Faculty of Resource Science and Technology

DECAY AND TERMITE RESISTANCE OF EXTRACTIVES-FREE OF MODERATELY DURABLE WOOD

Nik Nadira Nazua Binti Nik Rusmadi

Bachelor of Science with Honours
(Plant Resource Science and Management)
2015

DECAY AND TERMITE RESISTANCE OF EXTRACTIVES- FREE MODERATELY DURABLE WOOD

NIK NADIRA NAZUA BINTI NIK RUSMADI

This project report is submitted in partial fulfilment of the requirements for a degree of Bachelor of Science with Honours

(Plant Resource Science and Management)

Faculty of Resource Science and Technology

UNIVERSITI MALAYSIA SARAWAK

2015

Faculty of Resource Science and Technology

UNIVERSITI MALAYSIA SARAWAK

2015

APPROVAL SHEET

BSc. Candidate : Nik Nadira Nazua Binti Nik Rusmadi

Title of Dissertation : Decay and Termite Resistance of Extractives- Free Moderately Durable Wood

____

Prof. Dr. Ismail bin Jusoh

Supervisor

Department of Plant Science

Faculty of Resource Science and Technology

DECLARATION

I hereby declare that no portion of this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

Nik Nadira Nazua binti Nik Rusmadi

Plant Resource Science and Management Programme

Department of Enviromental Science and Technology

Faculty of Resources Sciences and Technology

University Malaysia Sarawak

TABLE OF CONTENTS

3.0 MATERIALS AND METHODS

4.0 RESULTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASTM	American Society for Testing and Materials
mm	Milimetre
FAO	Food and Agriculture Organization of the United Nations
FRIM	Forest Research Institute of Malaysia
L	Litre
MEA	Malt Extract Agar

DECAY AND TERMITE RESISTANCE OF EXTRACTIVES-FREE OF MODERATELY DURABLE WOOD

NIK NADIRA NAZUA BINTI NIK RUSMADI

Plant Resource Science and Management Programme
Faculty of Resource Science and Technology
University of Malaysia Sarawak

ABSTRACT

Wood durability is closely related to the extractives content in the wood. Wood durability can be variable within and between the species. Wood extractives are known to impart wood resistance against fungi and termites attack. This study was carried out to determine the durability of *Sindora leiocarpa*, *Dialium laurinum* and *Diospyros bantamensis* against wood decay fungi and termite attack. This study also were carried out to identify and classify the resistance of the *Sindora leiocarpa*, *Dialium laurinum* and *Diospyros bantamensis* towards fungal and termite attack with and without the extractives content. A non durable wood, *Macaranga triloba* was used as control. Twenty one wood blocks from each species with 10 mm (radial) x 10 mm (tangential) x 10 mm (longitudinal) in size were selected. Some of the wood blocks underwent solvent extraction and the others remained unextracted. Wood decay fungi used were *Trametes versicolor* and *Coniophora puteana*. In the termite resistance test *Nasutitermes* sp. was used. Weight losses of decay fungi and termite attacks were determined after eight weeks and one week of exposure, respectively. Results showed that *Macaranga triloba* acts as a control recorded the highest weight loss in both decay and termite resistance attack. *Sindora leiocarpa*, *Dialium laurinum* and *Diospyros bantamensis* are categorized as the durable wood after expose to the decay test and termite test.

Keywords: Wood durability, extractives, fungal decay, termite attacks.

ABSTRAK

Ketahanan semulajadi kayu berkait rapat dengan ekstraktif semulajadinya. Ketahanan kayu adalah berbeza di antara kayu. Ekstraktif kayu boleh mempengaruhi ketahanan kayu apabila didedahkan dengan kulat dan serangan anai-anai. Tujuan kajian ini dijalankan adalah untuk mengenalpasti ketahanan Sindora leiocarpa, Dialium laurinum *dan* Diospyros bantamensis *apabila didedahkan dengan kulat dan serangan anai-anai. Ia juga penting untuk mengenalpasti dan mengklasifikasi ketahanan tiga jenis kayu yang diuji apabila kayu itu mengandungi ekstraktif dan tidak mengandungi ekstraktif. Spesies kayu yang tidak tahan iaitu* Macaranga triloba *digunakan sebagai rujukan. Dua puluh satu kayu setiap spesies dengan saiz 10 mm (jejarian) x 10 mm (tangen) x 10 mm (membujur) akan dipilih. Sebahagian daripada kayu akan didedahkan kepada larutan ekstraktif manakala sebahagian lagi dibiarkan tanpa larutan ekstraktif.* Trametes versicolor *dan* Coniophora puteana *adalah dua jenis kulat yang akan digunakan dalam kajian ini. Kayu tersebut juga akan didedahkan dengan anai-anai* Nasutitermes *sp. Kehilangan berat akan dikenalpasti selepas lapan minggu dan seminggu kayu itu didedahkan. Di akhir eksperimen,* Macaranga triloba *menunjukkan paling banyak kehilangan berat apabila didedahkan dengan kulat dan serangan anai-anai.* Sindora leiocarpa, Dialium laurinum *dan* Diospyros bantamensis *dikelaskan sebagai kayu yang mempunyai ketahanan tinggi apabila didedahkan dengan kulat dan serangan anai-anai.*

Kata kunci: Ketahanan kayu, ekstraktif, pereputan, serangan anai-anai.

1.0 INTRODUCTION

1.1 General Introduction

Wood is a highly variable material and closely related with natural durability. Natural durability can be defined as the ability of the wood to undergo biological degradation for a period of time. The natural durability of heartwood is categorized by wide differences both species and even the same individual trees of the same species (Scheffer & Cowling, 1966). The variations of the wood natural durability are due to many factors such as timber species, adaptability and climatic and geographic regions. It can be the special features of the wood and classified according to their morphological and its function to the tree (Hillis, 1971). Other than that, the durability of wood can be classified according to the polarity of different solvent. By using different polarities of the solvents, the chemical of the wood can be removed.

Natural durability can be classified into several groups that are perishable, non-durable, moderately durable, durable and highly durable. According to Findlay (1985), the moderately durable wood service life is both in temperate climate and tropical climate are different. The service life in temperate climate are 10-15 years whereas in the tropical climate are 2-5 years. It is important to study the moderately durable wood to know its actual natural durability. Moderately durable woods are commonly used for moderately heavy to heavy construction purpose. Some timbers that fall in the moderately durable wood are strong and heavy, but under the tropical condition, its natural durability is unsuitable for used in exposed condition and in ground contact except it properly treated with the chemical preservatives.

According to the Hinterstoisser *et al.* (2000), the durability of woods is influenced by the contents of the extractives. Extractives can be defined as the large variety of different chemicals produced by the tree for many purposes for example protection and food storage. According to FAO (2005), the importance of extractives is to provide protection from predators that wish to give the cell wall structural components. The main reason of doing the wood extractives is to make the woods become resistance against fungal and termites attack. Heartwood is more durable than the sapwood because it contains more extractives. Heartwood of some species has darker in colour compare to the sapwood. According to the Leightly (1995), the dark colour of the heartwood is due to the changes on starches, sugar and nitrogenous material into dark colour polyphenol substances which often provide natural resistance to biological degradation.

Apart from resistance against fungi and termite attack, other roles of wood extractives are to preserve the quality of the wood and extend its shelf life by protecting the timber against fungal degradation and termites attacks. Besides that, wood extractives are to produce the natural products that are environmental friendly and safe for human use.

1.2 Objectives

The specific objectives of this study are:

1) To determine the decay and termite resistance of *Sindora leiocarpa*, *Dialium laurinum*, and *Diospyros bantamensis* against wood decay fungi and termite attacks.

2) To identify and classify the resistance of *Sindora leiocarpa, Dialium laurinum* and *Diospyros bantamensis* towards fungal and termite attack with and without the extractives content.

2.0 LITERATURE REVIEW

2.1 Wood as a raw material

Wood has remained as the most important raw material uses to improve the demand of live and important as a regenerating material. The wood is essential in human daily life to satisfy the basic needs of a growing population worldwide. Wood has various physical properties and mechanical properties that can make it withstand in any conditions. According to the Panshin & Zeeuw (1980), wood has different characteristics properties for example cellular in structure, anisotropic, hygroscopic, biodegradable, combustible, and remarkably inert to the action of most chemicals, durable and fibrous structure. Timbers are used in construction for building houses, bridges and ships and for forest crops (Soerianegara & Lemmens, 1994). According to Joao (2012), there are approximately 5,000 enormous types and uses of wood products proof that wood still is an important raw material worldwide. Other than that, wood is also providing a source of extractives that are widely used for industry, domestic and pharmaceutical purposes. Wood is well known as a sustainable, innovative and ecological commodity. Wood can be used either indoor or outdoor depends on the species of the woods. It is important as a raw materials in the producing many types of product. Other than construction and making furniture, it is also important in producing toys and sport equipment and as resonator for manufacturing musical instruments. According to Young (1989), wood is the basic materials in paper production industry, also widely used in manufacture of wood composites and panel products for building industry.

2.2 Natural durability of wood

Decay resistance or natural durability can be described as the ability of the wood to undergo biological degradation. The term natural durability in wood industry shows the resistance of wood to many deteriorating factors such as insect, marine borers, decay fungi and weathering (Zabel & Morrell, 1992).The natural durability is referring to the heartwood timber species except for those species that do not have differences between heartwood and sapwood (Zabel & Morrell, 1992; Eaton & Hale, 1993; Bowyer *et al.*, 2003; Wong *et al.*, 2005).

According to Eaton & Hale (1993), the toxic compounds are deposited in the heartwood during the production and also because of its lower permeability to water and oxygen the heartwood has the same strength as sapwood but its natural durability is greater. During the metabolism of the tree, the heartwood that contains the chemical products will be produced. Performances of the timber species are different when exposed to decay risk. Fungi and insect are the organisms that can degrade the wood and lumber products.

Extractives components are small molecule that can be extracted with a solvent from wood, bark or the foliage. Different types of wood have different extractive compound, between the individual trees of the same species and within a single tree. According to Hinterstoisser *et al.* (2000), durability of wood can be observed based on the extractive content.

By doing the further research of the plant extractives, the plant disease and pathogen can be controlled (Amienyo & Ataga, 2007). Wood extractives are natural compounds which are toxicity to the wood degrading organisms. One of the advantages of wood extractives is it can prolong the service life of wood.

2.3 Classification of Natural Durability

Table 1 shows the natural durability classes for timber service life under temperate, tropical and laboratory. The service life of the timber is different between temperate climate and tropical climate. The table shows the service life of timber in temperate climate is longer than the tropical climate. In tropical climate, the timber easily undergoes decay compare to the temperate climate.

Table 1: Natural durability classes for timber service life under temperate, tropical and laboratory (Findlay, 1985).

Natural Durability of Decay Resistance Class	Temperate climate Service life	Tropical climate Service life	Laboratory test (% weight loss)[a] (Findlay 1985) ASTM*
1. Very durable	>25 yr	> 10 yr	<1
2. Durable	15 – 25 yr	5- 10 yr	1-5
3. Moderately durable	10 – 15 yr	2-5 yr	5-10
4. Non- durable	5-10 yr	< 2 yr	10-30
5. Perishable	<5 yr	< 2 yr	>30

[a] 16 week incubation at 22°C

[b] In Malaysia and some tropical countries the term perishable is not used and non-durable is used to describe to class

2.4 General characteristics of moderately durable wood

Most of the wood worldwide falls under two categories that are softwoods and hardwoods. The characteristic of softwood is evergreen needle or scale-like leaves that also can be known as conifers. On the other hand, the hardwood derived from broad-leaved trees which bear seeds in seed cover. In Malaysia, the woods produced are mostly hardwoods. The natural durability of the heartwood can be classified into several categories that are very durable, durable, moderately durable, non-durable and perishable (Findlay, 1985).

The moderately durable wood is the wood that has the service life of 10-15 years at the temperate climate (Findlay, 1985). On the other hands, in the tropical climate, the service life of moderately durable woods can be decreased to the 2 to 5 years. It is shown that under the tropical climate, the natural durability is insufficient in the ground contact unless it is treated with the chemical preservatives. The percentage of weight loss under laboratory test 6 to 10 % or 25 to 44%.

2.5 Decay of wood

According to Zabel & Morrell (1992), decays are the main types of damage to wood in use and essentially are due to the wood digestion by fungi. Decay fungi occur when the wood exposed to weather either aboveground or in ground contact and then exposed to the fungal decay. Decay fungi are either rapid or slow in timber based on the species of timber. There are some conditions that cause the decay development grows rapidly such as the presence of fungal reproductive parts, low natural durability of wood, suitable temperatures, sufficient supply oxygen or air and enough amounts of water moisture and nutrients (Wong & Hong, 1993). Fungi are among the most diverse organisms on Earth, and are considered only second to the insects in a species diversity. For organism, fungi act as saprotrophs, particularly for decomposers, fungi are essential components of the carbon cycle and are among the few organisms that can break down lignin. Fungi reproduce by releasing spores that are produce either sexual or asexually. Fungi attacked the wood under certain conditions of moisture and temperature makes the decay of the wood. Infection that leads to germination and fungal growth influenced the decaying of the woods. Other than that, the light density and wood pH also contribute to the decaying of the woods. According to Wong & Hong (1993), fungi can be grouped to white rot (basidiomycetes), brown rot (basidiomycetes), soft rot (ascomycetes and Imperfect Fungi), causing heartrot, sapstain and mould fungi. These different fungi will attack the three components of wood that are cellulose, hemicelluloses and lignin. The strength of the wood will decrease when wood- degrading fungi metabolize wood.

2.5.1 Brown rot fungi

Brown rot are mainly distributed anywhere especially in coniferous forests. The brown rot decay primarily degrades cellulose and hemicelluloses and only slightly modifying effect on lignin. The appearance of the brown rot fungi are reddish brown to dark brown in colour. Most of the brown rot fungi will produce the fruiting body. When the brown rot infected to the wood, the first carbohydrate to be lost in any measureable quantity is hemicelluloses. According to the Highley & Kirk (1979), the function of the hemicelluloses is to provide enzyme substrate for hydrogen peroxide production and initiate the attack on lignocelluloses by fungi causing brown rots. The fungi that are caused by the brown rot usually bring about a more rapid drop in most strength properties than those in the white rot category, but both can give the effect by soon reduce the toughness of any wood they attack.

2.5.2 White rot fungi

White rot fungi able to decompose cell wall components. It is commonly seen in tropics on hardwoods. White rot fungi can reduce the strength and wood will reduce to the fibrous mass. According to the Kirk & Farell (1987), white rot fungi metabolize carbohydrate and lignin in wood and lignin oxidation cannot continue in the absent of metabolism of some cellulose or other carbohydrate. White rot fungi attack lignin, cellulose and hemicelluloses. The appearance of white rot fungi are bleached or whitish colour. A typical bleached appearance of the wood is due to the utilization or modification of chromagenic materials (Negi, 1997). The example of white rot fungi are *Trametes versicolor* and *Schizophyllum commune*.

2.6 Termite attacks

Termite attack is the one of the main problem related to the tropical forestry especially where the exotic tree species are used. This is due to the characteristics of the wood that is biodegradable and makes it easy to be attacked by the termites. According to the Creffield (1991), termite can also be known as the white ants are widely distributed in tropical countries and found abundantly in warmer countries that are sub-tropical and tropical and warm temperate. It can be found only few in cold countries. . There are approximately 1900 identified species of harmless and 150 are known to be damage wood as building and other structure (Richardson, 1993). Other than that, it attack wooden structures, good made of wood, paper and textiles, agricultural crops and occasionally attack growing trees. They cause the high cost of damage to wood structure for treatment cost and replacement cost of damaged wood. The termite has special characteristics of the environment requirements including a food source, oxygen and sufficient supply of moisture. The way in which termite attack wood is by chew the wood and by forming the large cavities for nest (Zabel & Morrell, 1992). According to ASTM D 3345-74 (1999) with minor modifications, examines and visually rate each block using of termite attack consist of number from 0 to 10.

Table 2: Classification of visual assessment based on ASTM D 3345-74 (1999) with minor modifications.

Rating	Termite attack
10	Sound, surface nibbles permitted
9	Light attack
7	Moderate attack, penetration
4	Heavy
0	Failure

There are six major termites family that are Rhinotermitidae, Kalotermitidae, Termitidae, Termapsidae, Mastotermitidae, Hodotermitidae that leads to the different types of damage of the wood. There are three principal of castes and juvenile forms in the population of the mature colony of termites. The termite colony consists of king, queen, soldiers and the workers. They have the specific function for each of the colony. For example, the workers attack wood, forage, building, have no wings, are whitish in colour, are very numerous and attend to queen. The characteristics of soldiers defend colony are they have tough mandibles and large heads. Reproductive functions of the colony perform by king and queen termites (Gold et. al, 1999).

The termites can be classified into two groups that are Subterranean termites and wood dwelling termites. Subterranean termites are the social insects that can be widely found in colonies consisting of many individuals (Koehler & Tucker, 2003, Gold *et al.*, 1999). The

Subterranean termite lives completely or partially in ground, always linked to soil. The example of wood dwelling termites are drywood termite that lives in dry seasoned wood and damp wood termites that lives in fallen logs and growing trees. The main diet of the termite is cellulose but some termites digest lignin to limited extent with the aid of gut bacteria. Commonly the termites eat felled and worked timber, woody debris, paper, cotton, straw, jute and fungi.

Different species of termite have different ways attacking the wood. The colonies of the termite can be found widely in terrestrial environments and are distributed throughout the warmer regions of the world (Nunes & Nobre, 2001). The subterranean species of termite are the most active termite and widely distributed, and can cause serious damage to unprotected wood structure or to other cellulose materials in only short time (Lee *et al.*, 2007, Nageel *et al.*, 2004, Bultman & Southwell, 1976).

One of the ways to prevent the termite attack is by using the chemical soil that decrease around the base of wood structure. Other than that, termite attack can also be prevented by simple construction practices, including the remaining wood around the structure. Many fundamental studies to control the termite attacks and various laboratory methods have been conducted (Somnuwat *et al.*, 1995). The function of the laboratory test of the termite attacks is to give an indicator to prevent the damage to the timber products and other materials in the fields.

3.0 MATERIALS AND METHODS

3.1 Sample selection and collection

The heartwood of mature tree of three different species of moderately durable wood namely *Diospyros bantamensis*, *Sindora leiocarpa* and *Dialium laurinum* were selected for this study. These three different species was collected from Kampung Pueh, Sematan, Sarawak. The bolt was quarter sawn into planks. The planks was ripping to obtain wood block of 10 mm (radial) x 10 mm (tangential) x 10 mm (longitudinal) for subsequent experiments (Figure 1). The sample size of both soil block test and termite resistance test were the same.

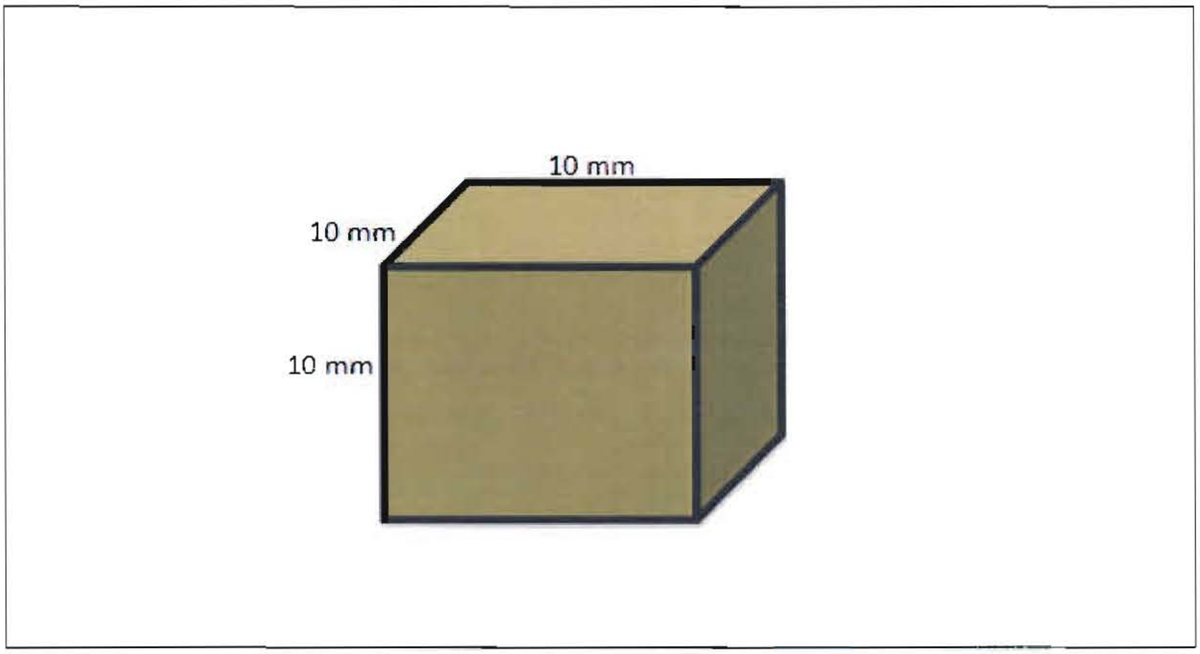

Figure 1: Sample block (10mm x 10 mm x 10 mm)

3.2 Preparation of wood blocks

Forty-two detect free wood blocks from each species namely *Diospyros bantamensis*, *Sindora leiocarpa* and *Dialium laurinum* were selected. Twenty-two free wood block from *Macaranga triloba* were cut as control. The sample block were clean from any dust and