

A Review on the Malaysian *Aquilaria* species in Karas Plantation and Agarwood Production

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DOI: 10.6007/IJARBSS/v7-i4/2911 URL: <http://dx.doi.org/10.6007/IJARBSS/v7-i4/2911>

Abstract

Malaysia is one of the countries which is rich in its flora and fauna bio-diversity. Malaysian forest products have been exploited since ancient times for its high economic values. One of these high economic value products is agarwood. Thymelaeacea is one medium-size family tree where it is estimated to consist of 50 genera and 900 species of which many can be found in Africa, Australia and Asia. Most species of *Aquilaria* in Thymelaeaceae family produced agarwood or 'gaharu'. *Aquilaria malaccensis* is a species of the highest recorded number of planting by karas tree farmers and known as the primary producer of agarwood in Malaysia. Agarwood is non timber forest product it is one of the precious wood on earth and prized for its rich and wonderful fragrance. Agarwood is formed due to the pathological process as respond to fungal infection or chemically stimulated. This paper seek to understand in general the type of karas trees species most favoured by karas farmers and to know what other similar species that are capable of producing resin for gaharu products. This research is to review the natural process of producing gaharu and its importance to the diverse related industries. This research also found the high commercial value and its potential for further development

Keywords: *Aquilaria malaccensis*; Agarwood; Gaharu; Karas Tree; Malaysia

1. Introduction

Malaysia is one the 12 countries in the world which host more than 500 00 species of plants that survive in a diversity of habitats; which can be found from the lowland villages to the deep interior of the forest. Malaysian rainforests is said to be the oldest in the world, hosting a complex ecosystem where both animals and plants mutually interact as they evolved more than 10 millions years ago (Napis, Salleh, Itam, & Latiff, 2001)

In Malaysia, *Aquilaria* trees or Karas trees; also locally known as *depu* or *engkaras* are well known for their *gaharu*; a scented wood or agarwood/sandalwood harvest. The products of these trees are categorized as non timber products and are highly valued in West Asia and the Middle East (Zhang *et al* 2010), such trade activities of these products have been documented as far as 2000 years ago (Lim, 2010).

Aquilaria or Karas trees come from the Thymelaeaceae family and have a vast natural distribution encompasses the whole of Peninsular Malaysia. It can grow up to a height of 15 – 30 m with a diameter between 1.5 to 2.5m and produce white-coloured flowers. Naturally, these trees take a long time to produce quality *gaharu* (agarwood/sandalwood) between 40 to 50 years. But not all Aquilaria species will produce *gaharu* (Chakrabarty *et al* 1994), out of 21 Aquilaria species on 13 are reported to have the capability of producing scented, aromatic *gaharu*. These are *A. bailonii*, *A. beccariana*, *A. crassna*, *A. filarial*, *A. hirta*, *A. khasiana*, *A. malaccensis*, *A. microcarpa*, *A. rostrata*, *A. rugosa*, *A. sinesis*, *A. subintegra* dan *A. yunnanensis* (Hou, 1960 and Ng *et al*, 1997). The reminder species still require further future study on the capability of producing *gaharu*.

According to Lim (2010), there are 19 indigenous species in Malaysia that capable of producing *gaharu*, 13 in Peninsular Malaysia, 11 in Sabah and 13 in Sarawak. These recorded species come from 5 genera consist of *Aquilaria* 7 species; *Gonystylus* 6 species; *Wikstroema* 4 species; *Aetoxylon* 1 specie; and *Enkleia* 1 specie. They also pointed out that Aquilaria spp which is *A. malaccensis* is the most popular source of *gaharu* among the karas trees.

These trees are known as hardwood trees where the scented, fragrant and aromatic *gaharu* are obtained from the trunk and roots either by way of nature or induced by man. No *gaharu* will be obtained from a healthy tree (Zhang *et al*, 2014). The *gaharu* resin (oleoresin) is the result of the karas trees reaction to fungus infection, micro-organism infection, lightning strikes, fire and insects attacks (Chen *et al*, 2011). Healthy karas trees usually have softer wood core and light in colour. Only when karas trees are exposed to pathogen infection or parasite the trees will produce resin which will caused the infected tissue to turn darker or dark red in colour (Chua, 2008).

2. Literature review

According to Rogers (2009), Thymelaeacea is a family of medium size trees and it is estimated that there are about 50 genera and 900 species, largely found in Africa, Australia and Asia. Apart from its height, plants from the Malvales order also encompass shrubs, grape trees and non-woody herbaceous plants. Its wood tissue usually include floem, very sturdy, very strong fiber contents. These types of plants have very bisexual flowers found at the base of the buds or the end points. The flowers are either stemmed or of sessile types. Its fruits are of indehiscent type which means they will not crack opened even when ripened. Some of the plants from this family will bear fruits with or without its contents and in a dry condition. The fruits will either be in the form of seeds or capsules (Yih, 2011 and Hou, 1960).

Thymelaeacea is said to be very special because it has genus such as Aquilaria, Gyrinops and Wikstroemia that are capable of producing fragrant, aromatic and scented wood which is generally known as *gaharu*. But only species from genus Aquilaria is most commonly planted for *gaharu* and downstream products related industries (Lok, 2016).

Aquilaria malaccensis Lam. is one of the 17 Aquilaria species found within the Indomalesia area (Mabberley, 2008). While, Nor Azah *et al* (2008) stated that there 5 indigenous species found in rainforests of Malaysia such as *A. malaccensis*, *A. microcarpa*, *A. hirta*, *A. beccariana* and *A. rostrata*.

4. Aquilaria

This evergreen specie comes from the Thymalaeceae family, has a very fast growth rate and able to reach the height between 18 – 40 m with an average diameter of 40 cm. In Malaysia, most common natural habitat will be the rainforests area and around 3 – 1000m above sea level. It is noted that it commonly can be found striving at 500m above sea level. Genus Aquilaria is reported adaptable to a vary types of soil even sandy soil. This genus can be also found in other countries such as Indonesia, Cambodia, Laos, northern India, the Borneo and New Guinea (Kassan, 2014).

The angiosperm species is reported consist of 25 species but only 16 of them able to produced gaharu (Barden et al, 2000). While table 1.1 below shows the distribution of Aquilaria according countries.

Table 1.1 Aquilaria species distribution in its indigenous country

Aquilaria species	Country
<i>Aquilaria khasiana,</i>	Pakistan & India.
<i>Aquilaria apiculina,</i>	Filipina
<i>Aquilaria acuminata</i>	Papua New Guinea, Indonesia & Filipina
<i>Aquilaria baillonil</i>	Thailand and Cambodia
<i>Aquilaria baneonsis</i>	Vietnam
<i>Aquilaria beccariana</i>	Indonesia
<i>Aquilaria brachyantha</i>	Malaysia
<i>Aquilaria crassna</i>	Kemboja, Malaysia, Thailand & Vietnam
<i>Aquilaria cumingiana,</i>	Indonesia & Malaysia
<i>Aquilaria filaria,</i>	New Guinea & Mindanao (Filipina)
<i>Aquilaria grandiflora,</i>	China
<i>Aquilaria hirta,</i>	Thailand, Indonesia & Malaysia
<i>Aquilaria malaccensis,</i>	Malaysia, Thailand & India
<i>Aquilaria microcapa,</i>	Indonesia & Malaysia
<i>Aquilaria rostrata,</i>	Malaysia
<i>Aquilaria sinensis,</i>	China
<i>Aquilaria subintegra,</i>	Thailand

(Gaharu-Malaysia.blogspot, 2013)

5. Ecology and Aquilaria genus distribution in Malaysia

Locally known as karas trees, they are found surviving from the lowland forest areas to the mountainous rainforests area at the altitude of 750 m above sea level. They are also found from the fringe of forests up to the virgin forests apart from the documented and recorded areas of farmlands and on privately owned lands in the states of Kelantan, Pahang, Negeri Sembilan, Selangor, Kedah and Perak with a total combined area of 1 – 2% of forest area in Malaysia (Muhammad Ismail & Mohd Zin Jusoh, 2011). A mature medium size tree may reach the height of 40 m with an average diameter of 60 cm, it boasts a crossed, fiborous and

elliptic shaped leaves of 6 – 8 cm in width and 3 – 4 cm in length. It starts to fruit from the age of 5 -6 years old (Gaharu-Malaysia.blogspot, 2013). Normally the trunk is straight but fluted trunk it not uncommon. The bark of the trunk is smooth with either grayish white or reddish white in colour. It buttress root may reach the height of 2 m.

A. bericana is specie commonly found in its natural habitat in the lowland forests area in Johor, Sabah and Sarawak and it has been recorded and documented to be found in the high altitude of 850m above sea level. *A. hirta* commonly found in the hill cliff areas up to the altitude of 300 m above sea level mainly in the west coast of Peninsular Malaysia but can also be found in parts of the eastern coast in the states of Terengganu, Pahang and eastern coast of Johore (Ismail, 2014).

A. microcarpa is found in the wild in the states of southern Johor, Sarawak and Sabah, capable of thriving in even in areas of acidic soil between pH 3.5 – 4.0. *A. rostrata* mainly found in the states of Terengganu and Pahang, initially thought to be extinct according to a documented 100 year old British research until it was found again by a group of UPM a local agriculture university in mid 2015 in the area of *Gunung Tebu* in Besut, Terengganu thus giving a glimmer of hope on the survivability of indigenous natural resource which locally known as *Karas Gunung* or *Chandan Gunung* (Azman Zakaria, 2016).

A. malaccensis is the most abundant species found in all states with exception of Perlis (Hou, 1960) stated by Yih (2011). *A. malaccensis* starts producing seeds at the age of 7 – 9 as reported in western India areas and a medium size tree may produce up to 1.5kg. The average diameter growth rate of this species in the wild is reportedly to be lower with an average of 0.33cm per annum as compared the growth rate of height is much higher with an average value of 0.8 -1cm per annum (La Frankie, 1994). The table below presents a summary of the five main karas of genus *Aquilaria* found in Malaysia.

Table 1.2 Natural distribution of *Aquilaria* in Malaysia

Scientific Name	Natural Distribution	Feature,shape Trunk/fruit/leave
<i>Aquilaria malaccensis</i>	Peninsula, Sabah, Sarawak	Big trunk, tall (up to 40m) circum. 80cm, shining leaves surface, pointy & oval like Spanish Cherry
<i>Aquilaria hirta</i>	East coast of Peninsula: (Terengganu,Pahang & Johor), Sabah & Sarawak	Small (15m) furry leave underside, fruit, branch and flower included
<i>Aquilaria beccariana</i>	Southern Johor, Pahang, Sabah & Sarawak	...continued Medium height (20m) second vein leave visible, grayish green, not shiny
<i>Aquilaria rostrata</i>	Gunung Tahan, Pahang	Small (16m) second vein leave not visible
<i>Aquilaria microcarpa</i>	Johor, Sabah & Sarawak	Tall (> 36m), small heart shaped leave

Source: (Muhammad Ismail & Mohd Zin Jusoh, 2011)

6. Karas tree farming in Malaysia

Farming of karas tress began in the 70’s in Assam, India followed by Thailand and Cambodia in the 80’s. Australia began its commercial farming in earnest in 2007 in Western Australia totaling 5000 acres of Red Sandalwood or Cendana Merah; *Santalum album L* (Ismail, 2014). What is important that such endeavour will inevitably ensured the continuity of the survival of the species in the wild as well as keeping up ever growing demand for *gaharu* products.

Karas farming in Malaysia is reportedly reaching a total of 232.8 ha (575 acres) initially. It began around 2000 – 2005 involving government agencies such as the State Forestry Department. It is estimated that private companies have a total of 1.068 ha (2,626 acres) with an estimation of between 256,080 to 1,169,028 trees. A consensus conducted in 2014, 1,571,100 tree with a ratio of 1, 19 ha or 2,763.9 acres, worth about RM 785,550,000 compared to 2010: RM128, 040,000 (Ismail, 2014). In Malaysia, such farming is run either as monoculture, crop rotation with rubber trees, palm oil, lime, pineapple and coffee (*Panduan Penanaman Karas*, 2012).

According to Barden *et al* (2000), *A. malaccensis* is the most popular specie favoured by the farmers due to it ability to survive in many types of soil and condition such as rock area, sandy soil, limestone soil, hilly or areas proximity to swampy soil as well as it fast growth rate. Malaysia hot and humid weather with daily temperature of 20 – 22 degrees Celcius further facilitate the growth. Table 2.4 below shows the statistics of Gaharu Farms in Malaysia for 2014

Table 1.3 The statistics of Gaharu Farms in Malaysia for 2014

State	Area		Number of tress	of Estimation (RM500/tree)
	Ha	Acres		
Johor	2.0	5.0	5 000	2 500 000
Kedah	44.1	109.0	109 500	54 750 000
Kelantan	40.5	100.0	43 200	21 600 000
Melaka	2.0	5.0	5 000	2 500 000
N. Sembilan	20.6	51.0	45 000	22 500 000
Pahang	144.1	256.0	351 000	175 500 000
				...continued
Perak	298.2	736.6	415 800	207 900 000
Perlis	5.7	14.0	14 000	7 000 000
Pulau Pinang	4.0	10.0	10 000	5 000 000
Sabah	311.0	768.2	342 100	171 050 000
Selangor	16.6	41.0	450500	22 750 000
Terengganu	230.0	568.1	185 000	92 500 000
TOTAL	1 119.0	2 763.9	1 571 100	785 550 000

Source: (Ismail, 2014)

Due to the continual rising price, value and demand for *gaharu* both internationally and locally have place undue duress on the survival of karas trees in the wild and nature as it will drive unmanageable and uncontrollable harvest of the source in the wild (Chakrabarty *et al*, 1994). Thus, sent alarm signal on the continuity of survival of the species which may cause it extinction, due to unscrupulous and illegal deforestation (Soehartono & C. Newton, 2001). True to the fact that since 1990 Malaysia has faced with illegal harvest and cutting of karas trees by illegal *gaharu* traders perpetrated by smugglers from her borders such as Thailand, Indonesia, Philipines (active in Borneo) and Cambodians (Peng *et al*, 2015). An international joint efforts resulted in actions and cooperation have place all species under the genus *Aquilaria* be included in Appendix II of Convention on International trade in Endangered Species of Wild Fauna and Flora (CITES) in 1994 and in 2004 (Nor Azah *et al*, 2013 and Liu *et al*, 2013). Presently *Aquilaria* is listed in IUCN Red List Appendix III which not only involving karas trees and *gaharu* but encompassing all products related to or based on *gaharu* regulating an importing and exporting permits are now required.

7. Gaharu production and its uses

Gaharu is said to be the result of the infliction process by letting in oxygen into the tissue to purposely damaging a living cell. The plant reacted by producing fragrant and aromatic extract (Rasool & Mohamed, 2016). Originating from Sansrit word *Aguru* which means heavy wood that will sink in water. Technically it is defined as a physical and chemical changed wood cell from its original form. It is said to be a type of wood of different shapes and colour stripes ranging from orangy to dark (Yahya, 2011). It is also said to have a density of 0.5-1.5kg/m³. Malaysian *gaharu* is graded according to colour, density and its unique aromatic smell (Nor Azah *et al*, 2013).

According to Akter *et al* (2013) *gaharu* generally is not artificially synthesized in laboratories due to the chemical complexity and difficult structure therefore according to Chung (2013) can be produced synthetically which will resulted in the loss of its unique aroma. Rasool & Mohamed (2016) further elaborated that *gaharu* is rich with terpenoid compound and no industrial produced has ever been made possible therefore it is safe to assume industries have to depend on naturally made *gaharu*. However, sesquiterpene which is the main group in the making of *gaharu* concentrated oil can be laboratory synthesized but at a higher cost that deterred many concerned parties.

The highest grade *gaharu* is said to be tagged at the price as much as USD30, 000/kg depending on the demand and the user country (Jayachandran *et al* 2014). Suharti, Santosa, & Turjaman (2011) reported the price of super double *gaharu*, blackish in colour in Indonesia which is the highest onced fetched Rp 25 million/kg involving exports to countries such as Saudi Arabia, Hong Kong, Korea, Japan and Taiwan.

There are many uses for *gaharu* but it is mainly used in religious ceremonies and prayers, as a form of healing or medication, essence of *parfum* and grooming or hygiene purposes. Due to its aromatic fragrance, *gaharu* (when burned) is much favoured by Taoist, Buddhists, Hindus and other faiths and in certain cultures such as the Japanese, whom also used it not only in anti emetic treatment to relieve and alleviate vomiting, nausea, tranquilizer,

indigestion complaints and meditation (Okudera & Ito, 2009). The Chinese have long used it to treat renal and lungs illness, stomach aches, diarrhea. The European and Indians has used it in the formulation of medication for cancer treatment. The East Asians have long used it as an expensive *parfum* extracts attar oil apart as well as for shampoos and soaps (Barden *et al*, 2000).

8. Conclusion

In nutshell, we have described the ecological and importance of *Aquilaria* species for agarwood formation. Furthermore the knowledge related *Aquilaria* species and the production of gaharu are hoped to trigger the ideas of the next step in research. This involves the produce of inoculant to stimulate the production of gaharu. This paper also intends to explain the relationship of karas trees and gaharu products is inseparable. In addition of that, the review of past studies toward agarwood also revealed numerous factors or variable that may influence the resin formation. It will help on the methodological aspect as well as significant finding.

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