

Application of organic fertilizer is regarded as a crucial step in making of bio-Gaharu. Organic fertilizers are fertilizer compounds that contain one or more kinds of organic matter. The ingredients may be animal or vegetable matter or a combination of the two. Many different natural elements can go into the creation of organic fertilizer. Animal manure is a common ingredient in the blends. A right combination of organic fertilizer based on the requirement of Gaharu trees and its age should be formulated properly. There are many factors to be considered in fertilizing activities such as type of soil to be applied, condition of plantation, location, rain distribution and other related activities.

Bio Inoculant of Gaharu

The most important decision in the making of bio-Gaharu is the application inoculants to induce resin formation in trees. Since most of the Gaharu products are directly involved to internal and external parts of the human body, chemical based inoculants should be avoided to ensure safe formation of compounds in resinous wood. Injection of bio-inoculants in Gaharu trees or sticking at the outer surface of trees is artificially to develop injury and fungi growth. However, the process itself is not yet fully understood. Biological formation of resinous material would create a better market and competitive price of the harvested products from Gaharu trees. Application of bio-inoculants in this country will be a driving force towards establishment of International Hub of Bio-Gaharu. It was found that a few Gaharu planters lost thousands of ringgit due to the usage of chemical based inoculants, thus, resulting in the low quality resin formed and total damage of the inoculated trees. It is found that Gaharu trees have been chopped by a few planters due to long wait and lacking of knowledge of inoculation technique as well as availability of inoculants.
Gaharu Extraction

Gaharu extraction is already established in this country, the common technique used is hydrosol distillation. Probably, chemical extraction is not being practiced for commercial purposes in order to avoid harmful chemical in finished products. There are few potential extraction processes to be investigated by local researchers in order to produce economic process with good quality essential oils. As an example, extraction process using ultrasonic assisted steam distillation method may contribute to improve the efficiency and capacity of Gaharu essential oils extraction. Besides that, supercritical extraction by using CO₂ is also not being actively explored for commercial purposes in this country.

Bio Finish Products

Significant and drastic action should be carried out to develop finished Gaharu-based products by using locally harvested Gaharu. It is important to note that sizeable Gaharu market in the Middle East countries has to be captured by Malaysians, due to many encouraging factors such as Halal, Muslim brotherhood, medicinal values and available purchasing power. Since Gaharu is trendy among Arab community, cosmeceutical Gaharu-based products would be easily accepted. The challenge to face is the suitability of products with the desert atmosphere and market outlets.

Gaharu Trading

Understanding trading and grading of Gaharu is very important for Gaharu player, especially the planters. There are many occasions that Gaharu planters were under paid with the quality that they produced, especially water sinked grade of Gaharu. The vision to establish International Hub of Bio-Gaharu requires many skills among Gaharu players in order to protect national interest as well as to build Malaysian reputation among international players. Forceful effort to market Gaharu directly from this country has to assemble many parties such as Gaharu players, related government agencies
and research institutions. No doubt that Gaharu from Malaysia has been traded internationally for quite sometimes, by avoiding middle traders, Gaharu products from this country might be acknowledged in better manner by international traders. This is another important factor to succeed the Hub of Bio-based Gaharu establishment. It is not impossible to achieve this aspiration since traders from this country have enough experience in international dealing.

ACCESSIBLE ADVANTAGES FOR HUB OF BIO-GAHARU

International Halal Hub

Being a harmony of multi-racial country with majority Muslim population, strategic location and good trade facilities and infrastructures, Malaysia has, not surprisingly, emerged in stature as a key centre for halal products and services. It has put in place the necessary infrastructures and support base and to leverage on its advantages to become a premier hub for halal products. In the ASEAN region, Malaysia is the undisputed leader in halal trade and industry, and has gained global recognition for its efforts to facilitate the development of halal industry and trade. In attaining this status, Malaysia hopes to serve as the gateway for players in the halal industry worldwide to converge, do business, source products, exchange ideas, conduct R&D, get accreditation and certification, and trade with one another (Nazery Khalid, www.maritimegateway.com, September 2010). These advantages should be exploited in establishing the Hub of Bio-Gaharu and quicker recognition from international society would be accomplished.

Suitable Land for Gaharu Plantation

Malaysia has been recognized as an important player in Gaharu plantation internationally, mostly a supplier of raw Gaharu and essential oils. With the fertile land blessed to this country, many parts of the land would be suitable with Gaharu plants. The robustness of
Gaharu plants by nature is also another advantage in the development of Gaharu plantation throughout the country. Nowadays, Gaharu plants could be found in most of the states.

**Nature of Plantation Spirit**

Geographically, Malaysia is divided in the west land area as the Malay Peninsula to the south of Thailand and the eastern part which consists of two States, Sabah and Sarawak, which lie on the northern side of the island of Borneo. The landscape in both east and west is similar, characterised by high mountains and fast rivers flowing down to coastal plains. Nearly 60 percent of the country is still covered with natural rainforest, the only clear areas being along rivers, including some larger alluvial plains in the west of the peninsula, and where land has been developed for urban settlement or agriculture. Much of this agricultural land is devoted to cash crop plantations, particularly oil palm and rubber, with tree crops occupying 17 percent of Malaysia’s land area. These are ideally suited to Malaysia’s hot, wet, and humid climate (www.historycentral.com, October 2010). It is believable that with the blessed climate and agricultural spirit that has been practiced throughout, it would magnificently benefit the Gaharu plantation.

**Research Institutions**

There are institutions that are already involved in Gaharu plantation and extraction such as the Forest Research Institute (FRIM), Malaysia Nuclear Agency and a few universities. With their involvement and a few are in reliable position to step in the activities, Gaharu industry would flourish faster in this country. With lots of encouraging factors, the research institutions would be able to innovate the industry in better shape and able to groom local industries to compete globally. Intimate relationship of Gaharu players with the research institutions is very much needed.
CONCLUSION

Plantation must be aggressively started as soon as possible throughout the country with priority given to integrated plantation. Sizeable amount of tissue culture seeding from good species would be achieved by using local experts and existing facilities. A good relationship between Gaharu planters and tissue culture hub has to be transpired.

Vision of Bio-Gaharu Hub would be achieved with integration and determined endeavor of Gaharu players, government agencies and research institutions in this country. Total understanding of bio activities in Gaharu industry is a key of success in this aspiration.

Global market for Gaharu is huge and Malaysia can play an important role in its trading that has been monopolized by a few countries in the world. Amazingly the countries are not the major planters. Several key factors to succeed in this endeavor are naturally blessed into this country. Collective effort to materialize this aspiration is essential. Gaharu related activities might be a spin-off in creating job opportunity in this country.

Extraction facilities have to be established based on Gaharu plantation in order to setup economic activities of finish products. Consortium among Gaharu planters should be considered in this establishment.

Skilled and highly qualified of Malaysian in this area must be developed in order to face international challenges in trading of Bio-Gaharu. This aspiration would be a major task of local universities and related research institutions. Valuable inputs from established planters, Gaharu processing centres and traders are considered as important information in the human capital development.

Fragrancing the world with bio-Gaharu from Malaysia would be achievable by the establishment of the hub and continuously innovate the industry as a package to compete globally.
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Prof Dr. Ku Halim bin Ku Hamid was born in the district of Kubang Pasu, Kedah and now works at the Chemical Engineering Faculty UiTM, Shah Alam as the Deputy Dean of Research and Commercialization. He is also the Chairman of the Research Center for Environment UiTM. He has a Bachelor (Hons) in Chemical Technology (UKM), Master in Mechanical Engineering and Materials (UKM) and PhD in Chemical Engineering (University of Sheffield, UK). Since 1988, he actively involved in research and invention, especially in the area of environment and now has a total of 20 patented inventions that have commercial value and eight of them have been commercialized.

As an inventor, Professor Dr. Ku Halim has won numerous awards from foreign countries like Switzerland, USA, Britain, Belgium, Russia, Germany, Korea, including the World Intellectual Properties (WIPO), the Government of Romania and Taiwan. So far he has obtained more than 90 design awards from various competitions around the world. His product, Oil Spill Bio-Absorbent has received the Innovation Award of the Public Sector Collaborative Research with Private Sector, 2008 organized by Ministry of Science, Technology and Innovation, in conjunction with the Prime Minister’s Quality Award 2008 won by UiTM.
Prof Dr. Ku Halim was then being chartered by the Bumi Gemilang Biotechnology (M) Sdn Bhd (BGBT) for a year as Technical Director to smoothen the company’s commercialization and promotion. Since June 2007, Prof Dr. Ku Halim had some time to explore some places in Saudi Arabia along with Secorp Strategic Enterprise Corporation Limited Company, partner of BGBT in the Middle East. His product, Integrated Sewage Treatment System has started to gain recognition in Saudi Arabia and the Philippines. At the beginning, this product was adopted by Al-Amanar (Jeddah Municipale) and is being tested for their efficacy at King Abdul Aziz University, Jeddah in March 2009. His experiences in promoting the products in foreign countries as well as being selected as the Technical Director is very valuable to him in producing commercial value products.

As an academician, he has produced more than 100 technical papers in various fields of research and has supervised more than 35 postgraduate students. As an experienced researcher, he was appointed as a Malim Sarjana by UiTM to guide young lecturers with an interest in research.
This book is intended to provide a clear explanation to overcome the problems related with gaharu. This can be used as a guide to all operators of gaharu in Malaysia. Gaharu industry is expected to grow and contribute to the economy of Malaysia. Its high commercial value can be seen in the increasing demand particularly by the countries in the Middle East. Improvements made in the research of gaharu is one of the major steps that have been taken to develop the industry in this country.