ASSESSMENT OF INDUCTION TECHNIQUE AND SELECTION FACTORS FOR AGARWOOD PRODUCTION FROM CULTIVATED *AQUILARIA*

By

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Abstract of thesis presented to the Senate of the Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Diana Emang, PhD
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Aquilaria is a genus belonging to the Thymelaeaceae family. This genus produces the valuable, non-wood fragrant product known as agarwood (*gaharu*). Agarwood is a highly commercial non-timber product due to its important role in the fragrance, aromatherapy, and medicine industries, and its usage in religious activities. Along with the increasing agarwood demands and growth of *Aquilaria* plantations, some artificial methods to induce agarwood formation have been developed, not only to improve agarwood yields but also to produce sustainable agarwood with quality closely resembling the wild-sourced agarwood. In this study, an underrated method with high potential to increase agarwood yields were assessed in a field trial in a local plantation. Six cultivated *Aquilaria subintegra* trees were induced using a patented agarwood inducer, where three stands were harvested at six- and 12-months post induced, respectively, and were assessed (i.e., documenting agarwood formation, yields estimation and agarwood grading). It is shown that the inducer has the potential in maximizing the agarwood yields at 12 months post induced with higher quality than after six months post induced. A survey was conducted to evaluate the potential of agarwood inducer in local market. It highlighted five influential factors on inducer selection among smallholders/plantation owners. Chemical inducer has potential in local market since the desire to use chemical inducer among planters is about 48%. In addition, the trends of agarwood trade were found fluctuating but gives impression that the industry has potential to bring huge profits for planters and country. Overall, this study is informative and contribute analytical analysis for the advancement of agarwood industry.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENILAIAN TERHADAP TEKNIK INDUKSI DAN FAKTOR-FAKTOR PEMILIHAN UNTUK PENGELUARAN GAHARU DARI PERLADANGAN *AQUILARIA*

Oleh

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Aquilaria adalah genus dalam keluarga Thymelaeaceae. Genus ini menghasilkan produk bukan kayu yang wangi dan bernilai tinggi yang dikenalisebagai gaharu. Gaharu mempunyai nilai komersial yang tinggi kerana kepentingannya dalam produk pewangi, aromaterapi, perubatan dan aktiviti keagamaan. Selari dengan peningkatan permintaan terhadap gaharu dan pertumbuhan perladangan *Aquilaria*, beberapa kaedah buatan untuk merangsang pembentukan gaharu telah dibangunkan untuk meningkatkan hasil gaharu dengan kualiti yang sangat mirip dengan gaharu dari sumber liar. Salah satu kaedah buatan ialah induksi kimia, yang mana ia kurang dikenali namun mempunyai potensi tinggi untuk meningkatkan hasil gaharu. Dalam kajian ini, hasil gaharu dinilai berdasarkan percubaan lapangan di satu ladang tempatan dengan menggunakan satu produk induksi kimia yang telah dipatenkan.Enam batang pokok *Aquilaria subintegra* telah diinduksi; tiga batang pokok dituai, masing-masing pada enam dan 12 bulan selepas diinduksi dan dinilai (i.e., perekodan pembentukan gaharu, penganggaran hasil dan penggredan gaharu). Kajian menunjukkan induksi kimia berpotensi memaksimumkan penghasilan gaharu selepas 12 bulan diinduksi dengan kualiti yang lebih tinggi berbanding gaharu yang terbentuk selepas enam bulan diinduksi. Satu survei telah dilakukan untuk menilai potensi induksi kimia dalam pasaran tempatan. Ia mengetengahkan lima faktor yang secara signifikan mempengaruhi pemilihan induksi dalam kalangan pekebun kecil/pemilik ladang. Hasil survei mendapati bahawa keinginan pemilik ladang untuk menggunakan induksi kimia ialah sekitar 48%. Selain itu, tren perdagangan gaharu adalah berubah-ubah, namun memberi gambaran keupayaan industri ini untuk membawa keuntungan kepada peladang dan negara. Secara keseluruhan, kajian ini bersifat informatif dan menyumbang analitikal analisis untuk kemajuan industri gaharu.

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LIST OF ABBREVIATIONS

A.D	Anno Domini
Agar-Wit	Whole-tree Agarwood-Inducing Technique
Apl	Ant-processed Inducer
BGBB	Black Gold Bio Booster
BMW	Black Magic Wood
CA-Kits	Cultivated Agarwood Kits
CE	Common Era
CITES	Convention on International Trade In Endangered Species of Wild Flora and Fauna
DBH	Diameter at breast height
DCA	Drug Control Authority
DOA	Department of Agriculture
DOF	Department of Fisheries
FDPM	Forestry Department Peninsular Malaysia
FORDA	Forestry Research and Development Agency
FRIM	Forest Research Institute Malaysia
GMP	Good Manufacturing Practice
INTESA	International Trade in Endangered Species Act 2008
ITTO-CITES	International Tropical Timber Organization- Convention on International Trade In Endangered Species of Wild Flora and
	Fauna
IUCN	International Union for Conservation of Nature
KPI	Key Performance Index

MA	Management Authority
MAEPS	Malaysia Agriculture Exposition Park Serdang
MAPs	Medicinal and Aromatic Plants
MITC	Melaka International Trade Centre
MPOB	Malaysian Palm Oil Board
MPOC	Malaysian Palm Oil Council
MREPC	Malaysian Rubber Export Promotion Council
MTIB	Malaysian Timber Industry Board
R&D	Research and Development
RISDA	Rubber Industry Smallholders Development Authority
RMCD	Royal Malaysian Custom Department
ROI	Return of investment
SPSS	Statistical Package for the Social Sciences
TLC	Thin Layer Chromatography
UAE	United Arab Emirates
UNEP-WCMC	United Nation Environment Programme-World Conservation Monitoring Centre

CHAPTER 1

INTRODUCTION

1.1 General Background

Thymeleaceae family is known for its incense-producing tree species, especially from genera *Aquilaria, Aetoxylon, Gonystylus* and *Gyrinops*. *Aquilaria* is the main genus that producing the valuable, non-wood fragrant product, agarwood. There are 21 species recorded in the *Aquilaria* genus, and 13 of them are agarwood producer (Lee and Mohamed, 2016a). The distribution of this genus has been reported in Southeast Asia countries, India, Bangladesh, China, Hong Kong, and Taiwan. The main sources of agarwood are Indonesia, Malaysia, Thailand, Vietnam, Cambodia, Laos, and Papua New Guinea (Hou, 1960; Peersoon, 2007; Lee and Mohamed, 2016a). Other than agilawood, aloeswood and eaglewood, agarwood has other various name including *agar* (Hindi), *agaru* (Tibetans), *akil* (Tamil) in Indian subcontinent; *gaharu* (Malay) in Malay Archipelago, *mai ketsana* (Laos), *mai kritsana* (Thai) and *tramhuong* (Vietnamese) in Indo-chinese countries; *chenxiang* (Chinese), *jinkoh* (Japanese); and *oud* (Arabic) in Southwest Asia (Tran et al., 2003; Lee and Mohamed, 2016a; Rasool and Mohamed, 2016).

Agarwood is widely used in perfumery, incense, traditional medicines, and other aesthetic purposes, thus made this non-wood product valuable and fetch high economic returns. The history of agarwood trading was started over 2000 years ago. The primary markets for agarwood were the Middle East and East Asia regions back then. Southeast Asia region – especially those from Indo-Malesian archipelago and north-east Indian region were the main supplier for agarwood in that time (Hou 1960). Agarwood was harvested and traded in Peninsular Malaysia since before 684 CE (Shuhaimi and Rahman, 1998). *Aquilaria* receives great attention because of agarwood's economic value since the beginning of the twentieth century (Lee and Mohamed 2016a). Increasing in demands for agarwood due to its economic value have led to diminishing supplies of agarwood and causing price rising (Wyn and Anak 2010). The concerns of future supplies of agarwood have getting increase since extensive harvesting tree for agarwood threatened the reproduction cycle – which affected the availability of agarwood-producing species, especially *Aquilaria sp.* in their natural habitats (Faizal et al., 2016; Lee and Mohamed 2016a). In the wild, natural *Aquilaria* trees were destroyed in search of agarwood, thus adding it to the Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and any trading activity regarding *Aquilaria* require relevant licenses (CITES 2004). Agarwood is synthesized as defence system when plants are exposed to wounding or pathogen attacks. The formation of agarwood is triggered when damage signals were induced and transmitted to the plant's defence mechanism upon injury or attacks, then further

secrete defensive substances. The main microbial component responsible for agarwood formation is generally, refer to fungi (Mohamed et al., 2010). Pathogenic fungus is believed to attack the injured trees when wounded occurred in the stem or main branches, and trigger agarwood formation. This show that fungus played important roles either directly or indirectly in agarwood formation.

1.2 Problem Statement

Agarwood is rare and hard to be found in nature. Agarwood production in nature is low and cannot fulfil the market demand. As the natural formation of agarwood will take a long time to form, some alternative techniques are currently being practiced by agarwood's planters. These practices are meant to increase the agarwood productions and fulfil the demand in the market. Fungi inoculation is one of the techniques that has been used by *Aquilaria* planters. The introduction of inducer is welcomed by the industry and gets some demands in the market. The development of these techniques seems to increase the interest in *Aquilaria* cultivation among the people, locally and internationally.

The formation of agarwood in wild *Aquilaria* trees depending on natural occasion that caused wound and damaged in tissues (Oldfield et al., 1998; Rasool and Mohamed, 2016). The physical damages, usually occurred in small part of the tree caused it to be weaken, vulnerable and lead to fungal infection. The infection caused agarwood formation. Meanwhile, the introduction of inducer into tree aims to mimic the condition suitable to stimulate agarwood formation by *Aquilaria* stands. Generally, inducer is applied to cover as much as possible of the tree to maximized agarwood production. This may shorten the life of the tree compared to thus in wild.

The development of agarwood industry is believed to create high profit to the industry players and governments, yet there is no accessible complete published data on demand and supply analysis of local and global agarwood industry to support this believe. Some formal reports on market prices are vary and limited to the scope of agarwood products across producers and importer countries. In addition, agarwood price is not fix, but rather subjective, where information of its market value often differs based on region, sources, and grades (Mamat et al., 2010).

For planters, inducer will help them to increase their production, which gives them high return of investment (ROI). The inducer offered in market are varies, but basically, are classified as biological and chemical inducer. Some of the inducer products are backed by scientific reports, while others are based on personal experiences and observations (Azren et al., 2017). It is important to

understand planters' preferences in choosing agarwood inducer to support this technology development.

1.3 Justification of Study

As the demanding for the agarwood increasing with limited stock can be offered by planters, inducers now look very important and play big role in agarwood-related industry. The introduction of the technologies to induce agarwood formation led to increasing of cultivated *Aquilaria* population. Inducer act as catalyst to get better amount of agarwood. Inducer's kits are now available in market to help planters to increase their production. Due to this reason, some planters are willing to pay for high price to get the kits, yet some are not. However, some kits are hard to be handled, not efficiency and not effective. Agarwood inducer in liquid form seems to be more efficient, usually paired with easy and convenient technique to apply.

Thus, this study will provide analysis on the trends in agarwood trades in Peninsular Malaysia, as the basis to evaluate the potential of chemical inducer in local market. It is important to know and understand the trends of agarwood industry in Peninsular Malaysia, to know better the availability of agarwood supply can be provided by the country. The finding may towards contribute the understanding of agarwood formation and marketing, thus assists future research in efforts to increase the efficiency of agarwood production in cultivated *Aquilaria* tree for sustainable agarwood resources.

1.4 Research Objectives

The general objective of this study is to evaluate the potential of an agarwood inducer in maximizing the agarwood yields, and its potential in local market through evaluation of the influential factors on inducer selection and analysing the trends in agarwood industry. The specific objectives are:

i. To assess the agarwood yields (the formation, yield estimation and agarwood grading) from *Aquilaria* trees treated with a patented agarwood inducer in a field trial.

ii. To evaluate the influential factors on inducer selection among *Aquilaria* planters.

iii. To analyse the trends in the agarwood industry of Peninsular Malaysia.

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