INVESTIGATION OF *SESBANIA GRANDIFLORA* LEAVE EXTRACTS AS ECO FRIENDLY ANTI TERMITE AGENT FOR WOOD PANEL

LIYANA BINTI YUSOFF

FACULTY OF EARTH SCIENCE

UNIVERSITY MALAYSIA KELANTAN

2017

INVESTIGATION OF *SESBANIA GRANDIFLORA* LEAVE EXTRACTS AS ECO FRIENDLY ANTI TERMITE AGENT FOR WOOD PANEL

by

LIYANA YUSOFF

A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Sustainable Science) with Honours

FACULTY OF EARTH SCIENCE
UNIVERSITY MALAYSIA KELANTAN

JANUARY 2017

DECLARATION

I declare that this thesis entitled "Investigation of *Sesbania grandiflora* leave extracts as eco-friendly anti-termite agent for wood panel" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : _____

Date : _____

ACKNOWLEDGEMENT

In this section, I would like to express my sincere gratitude to all who are participating whether it is coincidence or not until my Final Year Project (FYP) successfully accomplished. I am very happy with the blessed form god that made my work and my day smooth.

Not to forget, I am gladly wanted to say a humongous grateful to my inspire lecturer Dr. Boon Jia Geng for the continuous supports of my Final Year Project from his guidance, patience, advices, motivation and immense knowledge that he would likely to share. His guidance has helped me a lot for throughout all this time, during my research paper is still on the go. I could never imagine that I could have this kind of supervisor and mentor for my thesis writing. Thanks, a lot. May god blessed you hereafter. I finally accomplished my Final Year Project. Even though it was last minute to ask him, he was very thoughtful to give me with lot of tips and etc. Thank you.

I am also wanted to take this opportunity to express my appreciation to all my friends and my fellow lab mates for their support who are willingly take their time and give some valuable information and helping me. That was very good deeds for me until the last day. Even though at first, they are refused to accept my treats. I am grateful because of their corporation. Thank you.

Last but not least, I would like to thank my family members who are supporting me through the spiritual and physical way and encouraging me not to give up. Thanks a lot guys.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

TOC	Total Orgnic Carbon
OPM	Oscillating Pressure Method
$Na_2B_8O_{13},4H_2O$	Disodium Octaborate Decahydrate
$Na_2B_4O_7.10H_2O$	Disodium Tetraborate Decahydrate
H_3BO_3	Boric Acid
CCA	Cooper-Chromium-Arsenic
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand

LIST OF SYMBOLS

%	percentage
g	gram
°C	celcius
mm	millimeter

Investigation of *Sesbania Grandiflora* Leave Extracts as an Eco Friendly Anti Termite Agent For Wood Panel

ABSTRACT

Termites are well known for their deterioration pest. Instead by using chemical preservatives as a remedy, plants based products are derived from any potential plants that give positive effectiveness to test as an eco-friendly anti-termite agents. The aim of the study is to investigate anti-termite activities in the methanolic crude extracts of *Sesbania grandiflora* on wood against termites. 1% of concentration has been used in the experiment on mortality test, wood decay test and physical properties of wood. Impregnated filter paper with commercial preservatives, extractive preservative and control specimen were tested for a week to observe the toxicity effects against termites. Followed with the wood decay test, 1 month exposure was being observed on the potential of the repellent effects by using commercial preservatives, extractives preservatives and control specimen. The thickness swelling and water absorption in these study does not show any significant difference among the specimens with different treatments. This study is concerned on the determination of the potential of *Sesbania grandiflora* on anti-termite activities. The results showed that, methanolic crude extracts of *Sesbania grandiflora* leaf showed positives response in against termites. Hence, it has potential as wood preservatives against termites.

Kajian Penyelidikan Extrak Pokok Turi *(Sesbania Grandiflora)* Sebagai Ejen Anti Anai-Anai yang Mesra Alam Terhadap Kayu Getah

ABSTRAK

Anai-anai adalah binatang yang sangat dikenali sebagai haiwan perosak. Disebabkan penggunaan kimia dapat memudaratkan banyak pihak, jadi pokok-pokok yang mempunyai potensi diekstrak sebagai anti anai-anai. Tujuan kajian ini adalah untuk mengenal pasti aktiviti anti anai-anai terhadap extrak methanol daun pokok *Sesbania grandiflora* pada kayu terhadap anai-anai. Kaedah kertas turas yang dikenakan dengan 1% kepekatan pengawet komersial, pengawet extrak dan kawalan specimen, dimana ketiga-tiga spesimen diuji selama seminggu dan melakukan pemerhatian terhadap kadar keracunan terhadap jenis rawatan yang telah diuji. Dalam tempoh sebulan, anai-anai diuji dengan 3 jenis rawatan iaitu pengawetan komersial, pengawetan ekstrak dan kawalan specimen. Namun, pengembangan ketebalan dan keserapan air tidak ada sebarang perubahan yang berlaku keatas kedua-dua factor tersebut kerana 1% kepekatan tiada memberi apa-apa kesan walau diuji. Kajian ini dijalankan adalah untuk mengenal pasti pokok *Sesbania grandidlora* berpontensi sebagai anti anai-anai. Keputusan kajian ini menunjukkan, pati metanolik ekstrak dau pokok *Sesbania grandiflora* menunjukkan kesan yang positif dalam menjadikan ia sebagai anti anai-anai. Maka dengan itu, ekstrak daun pokok *Sesbania grandiflora* berpontensi untuk digunakan sebagai pengawetan kayu untuk mengelakkan kayu tersebut diserang oleh anai-anai.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Plants has their unique characterization that makes people seeking the cure from the natural based plants. Thus, the derivation of drugs is partly coming from plants that was not only for energy, food sources, raw materials but also being as crucial part for human life because most of the medicinal are based on chemical synthetic forms. The manufacturer of drugs mostly from the man made chemicals, but the function of the plants while in the making of the drugs are still important in a way of development as the core structural based in the making of drugs as a medicinal purpose. Until recently, plants were being primary function and sources in world of pharmacology with many principles either directly or indirectly drugs being derived from plants (Veeresham, 2012). Plants based are the most important in production of food, health care, cosmetics, pharmaceuticals, medicines, food supplements and etc (Kumar, 2016). The discoveries of the uses of plants brings history and lead to civilizations of human, thus brought lot of benefit to human in generating some new invention despite using chemicals.

Plant contain bioactive compound such as tannins, flavonoids, saponins and alkaloids. These phytochemicals constituents was designed as antitermitic activity of medicinal plant called *Sesbania Grandiflora* and can be measured in qualitative and quantitative. The extraction techniques in plant extracts have been widely been used to determines varieties of phytochemicals to obtain such valueable chemicals composition on the leaf as the techniques were included hot soxholet and cold extraction (Hussain & Kumaresan, 2014).

Sesbania grandiflora mostly known as a medicinal plant that had the value as an example antimicrobial activity, antifungal activity, anticonvulsant activity, anxiolytic activity, hepatoprotective activity, antioxidant activity, antihelminthic activity and antiurolithiatic activity (Noviany *et al.*, 2012). It has been state that several parts of these *Sesbania grandiflora* leaves contain chemical constituent that show high potential in against bio-assay (Abbas *et al.*, 2013).

The enormous impact on our ecology is that, the excessive use of artificial chemicals preservatives that we relying is by using wood panel in our homes, most of the wood are being preserved with the artificial chemical preservatives to ensure the life span of the wood panel that could be enhanced but, there is a few problems arises from the usage of these artificial chemical preservatives. The composition of boron based compound can give a negative effect to human and environment either directly or indirectly contact (Salamah & Mohd Dahlan, 2008).

In our daily life, we had never been realized, on how most of the people control the termites by using those chemicals pesticides, but todays the world need us to pay attention to curb this issues in terms of pesticides management. Pesticides are designed to kill things, unwanted organism as a protection for their crop yield, residential, gardens and buildings. The uses of these pesticides are to combat these harmful species that bring an adverse impact towards environment and human health, because it is associated with the pesticides usage (Goodarzi *et al.*, 2016).

There is no other way to kill the termites in such a furious time by using the pesticide that have been in the market. The termites will directly be killed by human using pesticides, as a result pesticides use around the house could give the person an exposure while using those applications of pesticides give the exposure on which through

inhalation of residual air concentration that was being left on atmosphere, clothing, bed, food, dust, or any other appliances (Damalas & Eleftherohorinos, 2011).

While most pesticide are designated to kill the target, the other animals could also be being in endangered also because the chain food is there. Nevertheless, it also could sometimes be harmed to the environment such as water and air contaminated and toxic effect on non-target organism (Damalas & Eleftherohorinos, 2011).

The products can be in a varied form in which they can be as a pellet, dust or powder, solution, sprayable concentrate, emulsifiable concentrate and some other types of the formed. This treatment brought us how important they are being lethal to human such as the processes of the chemicals being contact or penetrate to your skin, eye, swallowing of food and detrimental internal abdomen. For example, the usage of chlordane was used in non-agricultural field in a way to control the pest such as termites in which the chlordane has two constituents in which *trans*-chlordane (TC) and *cis*-chlordane (CC) (Becker *et al.,* 2012). These by products that has been releasing into the air or atmosphere bring the adverse effects towards any organism who are depending on breathing of oxygen gas that most probably containing harmful compositions of chemicals such as chlordane vapours that can caused variety of illness that may be related to human health.

Moreover, the usage of these pesticides has been an enduring challenge because it may affect to environment and human health. In improving the strains that environment faced, synthetics pesticides are going to be replaced by using natural based production in order reducing the adverse effect from the pesticides effects of their chemicals.

Implementation of ecologically based, is the best strategies that must be tied with a research study where the factors need to be countered as well as to be widely adopted in our community.

1.2 Problem Statement

Pollution, caused from preservatives of wood is the major problems in our society, the chemical residual of wood has an adverse effect towards environmental and human health. The chemical treatment that involved in the treatment are including the use of creosote, pentachlorophenol, borates and some other types chemical agents that were used while the treatment processing is carrying out. But still, nowadays, these preservatives of wood are still being practicing in the most industrialized that produced wood products. The problem is that, when those woods are getting dispose either onto the land or river. This will create an adverse impact to environment and to human health when those chemicals are getting into the main sources such as pollute the groundwater, it then makes the human being consumed the water and can caused the health effect to them. The effect also caused the environmental had to face is that the air pollution that arises from the dispersion of vapour chemical into the air and towards human being health where the most who the one get affected is the workers who are closed contact with the exposures of the chemicals. The symptoms may be dizziness, cancer, defect to the newborn baby and other symptoms can be arisen.

1.3 Objective

- To investigate the potential of methanol leaf extracts of *Sesbania grandiflora* against termite effect
- To investigate the physical properties of wood impregnated with methanol leaf extracts of *Sesbania grandiflora*

1.4 Expected Outcome

As the idea of new discoveries by the extraction of natural plant based as an alternatives way to replace the artificial synthetics chemicals could reduce the toxicity to environment, human health problems and the usage of chemical. Moreover, in term of production, the extraction of *Sesbania Grandiflora* leaf expected to give anti termite effect that could be as an eco-friendly product because it is derived from plant based.

CHAPTER 2

LITERATURE REVIEW

2.1 *Sesbania grandiflora*

Sesbania grandiflora is a scientific name while for the common name they known as agathi, sesbania and variety of names had been given based on where it was located and found. These species are very well known among the Ayurveda remediation mostly practicing by Indian peoples. *Sesbania grandiflora* is a native tree for mostly in Asian country such as Malaysia, India, Indonesia, and the Philippines and usually located between sea water level and 800 m (Reeta *et al*., 2013).

Sesbania grandiflora also can be used in medicinal field, health benefits, vegetables and many more. It has been proved that all parts of the trees have its own functionality like flowers, root, bark, leaves and fruits. The leaves functioned as cooling, tonic and diuretic, while for the flower parts, it consists lot of nutrient that may be possess as a vegetables and the juice of the flower is used to reduced headache. For the bark parts, they used to cure small pox, tonic, febrifuge and astringent (Alagesaboopathi & Deivanai, 2011). *Sesbania grandiflora* also being cultivated for the purpose of temporary wind-break and as an ornamental plant (Ouattara *et el.*, 2011).

Sesbania grandiflora tallness can be reached up within 15 meter tall and 30 centimeter diameter. The leaf was in nearly in an oval form and there are about 15-20 pair of leaflets approximately on 1 twigs. The diameter of the tree was about 30 centimeters and they have variety colors of flowers which existed in red, white, red and pink. Furthermore, before the leaf were falling off to the ground, the color of the leaf will be turned into yellow color (Reeta *et al*., 2013).

Variety colours of *Sesbania grandiflora* can be recognized including white, red and rose pink of flowers. The arrangements of the flowers are similar to the pea flowers in which they have five petals but only a bit difference with a standard, wing and keel petals. The standard petal and usually they look upright, the wing petals spread out on either it is on side of flowers, and the keel look like a boat shaped and it will curve down and away from the flowers. The pod of these flowers can be estimated around up to 60cm long and the seeds range from 15-50 (Kashyap & Mishra, 2012).

Lots of benefits can we gained from these *Sesbania grandiflora* plants because they pose with something biological and chemical value such as antimicrobial activity, antifungal activity, anticonvulsant activity, anxiolytic activity, hepatoprotective activity, antioxidant activity, antihelminthic activity and antiurolithiatic activity as a contributor in our pharmacology and research (Reeta *et al.*, 2013). In traditional way, most of the *Sesbania grandiflora* plants are used for an ailment for medicinal alternatives way to treat. These anti-viral activities can cure diseases such as gastrointestinal infections and cardiovascular diseases (Ouattara *et el.*, 2011). Moreover, the dried barks also can be used as a cosmetic (Padmalochana & Dhana Rajan, 2014).

Sesbania grandiflora also is best ideal to plant because the roots particularly of these species can improve soil through their ability by nitrogen fixation. *Sesbania grandiflora* are sensitive to frost and it thrives a sunlight to get growing. The tree will grow in a humid and hot temperature and it is a tropical tree (Rajagopal *et al*, 2016).

Figure 2.1: *Sesbania grandiflora* (source : Wagh *et al.*, 2009)

2.2 *Sesbania grandiflora* Chemical Constituents

The *Sesbania grandiflora* leaf extracts are by using methanol extraction, hence the result for the chemical composition in the leaf accumulate that the leaves contained the sources of vitamin C, calcium, iodine, pectin, saponins and aliphatic alcohol (Shyamala & Vasantha, 2010). Moreover, the chemistry of active ingredients such as leucocyanidin, cyanidin, oleanolic acid, and kaemferol-3-rutinoside were presents in *Sesbania grandiflora* are as shown on a table 2.1.

In the leave of *Sesbania grandiflora*, it has been found that the supplementation that could also attempts a significant hypolipidemic effect against Triton-induced hyperlipidemia in rats (Hasan *et al.*, 2012).

The chemical constituents that found in *Sesbania grandiflora* are galactommannans, linoleic acid, beta-Sitosterol, and carbohydrates (Vipin *et al.*, 2011). The phytochemicals analysis of methanol of leaf extract showed the existance of alkaloids, carbohydrates, protein, phytosterol, flavonoids and fixed oil while for the stem and root part, they found a presence of alkaloids, carbohydrates, proteins, phytosterol, phenol, flavonoids, fixed oil and gum (Mythili & Ravindhran, 2012).

The saponosides were more often been found in the leaf by using methanolic extracts than aqueous extract. The saponosides are rather would be in the form of triterpens while for the steroids would be rather in the form of heterosides. Leucocyanidin and cyanidin are the active ingredients that contained in the *Sesbania grandiflora L.* seeds and oleanolic acid its methyl ester & kaemferol-3-rutinoside are the major chemicals constituents in the flowers (Kashyap & Mishra, 2012). An aqueous extract of the plants is also could be a toxic to cockroaches (Padmalochana & Dhana Rajan, 2014).

Moreover, some of the researcher said that *Sesbania grandiflora* has a potent in terms for antidote for tobacco and smoking related diseases. However, the mechanism of how well the benefit effects against chronic smoking are still yet to be determined in research study. There is a massive of uses in *Sesbania grandiflora* where the powdered of the root can also be applied externally as a poultice, while the juice itself with the combination with honey can become as an expectorant in catarrh (Wagh *et al.*, 2009).

The chemicals constituent in the bark give a tonic and febrifuge when the bitter the bark is. A decoction of the bark can be requiring against the haemopthisis. The bark contains tannins and gum (Wagh *et al.*, 2009).

Name	CAS	IUPAC Name	Formula	Structure
Leuco-cyanidin	480-17-1	2-(3,4-dihydroxyphenyl) chroman-3,4,5,7-tetrol	$C_{15}H_{14}O_7$	a
Cyanidin	87225-42-6	[2-(3,4-dihydroxyphenyl)-3,7-dihydroxy-chromen-5-ylidene	$C_{15}H_{11}O_6^+$	b

Oleanolic acid	508-02-1	Oxonium10-hydroxy-2,2,6a.6b,9,9,12a-heptamethyl-1,3,4,5,6,6a,7,8,8a,10,11,1,2,13,14b,tetradecahhydropicene-4a-carboxylic acid	$C_{30}H_{48}O_3$	c
Kaemferol-3-rutinoside	17353-03-6	7-[4,5-dihydroxy-6-(hydromethyl)-3-(3,4,5-trihydroxy-6-methyl-oxan-2-yl)oxy-oxan-2-yl]oxy-3,4-dihydroxy-2-((4-hydroxyphenyl)-chromen-5-one	$C_{27}H_{30}O_{15}$	d

Table 2.1: Chemistry of active constituents (source: Wagh *et al.*, 2009).

a)

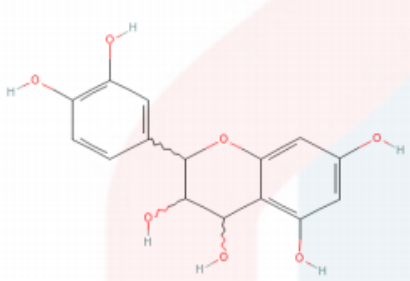

Figure 2.2: Leuco (source: Wagh *et al.*, 2009)

b)

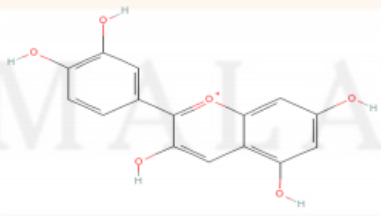

Figure 2.3: Cyanidin-cyanidin (source: Wagh *et al.*, 2009)

c)

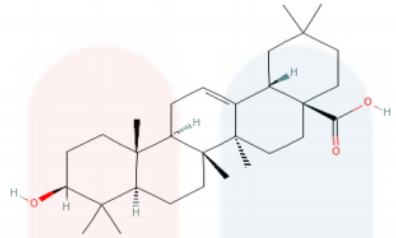

Figure 2.4: Oleanolic acid (source: Wagh *et al.*, 2009)

d)

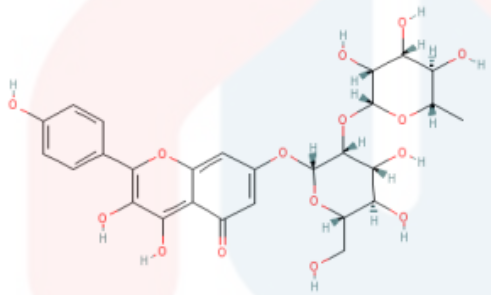

Figure 2.5: Kaemferol-3-rutinoside (source: Wagh *et al.*, 2009)

2.3 The Application of Leave Extract

People nowadays are concern about their lifestyle that is being threatened by the chemical composition that could harm to human health and also towards the environment. Thus, people nowdays rapidly growing in their research to study about determination of bioactive chemical that was found in plant looking forward the toxicity naturally contained in pharmaceuticals field (Srivasatava *et al.*, 2011).

There is multiple way in terms of extract the leaves, the decision in which is the best extraction for phytochemicals. The juice of the leaves is utilized for the treatment of

epileptic fits and clinical research supports the anticonclusive activity of agathi leaves, astringent, bitter, termogenic, styptic, alexeteric, anti-helmintic, vulnery, demulcent, constipating, expectorants and antipyretic, bronchitis, oral ulcers, proctoptosis, (Ghanshyam *et al.,* 2012).

Moreover, the leaves are also being used as aperient, febrifuge and tonic in form of poultice and they are applied to bruises for any uses that need to applied by using this leaves. It has to be said that it is more to traditional way where the leaves also can be chewed to disinfect any mouth or throat part (Shyamala & Vasantha, 2010).

It has been proved that from the previous study, the leaves have been found that, they can possess protectives roles against rat kidney organs with that the oxidative stress had been showed with the positive results during alcohol and polyunsaturated fatty acid test. This showed that the leaves contained anxiolytic and anticonvulsive activity on the rat experiment. The extraction of the leaves juice also seems that possess antiurolithiatic and antioxidant properties (Pajaniradje *et al.,* 2014).

2.4 Termite

Termite can be classified as a pest category or detritivores because they eat any cellulose material such as wood and dead plants. Termite also known as a white ant because they have the similarity with normal ants but not ants. They have 3 major species of termites which is dampwood termites, drywood termites and subterranean termites.

They are important in our ecological because they can decompose organic matter through consumption of nutrient recycling and the interaction of soil are very beneficial such as soil fertility for growth production of crop (Mugerwa, 2013) and many others. Termites live in a colony that they build by their own and the system of life is by caste

where they consist of queens, soldiers, and worker (Wu *et al.,* 2013). The ecology of termites is very impressive by human because they have the organization in their systems of their life such as responsible to build their nest that are made of from soil, mud and maintenance it, seeking for food and store it and lots of job that are assign to their soldier and workers.

Termite nest are made up from their feaces which is enriched with the clay-organic complexes, the passage was formed through the gut by the ingested soil of organic matter. Thus, their nest compared to the other surrounding with non ingested soil, are usually complex with the orgnanic matter, exchangeable base and fine particles. Moreover, their nest are vary with many functionality such as the aeration, porosity or aggregation that are brilliant (Roose-Amsaleg *et al.,* 2005).

In reproduction systems of termites, the high fertility among them are one of the important things in expanding their number of colony and maintanence the systems of their caste. Termites has their unique systems caste and that is why they make a reproductive startergy that is often differ from other species and animals. In general, termites are mostly founded by a single primary king and mate with a single primary queen thus, they can produce the other colony members. Reproductive of the termites are usually relatively weak, monogmous and fecundity during the initial establishment of the colony. In most of the termite species, abundant of neotenics will appear in colony when the primary reproductive die, thus those neotenics will take over the colonies to maintain the colony and for some other species of termites, they will make those primary reproductives who are already dead to serve them as a nutritive and supplementary reproductives. Thus, the life cycle and reproductive of termites has shown in a Figure 2.6 Thorne *et al.,* 1999).

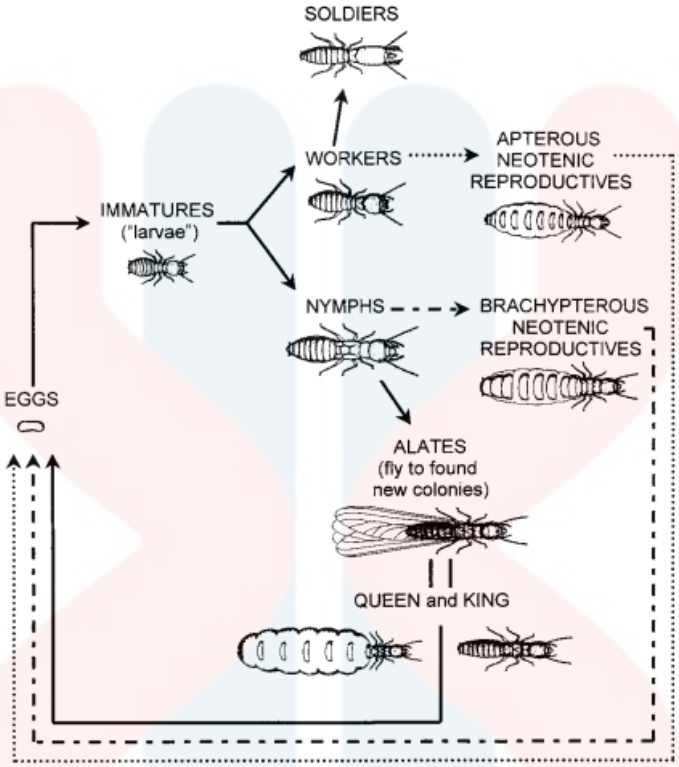

Figure 2.6: Life cycle and reproduction for termites (sources: Thorne *et al.*, 1999)

However, these destructive animal, they could harm to any things that they like such as by attacking crops hence reduce the production of the crops itself, by destructing any building material such as home hence could lead to unstable structure of houses. People has tendency to destroy the termite population by controlling the termite population that lead to harm our safety by taking granted for terminate these pests by using various synthetic pesticides to kill them such as fapronil, organo-phosphate, organo-chlorides, chlorodane (Upadhyay., 2013), cypermethrin (Upadhyay., 2013), hydroquinone (Upadhyay., 2013) and indoxcarb (Upadhyay., 2013) have been used. Due from these practices, it caused environment in a state that high toxicity contained to human health and environmental.

2.5 Subterranean termite

Subterranean termites are insects that live in colonies that they built by their own within the ground and have castes to perform specific colony functions. The termite colony has three primary castes: workers, soldiers, and the reproductive (kings, queens, and secondary). The specialization of these termites is their favourable can be attributed to their cooperative behaviour because they live in a family group called colonies. Subterranean termites can be found in a variety of habitat such as in the forest and urban environment, but as economic pest also because, the damaging of structural wood by the harming activities of termites in urban areas (Botch & Houseman, 2016). In handling termites, a better understanding and knowledge on their biology and behaviour are required.

Colonies are generally founded by primary king and primary queen who pair during their nuptial flights, mate and then they will produce a new colony member that consists worker, soldier and nymph. When there is king or queen die, they will be replaced by neotenics that develop from nymph which is the second form of neotenics reproductive or workers which is the third form of neotenics reproductive. Neotenics, can be formed from a few to a multiple number of colony because of the engagement with the interbreeding systems. They will then land and search a place to begin a family. When the landings time, their wings had a little bit off and the primary king and primary queen will start their excavation for a small hollow or room on a soft soil. The primary queen lays her first batch (6-12) of eggs within a few days or weeks of mating (Miller, 2010). Mostly the reproduction system of subterranean termites can be assumed as a mode of sexual reproduction even though there is asexual reproduction can be made by the primary queens to get their colony members (Vargo *et al.*, 2012).

In development and the castes systems of termites, they were very unique among the other social insects because they undergo incomplete metamorphosis. Metamorphosis is a stage where all insects need to change in form to the next stage in a life history of that organism. The caste systems of termites are very complicated especially in lower termites. For the process of the termites, larvae develop either into worker or nymphs, nymphs develop either alates with wings and eyes or develop with rudimentary wings with no eyes. While for the workers, they can either transform with no wings and eyes or become a soldier that molt into a soldier (Vargo & Husseneder, 2009).

After the establishment of finding mate, the colony development is a bit slow in growth and they reaching population size after one year estimated around 30-90 individuals depends on what species they are. When the colony of the termite family structured has been determined, the information on how they were related in reproductive, the way they were breeding within the colony, and the number of the colonies that has been extending among and within that termite (Vargo & Husseneder, 2009).

Subterranean termite actually can locate their food by as they digging into the soil. When the sources of the food have been found, while other termites are gathering to the food source and non-productive tunnels are being closed off. The foraging range of a single termite colony is difficult to predict. While in the scavenging activities of termites, they produce a diversification of chemicals called pheromones that dominate their behaviour. These pheromones are normally odours that send sense or commands to other termites in the territory (Miller, 2010). In their hindgut, contain the bacteria, protist and fungi in which those elements breakdown all the cellulose and those indigestions that allows subterranean termites to cycle nitrogen back into the ecosystem, thus lead to enriched the nutrient in the soil itself (Collins, 2013).

In foraging food by subterranean termites, they need a strategy to locate their food in such an efficient way. Termites are well-known for their behaviour and integrated action for their very significant in locate and feeding their sources of food made by workers for their colony members. Those foods also depend on how much does the colony members require the nutritional food and the amounts of food are available (Lima & Costa-Leonardo, 2014).

Subterranean termites nest was built in the soil to obtain moisture and rich with microorganism to enhance their microbial activity. Moreover, subterranean termites easily to attack any wood in contact with the ground to infest as their sources of food. If the wood does not contact the soil, termites can build mud tunnels or tubes to reach wood several feet above the ground. As to build the nest, the materials that they need are faeces and saliva because those compositions composed with cellulose decomposers that altered by microorganism (Chouvenc *et al.*, 2011).

The diet of subterranean termites is wood infected caused by fungi, but fungi can bring either beneficial or detrimental effect to the growth of the subterranean termites. The product of fungi can bring those subterranean termites foraging their sources of food (Esenther *et al.,* 1961). Activity of termite infestations can be hardly to detect, thus your houses should be inspected regularly. Signs of infestation can be seen when there are the damages wood inside or around a structure of your structure being so hurtful. Usually chemical insecticides are often being used to control subterranean termites population from being destruct our property (Tikhe *et al.,* 2015).

2.6 Wood

Wood is natural product based that made up from cellulose and consists of organic compounds thus, wood become the most valuable and usable resources in the world as it can be used in furniture, construction, material in the building and etc. Wood based consists varieties types of wood as an example particleboard, oriented strand board or known as (OSB), medium density fiberboard, low density fiberboard, high density fiberboard, rigidboard, flexboard, softborad, hardboard, plywood and etc. Moreover, when building is constructed using timber and it would have the capacity to store large quantities of carbon also known as "carbon sink" (Lehman, 2013).

Despite, while production of wood getting be usable, there is an issues on environmental that arises from the production of these wood that caused the emissions of dust, TOC (Total Organic Carbon), and formaldehyde occurred (Meyer & Boehme, 1997) mostly in air layer and impregnated of wood that is being preserved by the chemicals.

Wood plant is biodegradable, thus they need to face risk on bio deterioration on certain criteria that might lead the attack of termites or pest that can bring destructive to the structure of the wood. The attacking of these pest can be either their using the wood as a food or as a shelter. Moreover, to have the maximum life of wood, they need to be preserved to have their maximum life span from these pests. The most applicable to preserve wood is by using chemical preservation because these treatments mostly for most wood products who are resistant on attacking of pest. There are three types of perseverance of wood such as creosote and creosote solutions, oilborne preservation and water borne preservation (Freeman *et al., 2003).*

There is an adverse effect using chemicals preservatives for wood as a protection from pest damage because it associated with the human health and also towards the

environment. Based on three types of chemical treatments that has been mentioned before, there still got a few advantages and disadvantages from those treatments. When these chemical are into the environment, people are one of the factors that being contacted and affected like human health it can lead to the cancer, vomiting, headache and other symptoms (Roll, 2003).

2.7 Chemical Perseverance for Wood Protection

Wood has been widely being used in construction or any kinds of commercial products that were produced from wood based and has their own valued. However, wood is susceptible to decay, fungal growth, insect infestation and fire retardant which can make the life span of wood would be decrease. Thus, any kind of wood based products need to be preserves and treated first before turn it to any kinds of commercial products. Various chemical properties and processes has been applied to treat the woods to have prolonged effectiveness and cost effective value (Akhtari *et al.*, 2012).

There are several processes that need to undergone to treat the most of the wood such as dip treatment, dip-diffusion, pressure treatment, vacuum-treatment, the oscillating pressure method (OPM), and the double vacuum process. As for borate, these chemicals are widely being used in wood preservation and are said that they are environmentally effective in which they are been accepted by many countries. Borate are design and suitable for wood preservatives against fungi and termites. Borate can be both either preservatives or pesticides. As for preservatives treatment, the used of borate is to make the wood life span increase or as a remedial treatment for the wood and there are many ways can be done such as dipping, soaking, spraying and compression rolling. As for

pesticides, borates products also act as insecticides, fungicides and widely been used against pest. The borate pesticidal products also shown that they have the toxicity contents that can eliminate termites and other decay organism (Williams, 1996).

An economical treatment has been used such as in rubberwood, they are using boron compounds in the form of disodium octaborate decahydrate ($Na_2B_8O_{13,}4H_2O$), disodium tetraborate decahydrate ($Na_2B_4O_7.10H_2O$), and boric acid (H_3BO_3) has been developed to protect from insect and fungi attacks. Boric acid also is used to serve as an effective agent in repellent of insecticides, pesticides, fungicides and fire retardant. Boron compounds also been design that they are suitable for indoor applicants while performing the treatment (Teoh *et al.*, 2011)

There are several chemical preservation of wood from deterioration such as creosote and creosote solutions, oil based preservatives and water based preservatives that shown on the Table 2.2. Cooper-chrome arsenic (CCA) is one of the best agent preservatives used for treated wood. These chemicals are very effectively against termites infestations. The chemical interaction that occur between chromium and cooper makes them water insoluble. Thus, lead to incorporating with leaching problem and water contacted. However due to the high toxicity of the cooper-chrome arsenic that gives a detrimental to human life, these chemicals kindly substitutes with cooper-chrome boron (CCB) which proves that boron have much lower toxicity compared to arsenic. In spite of, the boron can also be used in indoor applications (Selamat *et al.*, 1993).

Boron and cooper-chromium-arsenic (CCA) are the most popular processing method while performing in treated wood such as to rubberwood treatment preservatives. Boron are less toxic and odourless compared to other chemical preservatives such as lindane that can give negative impacts to human health. CCA compound are rarely used,

because of the unnatural colour itself, thus it is suitable for construction or structural purposes to ensure the resistance against bio-deteriorating organism. However, these substances are less popular because they are toxic and can bring detrimental effects to human health (Teoh *et al.*, 2011).

Table 2.2: Chemical preservation of wood from deterioration (sources: Teoh *et al.*, 2011)

Method	Description	Advantages	Disadvantages
Creosote and creosote solutions	-Creosote preservatives mostly applied on wood compared to other non wood product and it is widely used as a preservatives products such as railroad ties, large timber, fence posts, poles and pilings.	-brings toxicity to wood by break down fungi, insects, and some marine borers. -Low volatility -Insolubility in water -Ease of handling	-Dark colour, strong odour, oily, unpaintable surface, tendency to bleed or exude from the wood surface and toxic fumes.
Oil based preservatives	-Insoluble in water -Usually dissolve in petroleum - quick drying - water repellent	-Toxic to fungi, insects, and mold. Can be dissolved in oils having a wide range of viscosities, vapor pressures and colours. -Low solubility -Can be glued, depending on the diluents or carrier -Ease of handling and use.	-Oily, unpaintable surface -For some applications, provide less physical protection to wood and creosote -Should not be used in homes or other living areas because of toxic fumes -Toxic and irritating plants, animals and humans
Water-based preservatives	-Includes various metallic salts and other compounds. The	Treatment presents no hazard from fire or explosion	Unless redried after treatment, the wood is

	principle compounds used are combinations copper, chromium, arsenic, and fluoride. -Mostly applied on dried wood with deposition of insoluble chemicals	-The wood surface is left clean, oaintable and free of objectionable odours -Safe for interior use and treatment of playground equipment -Leach resistance	subject to warping and checking. Does not protect the wood from excessive weathering.

The use of artificial chemical preservatives on the wood panel is for the industrial purposes advantages which is for wood preservative to make the wood long lasting, fire retardant (Colakoglu *et al.,* 2003). The preservatives contain harmful compounds such as boric acid and mixture of borax pentahydrate resulting in high boron content in wastewater. Boron is released into the environment mainly by industrial wastewater discharge or any kinds of human activities and it is difficult to determine the exact extent for how much the chemical is being thrown away into any environmental sources and get polluted with those chemicals released. Eventually, boron based compounds are being considered as a good preservative because of the low mammalian toxicity but regarding killing termites and fungi they are more susceptible. However, boron can be easily leached out their chemicals from the wood if they keep contact with any water sources because of their high solubility in the water (Lyon *et al.*, 2007).

The industrial wastes from wood processing industries generally contain high quantities of dissolved and suspended solids, inorganic chemicals and have high Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), besides carrying toxic metals which cause detrimental effects on freshwater fish, when discharged into water bodies (Shenkani & Sam, 2014).

When Boron contaminated or discharged in any water sources it is unfit for human consumption and irrigation due to its toxicity for plants and animals because of the high concentration and exceeding the level of pollutants of environmental. The used of borates products have been effectively showed a positive result in approving against the termite attacking or any other destroyer organism. Since the environmental awareness has been raising among public communities, they try to take an alternatives way by using non-biocide products or environmentally friendly chemical products that can substitute all harmful chemical products to preserve wood (Razak *et al.,* 2011).

2.8 Rubberwood *(Hevea Brasiliensis)*

Rubberwood are most popular wood used and was planted in Malaysia, Indonesia and Thailand. The woods are light and easy to handle and usually being used in any light construction and furniture products. Thus, the industry can sell their products in a variety of prices according to the quality of the wood itself. Moreover, wood particleboard, medium density fiberboard and plywood are also made from rubberwood (Simatupang & Schmitt, 1994). This can create a big market in wood industry because of low price but high export in abroad. Using rubberwood has a restriction because of they have low strength, low durability, and instability of dimensional makes them limited used (Umar *et al.,* 2016). Today, rubber tree has been planted widely in 20 countries around the world for the production of latex besides from the wood productions itself (Ratnasingam *et al.,* 2011).

Furthermore, rubberwood are very vulnerable to fungal and insects attack, especially termites (Muhammed *et al.,* 2009). Thus, the rubberwood need to be treated by

preserving chemical compounds in order to make the life span of the wood increases. There are many ways in preserving wood, one of it is by using dip diffusion treatment process using boron compound were used to protect the fresh and partially air dried sawn rubberwood for any insects attack. The dip-diffusion must be partially moisture and are not suitable for low moisture content because it takes a long time for the chemical to react and diffuse. For the double vacuum pressure treatment process, both the chemicals and the solvent need to be corporate with each other because they need to be into the wood or diffuse while using artificial pressure instead of natural diffusion. It is because the diffusion need a strong chemical agent to force into the rubberwood thus, the dilution of the chemical must be occurred at high concentration to low concentration until they reach at the equilibrium point (Selamat *et al.,* 1988).

For the rubber tree to get mature enough, the tree is usually range of between 20 to 30m tall, and the diameter can reach up to 30cm while for the trunk of the tree usually free branch which is up to the height to 3 to 10m. The rubber tree is also well known with the creamy milk colour and sometimes the colour is white to pale cream, sometimes getting to pinkish in colour that was being produced by the tree known as a raw rubber and they also have an unpleasant odour.

Today, rubber tree has been planted widely in 20 countries around the world for the production of latex (Ratnasingam *et al.,* 2011). Rubber wood are one of the greatest evolutionary in the production of their latex and rubber by producing lot of latex and rubber in a sense of tire for car, and other kind of remarkable latex and rubber products. The latex from the rubber became the most important in generate economic source for our country. Nowadays, rubber and latex are still vital in terms of production because variety of new products are still being produces to be used in our daily life. For many years rubber brought millions of dollar with the evolution of new world.

Eventually, our product forest for timber are getting decreasing enabled rubber plantations are being logging to get the timber sources especially for the wood based manufacturer furniture, wood panel and many kinds of wood productions. The industry has made the investment in terms of machinery, research and development (R&D) and design to maintain the existing of market for the furniture production stands firms and to expand the businesses more. In addition, rubberwood also been in the manufactured of particleboard, medium density fiberboard, wood cement board and plywood.

Malaysia has been two decades in exporting this manufactured furniture from rubberwood based products (Sarani *et al.*, 2010). But today, the rubber plantations in Malaysia has been decreasing from 1990 to 2009 because the main problem is the rubber tree are not getting so worth compared to the palm oil. The commodity of palm oil is much higher and high profit thus, lead the estate owner to converted their rubber plantations to oil palm plantations (Ratnasingam *et al.*, 2011).

The production of rubber wood is beginning with the sawn timber processing mainly for exports. In India and Sri Lanka, they have used rubberwood for long time ago as a timber source, because the scarcity of timber source at their place. But here in Malaysia, the export of the rubberwood was a successfully in a long time ago with the high proportion of exports the products due to the logging control on the natural forest but today, rubberwood declining in their export value because the imposition of export levy in June 1990, and also the export quota that has been imposed (Ratnasingam *et al.*, 2011).

Wood had many processing and treatments before they were in the market. When the wood is being treated with thermal treatment, there is a bit slightly changes in terms of physical, chemical and structural properties of the wood itself. It is because wood will

be treated by using temperature in many kinds of processing activities that leads such as drying, pulping, production of wood composites and others (Sarani *et al.*, 2010).

CHAPTER 3

MATERIALS AND METHOD

3.1 Plant Collection of *Sesbania Grandiflora*

Sesbania grandiflora were collected in Kelantan area and was plucked at the end of the branch. The leaves then were left until dried enough to be blended into coarsely form.

3.2 Termite Collection

Termites were collected from infested wood at University Malaysia Kelantan near agropark. The infested wood then were cut into small pieces and being placed into a zipper bag, and brought back into laboratory for sorting processed.

3.3 Sample Preparation

Sesbania grandiflora leaves were left under the sun until it dried completely and were grinded into fine particles and the powder were then being sieved to get all the same size of particles to standardized all the sizes. 100g of *Sesbania grandiflora* were taken from the portion.

3.4 Extraction of *Sesbania Grandiflora* leaf extracts

Sesbania grandiflora leaves were soaked with methanol solvent for 2 days in an enclosed glass jar at room temperature by using orbital shaker so that the concentration of methanol is efficiently being absorbed by the leaves. The extraction of the leaf will

further repeat (twice) with methanol. After 2 days soaked processed, the leaves were filtered in order to get rid the course of the leaves into the extraction.

The filtrate of the extraction was evaporated under reduced pressure at 40°C using a rotatory evaporator, to give concentrated crude methanolic extracts and the leaves will be dried in the oven at 50°C to give dark green extracts. The weights of the leaves extracts will be measured after solvent evaporation and then kept into a glass container prior to use (Khalil *et al.*, 2013).

3.5 Antitermite/Mortality test

The methanol crude extract of leaves was used in bioassay method as to test the anti-termite efficacy. The termites were placed in a petri dish that soaked with different test such as *Sesbania grandiflora* extraction and chemical preservatives onto filter paper. Control petri dish were prepared by placing filter paper and were place in the center and adding 1ml sterile deionized water to the filter paper. The filter paper that already soaked with the methanol extractions and chemical preservatives were left alone for a few days to let the excess of methanol evaporates (Hashim *et al., 2009)*. There are 30 numbers of termites were introduced in the petri dish and were wrapped by using parafilm to reduced dessication. Petri dish were then being placed at 28°C room temperature in the dark situation. Small quantity of water was added to the filter paper to give humidity environment in all petri dish. The dead termites were removed and recorded. Data for the termite mortality were counted and 7 days for observation.

3.6 Termite decay

The termite decay was performed according to (Hashim *et al., 2009).* Rubberwood were treated with methanol extracts and commercial preservatives, respectively. Rubberwood without treatment were introduced as control. The test arena was likely observed in a container with a good air circulation maintained. Fine sand was washed and sieved at 0.42mm and oven dried. After the sand were dried, mixed it with drinking water at 1/3 portioned part of the sand only in the test arena. Triplicates of rubberwood specimens were randomly placed in the test arena and the termites at ratio of 100 workers to 5 soldiers were released into test arena. The test arena then were placed in the dark for 30 days. After 30 days, the rubberwood were taken, washed, oven dried and weight is determined (Hashim *et al., 2009).*

3.7 Physical Properties of Wood

The physical properties of wood specimen including thickness swelling (EN 317, 1993) and water absorption (EN 317, 1993) will be determined accordance to EN (European Standard).

3.7.1 Determination of increase of mass (water absorption) due to general absorption of water

The specimen should be 100mm X 100mm X 100mm board thickness conditioned and prepared. The wood was immersed and the flat-bottomed container were prepared not less than 140mm deep and 130 mm wide. The temperature were set up at 20 ± 2 °C in the flat bottomed container to test the specimen for 2 hour or 24 hours. The depth of

the water above the specimens will be maintained between 25 mm and 30 mm. The specimen test was removed after the timing either 1 hour and 24 hours immediately, and remove all the excessed water by using cloth. Each of the test specimen were weighted and mass is recorded (EN 317, 1993).

*Calculation and the expression of results. The water absorption *O,* will be expressed as percentage after for 1 hour O_1, or 24 hours O_2, will be calculated from the calculation,

$$O = \frac{(M2-M1)}{M1} \text{ x } 10 \quad \text{..... (equation 3.1)}$$

Where

M_1 is the mass of test specimen before immersion

M_2 is the mass of test specimen after immersion

3.7.2 Determination of increase in thickness (swelling) due to general absorption of water

The test specimen was immersed in the flat bottomed container for about 1 hour and 24 hours. All the excess of water was removed by using cloth appropriately. The mean thickness was immediately remeasured and recorded by placing the vernier caliper exactly at the same point as before. However, the immersion of the test specimen will cause roughening of the surface of the test specimen. Thus, to reduce the effect of the result, it is essential to measure the test specimen exactly the same place before and after soaking (EN 317, 1993).

*Calculation and expression of the results. The swelling of the test specimen *S*, will be expressed as percentage, after 1 hour S_1, and 24 hours S_2, will be calculated from the equation.

$$S = \frac{(T2-T1)}{T1} \times 100 \quad \text{(equation 3.2)}$$

Where

T_1 is the mean thickness of the test specimen before immersion (in mm)

T_2 is the mean thickness of the test specimen after immersion for 1 hour and 24 hours.

The result should be expressed to the nearest 0.1 %.

3.8 STATISTIC TEST

All the result was done in triplicates event while the results were expressed in form of mean and SD. The data and the result were analyzed by using ANOVA that were performed by using Tukey test at α=0.05.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Yield (%)

The powdered leaves of *Sesbania grandiflora* extracted with the methanol solvent for 48 hours. Solvent evaporations under reduced pressure yielded the methanolic extracts for solvent efficacy. The resultant yielded obtained from the extracts was 15.96%.

4.2 Mortality test/Non Choice test

In mortality test, 3 different types of treatment which is commercial preservatives and *Sesbania grandiflora* leaf extracts known as extractive preservatives and one control has been introduced.

Table 4.2: Mortality rate percentage with the 3 types of treatments.

Treatment	Mortality rate (%)
Commercial preservatives	100% ± 0 a
Extractive	66.67% ± 0.09 b
Control	48.89% ± 0.04 b

Different letters within the same columns are statistical significant difference at $\alpha = 0.05$

Based on the table 4.2 above, it showed that the percentage of mortality rate was the highest on commercial preservatives treatment, while for the specimen that treated with extractives, the percentage of mortality rate was higher compared with the control specimen. As for the control specimen, it was the lowest rate among 2 other treated specimens.

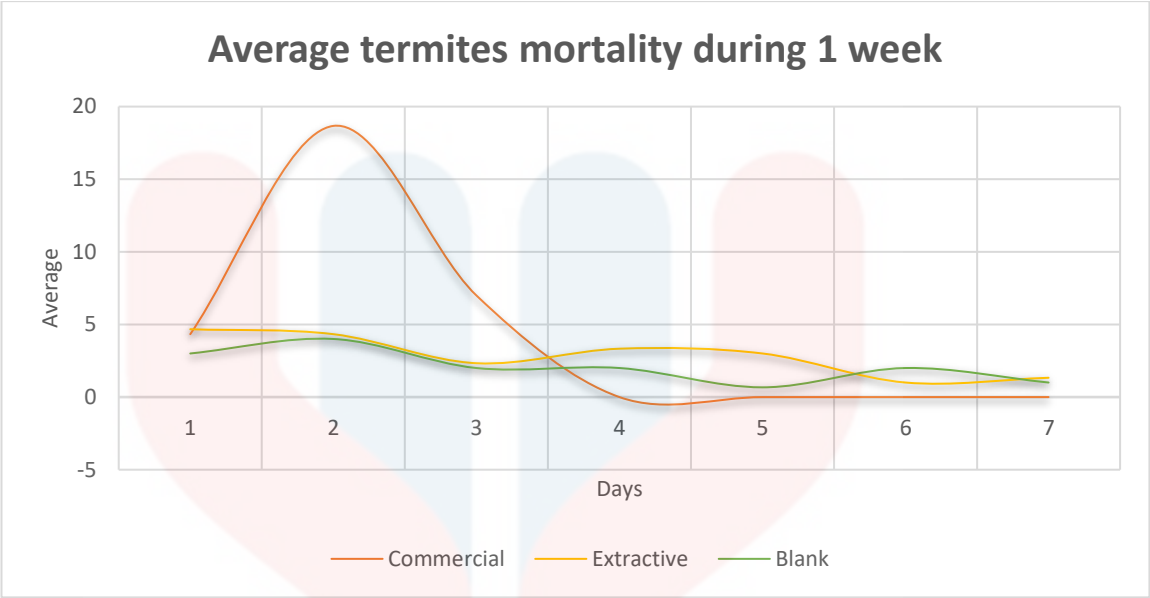

Figure 4.2: Termites mortality rate against 3 types of treatments.

The graph showed that, the mortality test, are the non-choice test in which for each of the petri dish, usually termites are forcing to feed the cellulose of paper disc that was been prepared with 2 different kinds of treatment to observe the effectivity of the treatment. When termites (*Coptotermes formoson)* been exposed to the commercial preservatives, it shows that the average of mortality termites was significantly high during the observation for a period in seven days. In both extractive preservative and control specimen, it showed that the average of mortality termites is nearly equal with slow and sluggish rate results during the observation for a period in seven days.

The performance of the mortality rate in the control specimen was the indicator to the commercial preservatives and extractive preservatives. For the control specimens, there were no protection and no value were added in the experiments. The highest percentage mortality rate was on the commercial preservatives because in commercial preservatives they contained various of active compound that make the commercial preservatives much more effective in which chlorothalonil is the active compound that

content in the commercial preservatives that are commonly used for pesticides (Lancaster *et al., 2005).*

Based on the table 4.2 and graph 4.2, it showed that the extractive preservative that was treated onto filter paper been observed for about seven days to see the efficacy significant on against termites activities. In these mortality test, the test is more towards on toxicity effects that could bring the elimination on the number of termites. Based on the percentage, it showed that the commercial preservatives exhibited the highest mortality rate as we can observe. However, based on the statistical data, the extractives preservatives and the control treatment had no significance difference in their mortality rate. For the extractives preservatives, the inhibited of mortality rate is due to the low proportionate of 1% of concentration that might be some of the active compound contained the toxicity content and some of it does not have these toxicity content in against termites.

It means, the toxicity content or toxicity effect may bring significance different towards these termites activities, yet these extractives preservatives indicates that the toxicity content of natural based products might not bring harmful towards human populations. In our experiment, phytochemical analysis was not conducted on the plants extracts, but these constituents that presence in the plants may exhibit the potential of active compound for the anti-termites activities such as alkaloids, carbohydrates, saponin, tannin, chlorogenic acid, flavonoid, anthocyanin, glycosides steroidal and phenolic compounds (Hussain & Kumaresan, 2014).

Due to the 1% concentrations that were tested in the experiments, extractives preservatives do not have a rigorous performance but slightly have the differences when it compared to the control specimens (Elango *et al., 2012).*

4.3 Wood decay/Choice test

In wood decay test, 3 different types of treatment which is commercial preservatives and *Sesbania grandiflora* leaf extracts known as extractive preservatives and one control has been impregnated onto woods.

Table 4.3: Weight loss of wood treated with different treatments after exposed to termites for 1 month period.

Treatments	Weight loss %
Commercial preservatives	9.40% ± 0.01 a
Extractives preservatives	11.33% ± 0.05 a
Control specimen	18.36% ± 0.13 b

Different letters within the same columns are statistical significant difference at α = 0.05

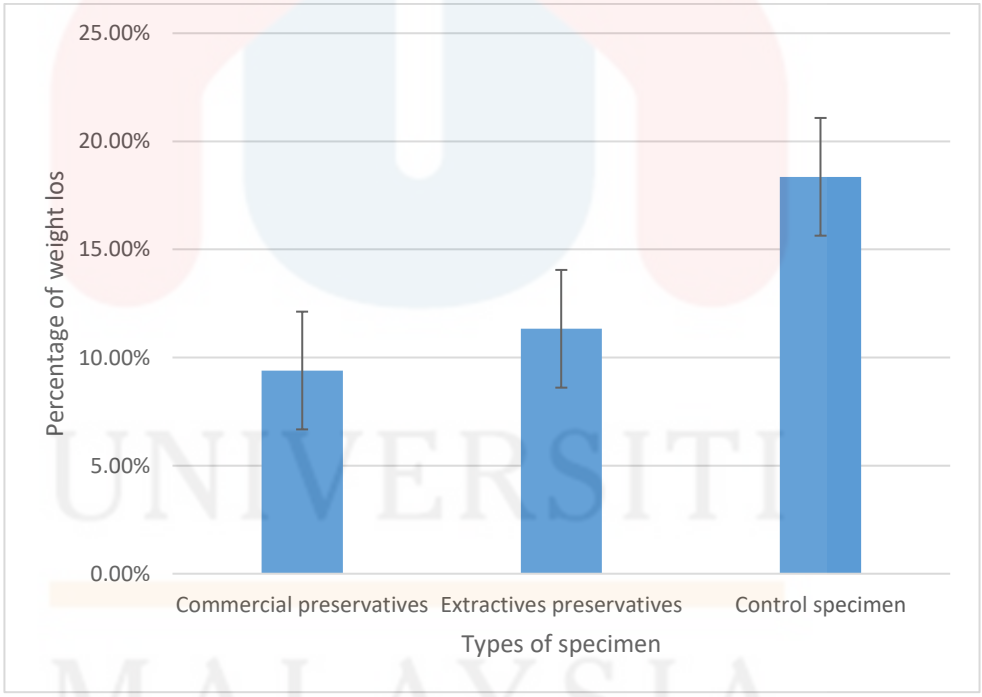

Figure 4.3: Weight loss of wood with different treatments after exposed to termites for 1 month period.

When the termites were firstly introduced in the test arena, they were diverted and nearly all the wood they were instantly attacked towards the wood sample. In decay wood test or non-choice test, the test is more towards on repellency agent because the termites

were given a choice to choose their food which food sources are most preferable for them. due to the termites instinct, the termites were only focusing on the wood that were not gave harmful effects towards them.

Based on the highest percentage weight loss of wood during 1 month observation was on control treatments 18.36% followed by extractives preservatives, higher than the control treatment with the percentage weight loss of wood decay was 11.33%. For the lowest percentage weight loss of wood was on commercial preservatives which is 9.46%. Hence, in extractives preservatives of *Sesbania grandiflora* it may have the potential for the termite resistant.

Meanwhile, based on the numeric state or statistical data, extractives preservatives and commercial preservatives showed that were no significance different on decaying of wood. It proves that, the performance for both treatment was on compatible performances. The extractive preservatives can be said there is repellency agent in against termitic activities. For the commercial preservatives, it can be said that the wood has a termite resistance because termite attack activities least occurred on commercial preservatives. However, in extractives preservatives, there is still have the tendency for the termites attacked towards the wood that has been treated with the plant extracts.

Naturally based products typically used greater than 1% of the concentration than that. As the results, the extractive preservatives are still on improvement and development to be applied on wood preservation. It can say that, the extractive preservatives can be viewed as environmentally biocides due to the potential of *Sesbania grandiflora* leaf extracts as anti-termites (Elango *et al., 2012).*

The least attract of termites attacked was occurred on commercial preservatives. In commercial preservatives, the content of active ingredient is varied and it showed that the commercial preservatives have greater amount of repellency effects towards the

termites. Chemically treated wood enhances life span of wood from any deteriorative organisms such as termites and fungi. Due to the used of chemically agent preservatives, any deterioration activities by pest would not interested to come by as the wood have a termite resistant. Like so, the wood can be said to have less vulnerable towards the termites attack and determining that, the commercial preservatives were effectively performance.

For the control specimens, was the highest and the one that showed the significant difference over commercial and extractive. In control specimen, the termites are highly preferred to the wood which is non-harmful and the expectations for the termites to attack the wood are highly susceptible and most of the weight loss were coming from control specimen. This happened because on control wood is highly susceptible to the termites attacked and offers no resistance which mean the wood are no shield and ready for termites attacked. Those woods with no shielding or no protection have a great vulnerable to attract termites attack. Any resistance effects were due to the chemically treated on wood (SSemeganda *et al.*, 2011).

4.4 Water absorption and Thickness swelling

Table 4.4 (a): Water absorption of wood specimen for 2 hours and 24 hours

Water absorption	Weight absorption (%)	
	2 hours	24 hours
Commercial preservatives	77.42% ± 0.32 a	119.33% ± 0.26 a
Extractives preservatives	80.05% ± 0.26 a	116.43% ± 0.16 a
Control	49.95% ± 0.14 a	96.96% ± 0.13 a

Different letters within the same columns are statistical significant difference at $\alpha = 0.05$

Based on the Table 4.4, the table showed that the water absorption of wood specimen over certain period. All the specimens were no difference means when the wood impregnated with 1% of concentrations according to the 2 hours and 24 hours.

Table 4.4 (b): Thickness swelling of wood specimen for 2 hours and 24 hours

Thickness swelling	Thickness swelling (%)	
	2 hours	24 hours
Commercial preservatives	3.18% ± 0.01 a	3.29% ± 0.01 a
Extractive preservatives	3.67% ± 0.01 a	3.94% ± 0.01 a
Control	4.26% ± 0.03 a	4.87% ± 0.04 a

Different letters within the same columns are statistical significant difference at $\alpha = 0.05$

Based on the Table 4.4, the table showed that the thickness swelling of wood specimen over certain period. All the specimens were no difference means when the wood impregnated with 1% of concentrations according to the 2 hours and 24 hours.

The thickness swelling that occurred on wood are causes from the intake of water absorption. It showed that when there is no protection on the wood, the water absorption and the thickness swelling are gained greater volume of water uptake because the wood had a bigger porosity structure which caused the wood to swells up. This may happen due on any untreated wood, where the percentage of thickness swelling and water absorption will get higher.

It has been shown that during the experiment was conducted, by impregnated wood with the commercial preservatives, extractives preservatives and control specimen by assuming that, it will give some effects towards the physical properties of wood such as water uptake and the swelling rates. But the results were obtained from the 2 hours and 24 hours does not gave any results to show that there will be have a difference rate

between water uptake and swelling rate by any means. It was happened due to the 1% of concentration that were tested on the physical properties of wood and assuming that, too low portioned concentration has been used, there would be no difference to be compared with (Wan & Kim, 2006).

Supposed to be, the experimental should prove that the water absorption and thickness swelling on impregnated wood with the extractive preservatives can be essentials preservatives for the naturally products. Due to 1% of concentration that were tested on physical properties of wood, the degree of water absorption and thickness swelling has no big difference to compare on varied treatment according to the period in 2 hours and 24 hours.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

It can be drawn from the experiment that was conducted, *Sesbania grandiflora* leaf extracts has the potential for anti-termite activities. On the physical properties of wood there were no significant different were observed because 1% concentration does not give any significant difference. In contrast, plant based repellent and toxicity, do not have a rigorous effect compared to the commercial preservatives.

These plants based products showed the positive results for new development in finding new drugs forms against termites. As naturally insecticides products, these materials can be easily available and it is safe for using it for the sake of human health and environment friendly.

5.2 Recommendations

As for the recommendation, results suggested that to achieve the efficacy on anti-termites, greater than 1% of extractives concentrations are needed and this may have a significantly difference when it compared with the commercial preservatives. Instead by increasing the dosage of the concentrations, there is an alternative way by isolating the active compound for testing during the experiment was conducted and by comparing the effectiveness with the commercial preservatives.

Results suggested, it can be assumed that for the naturally and environmentally based products, higher concentration or by isolating processes can be achieved for the effectiveness for the anti-termite activities. This natural preservative based products, are still in improvement and development for becoming natural based products.

REFERENCE

Alagesaboopathi, C., & Deivanai, M. (2011). Allelopathic potential of *Sesbania Grandiflora* Pers. on germination of *Cajnus cajan* Millsp. (Redgram) varieties. *International Journal of Bioscience,* 1(5), 2011.

Abbas, M., Shahid, M., Iqbal, M., Anjum, F., Sharif, S., Ahmed, S., & Pirzada, T. (2013). Antitermitic activity and phytochemical analysis of fifteen medicinal plant seeds. *Journal of Medicinal Plants Research,* 7(22), 1608-1617.

Becker, S., Halsall, C. J., Tych, W., Kallenborn, R., Schlabach, M., & Mano, S. (2012). Changing sources and environmental factors reduce the rates of decline of organochorine pesticides in the Artic atmosphere. *Atmospheric Chemistry and Physics.* 12, 4033-4044.

Botch, P. S., & Houseman, R. M. (2016). Landscape patterns of colonization by subterranean termites (Isoptera: Rhinotermitidae) in Missouri Neighborhoods. *Journal of Economic Entomology.* 109(2), 800-808.

Chouvenec, T., Bardunias, P., Li, H. F., Elliot, M. L., & Su, N. Y. (2011). Planar arenas for use in laboratory bioassay studies of subterranean termites (Rhinotermitidae). *Journal of The Florida Entomologist*, 94(4), 817-826.

Chouvenc, T., Elliott, M. L., & Su, N. Y. (2011). Rich microbial community associated with the nest material of reticulitermes flavipes (Isoptera: Rhinotermitidae). *Department of Entomology and Nematology,* 115-116.

Collins, D. P. (2013). Termite behavior: Measuring the postanoxic consumption rates of landscape mulches by eastern subterranean termites. *The American Biology Teacher,* 75(1), 41-45.

Damalas, C. A., & Eleftherohorinos, I. G. (2011). Pesticides exposures, safety issues and risk assessment indicators. *International Journal of Environment Research and Public Health.* 8, 1402-1419.

Elango, G., Rahuman, A. A., Kamaraj, C., Baagavan, A., Zahir, A. A., Shantoshkumar, T., Marimuthu, S., Velayutham, K., Jayaseelan, C., Kirthi, V. A., & Rajakumar, G. (2012). Efficacy of medicinal plant extracts against Formosan subterranean termite, *Coptotermes Formosan. Journal of Industrial Crops and Products.* 36, 524-530.

EN 310 (1993) Wood-based panel. Determination of modulus of elasticity in bending and of bending strength. European Committee for Standardization, Brussels.

EN 317 (1993) Particleboards and fiberboards. Determination of swelling in thickness after immersion in water. European Committee for Standardization, Brussels.

Esenther, G. R., Allen, T. C., Casida, J. E., & Shenefelt, R. D. (1961). Termites attractant from fungus infected wood. *Science,* 134(34710), 50.

Freeman, M. H., Shupe, T. F., Vlosky, R. P., & Barnes, H. M. (2003). Past, Present and Future of the wood preservation industry. *Forest Products Journal, 53*(10).

Ghanshyam, P., Chhayakanta, P., Shankar, M. U., Sujata, M., Gourishyam, P., & Kumar, A. A. (2012). Investigation of Possible Hypoglycemic and Hypolipidemic Effect of Methanolic Extract of Sesbania Grandiflora. *International Research of Pharmacy, 3*(5), 275-280.

Goodarzi, M., Coelho, L. D. S., Honarparvar, B., Ortiz, E. V., & Duchowicz, P. R. (2016). Application of quantitative structure property relationship analysis to estimate the vapour pressure of pesticides. *Ecotoxicology and Environmental Safety, 128,* 52-60.

Hasan, N., Hasnah Osman., Suriyati Mohamad., Wong, K. C., Khalijah Awang., Mohd Zahariluddin., & Safirah., A. (2012). The Chemical Components of Sesbania grandiflora Root and Their Antituberculosis Activity. *Pharmaceuticals, 5*(8), 882-889.

Hashim, R., Boon, J. G., Sulaiman, O., Kawamura, F., & Lee, C. Y. (2009). Evaluation of the decay resistance properties of Cerbera Odollam extracts and their influence on properties of particleboard. International Biodeterioration & Biodegradation, 1-5.

Hussain, Z, A., & Kumaresan, S. (2014). GC-MS studies and phytochemical screening of *Sesbania grandiflora* L. *Journal of Chemical and Pharmaceuticals Research,* 6(9), 43-47.

Kashyap, S., & Mishra, S. (2012). Phytopharmacology of Indian plant *Sesbania Grandiflora L. The Journal of Phytopharmacology,* 1(2), 63-75.

Khalil, A. S., Rahim, A .A., Taha, K. K., & Abdullah, K. B. (2013). Characterization of Methanolic Extracts of Agarwood leaves. *Journal of Applied and Industrial Science,* 1(3), 78-88.

Lancaster, S. H., Jordan, D. L., Spears, J. F., York, A. C., Willcut, J. W., Monks, D. W., Batts, R. B., & Brandenburg, R. L. (2005). Sicklepod (Senna obtusifolia) control and seed production after 2,4-DB applied alone with fungicides or insecticides. *Weed Science Society of America and Allen Press.* 19, 451-455.

Lehman, S. (2013). Low carbon construction system using prefabricated engineered solid woods panel for urban infill to significantly reduced gas house emission. *Sustainable Cities and Society,* 6,57-67.

Lima, J. T., & Costa-Leonardo, A.M. (2014). Foraging in subterranean termites (Isoptera: Rhinotermitidae): how do heterotermes tenuis and coptotermes gestroi behave when they locate equivalent food resources? *Bulletin of Entomological Research,* 104, 525-533.

Lyon, F., Thevenon, M. F., Hwang, W. J., Imamura, J., Grill, J., & Pizzi, A. (2007). Effect on oil heat treatment on the leachability and biological resistance of boric acid impregnated wood. *EDP S*ciences, 64, 673-678.

Meyer, B., & Boehme, C. (1997). Formaldehyde emission from solid wood. *Solid Wood Products.* 47(5), 45-48.

Miller, D. M., (2010). Subterranean termite biology and behavior. *Virginia coorperative extension,* 1-4.

Mugerwa, S. (2015). Infestation of African savannah ecosystem subterranean termites. *Ecological Complexity*, 21, 70-77.

Muhammed, S., Musgrave, O. C., & Petty, J. A. (2009). Impregnation of rubberwood and other Malaysian timbers with cooper naphthenate and trimethyl borate. *Journal of Tropical Forest Science,* 21(4), 345-352.

Mythili, T., & Ravindhran, R. (2012). Phytochemical screening and antimicrobial activity of *Sesbania Sesban (L.) Merr. Asian Journal of Pharmaceutical and Clinical Research, 5(4),* 2012.

Noviany, H., Hasnah, O., Suriyati, M., Wong, K. C., Khalijah, A., & Anis, S. M. Z. (2012). The chemical components of *Sesbania grandiflora* root and their antituberculosis activity. *Pharmaceuticals,* 5, 882-889.

Ouattara, M. B., Konate, K., Kiendrebeogo, M., Outtara, N., Compaore, M., Meda, R., Millogo-Rasolodimby, J., & Nacoulma, O. G. (2011). Antibacterial potential and antioxidant activity of polyphenols of *Sesbania Grandiflora. Journal of Biological Sciences, 3(4), 351-356.*

Padmalochana, K., & Dhana Rajan, M. S. (2014). Antimicrobial activity of aqueous ethanol, and acetone extracts of *Sesbania Grandiflora* leaves and its phytochemical characterization. *International Journal of Pharma Sciences and Research,* 5(12), 957-962.

Pajaniradje, S., Mohankumar, K., Pamidimukkala, R., Subramanian, S., & Rajagopalan, R. (2014). Antiproliferative and Apoptotic effects on *Sesbania Grandiflora* leaves in human cancer cells. *Hindawi Publishing Corporation,* 1-11.

Rajagopal, P. L., Premaletha, K., & Sreejith, K. R. (2016). Antihelmintic activity of the flowers of *Sesbania Grandiflora Pers. Journal of Innovations in Applied Pharmaceutical Sciences, 1(2),* 8-11.

Ratnasingam, J., Ioras, F., & Wenming, L. (2011). Sustainability of the rubberwood sector in Malaysia. *Not Bot Horti Agrobo,* 39(2), 305-311.

Razak, W., Izyan, K., Hanim, A. R., Othman, S., Aminuddin, M., & Affendy, H. (2011). Effects of hot oil treatment on colour and chemical changes in 15 years old *ACACIA* hybrid. *Journal of Tropical Forest Science,* 23(1), 42-50.

Reeta, M., Ravindra, S., Akhilesh, M., & A, R. M. (2013). Agastya (Sesbania Grandiflora Linn.): Ayurvedic Approach. *Universal Journal of Pharmacy, 02*(04), 1-5.

Roll, D. (2003). Wood Preservation Category 4b Study Guide For Commercial Applicators.

Roose-Amsaleg, C., Mora, P., & Harry, M. (2005). Physical, chemical and phosphate activities characteristics in soil-feeding termite nests and tropical rainforest soils. *Soil Biology & Biochemistry,* 37, 1910-1917.

Salamah, S., & Mohd Dahlan, J. (2008). Vacuum pressure treatment of Rubberwood (Hevea Brasiliensis) using boron based preservatives. *Journal of Tropical Forest Science, 20(1),* 1-7.

Sarani, Zakaria., Sahrim, Ahmad., Maisarah, Yusoff., & Chinhua, Choo. (2010). The influence of drying temperature on the hygroscopicity of rubberwood (Hevea Brasiliensis). *Journal of Agricultural Science,* 2(1), 48-58.

Selamat, S., Mohammad, H., & Said, Z. (1988). Preservation of rubberwood by boron double vacuum process. *Journal of Tropical Forest Sceince,* 1(2), 133-139.

Selamat, S., Said, Z., & Ahmad, F. (1993). Effectiveness of cooper-chrome boron as wood presrvative. *Journal of Tropical Forest Science,* 6(2), 98-115.

Shenkani, K., and Sam Manohar Das, S. (2014). Toxicity of rubberwood processing effluent exposed to fresh water fish *Poecilia reticulata. Journal of Entomology and Zoology Studies, 2(6),* 326-329.

Shyamala gowri, S., and Vasantha, K. (2010). Free radical scavenging and antioxidant activity of leaves from Agathi (*Sesbania grandiflora)* (L.) Pers. *American-Eurasian Journal of Scientific Research,* 5(2), 114-119.

Simatupang, M. H., & Schmitt, U. (1994). Wood extractives of rubberwood (*Hevea Brasiliensis*) and their influences on the setting of the inorganic binder in gypsum-bonded particleboard. *Journal of Tropical Forest Science,* 6(3), 269-285.

S. Kumar, N., & F. S, D. (2016). Phytochemcal Analysis and Antimicrobial Activities of Sesbania Grandiflora (L) Leaf Extract. *International Journal of Pharmaceutical Science Review and Research, 36*(1), 144-148.

Srivasatava, N., Shwarupa, S., & Bhagyawant, S. S. (2011). Comparative Study on the Anti-Termite, Antimicrobial and Antioxidant Activity on Leaf and Root Extracts of Photos Aurea (Epipremnum aureum L.). *Journal of Pharnmaceuticals Research & Clinical Practice, 1*(2), 1-11.

Ssemeganda, I. E., Mugabi, P., & Tumwebaze, S. B. (2011). Effectiveness of selected preservatives in protecting Uganda grown *Eucalyptus grandis* wood against termite attack. *Journal of Maderas Ciancia y Technologia.* 13(2), 135-142.

Teoh, Y. P., Don, M. M., & Ujang, S. (2011). Assessment of properties, utilization, and preservation of rubberwood (Hevea brasiliensis): a case study in Malaysia. *Journal Wood Science,* 57, 255-266.

Thorne, B. L., Traniello, J. F. A., Adams, E. S., & Bulmer, M. (1999). Reproductive dynamics and colony structure of subterranean termites of the genus Reticulitermes (Isoptera Rhinotermitidae): a review of evidence from behavioral, ecological, and genetic studies. *Ethology Ecology & Evolution,* 11, 149-169.

Tikhe, C. V., Sethi, A., Delatte, J., & Husseneder, C. (2015). Isolation and assessment of gut bacteria from the Formosan subterranean termite, *Coptotermes formosanus (*Isoptera:Rhinitermitidae), for paratransgenesis research and application. *Insect Science,* 0(0), 1-10.

Umar, I., Zaidon, A., Lee, S. H., & Halis, R. (2016). Oil heat treatment of rubberwood for optimumchanges in chemical constituents and decay resistance. *Journal of Tropical Forest Science,* 28(1), 88-96.

Upadhyay R, K. (2013). Effect of plant latex based anti-termite formulations on Indian white termite Odondotermes obesus (Isoptera: Odondotermitidae) in sub-tropical high infestation areas. *Open Journal of Animal Science, 3*(4), 281-294.

Vargo, E. L., & Husseneder, C. (2009). Biology of *Subterranean Termites:* insights from molecular studies of *Reticulitermes* and *Coptoterme.* 54, 379-403.

Vargo, E. L., Labadie, P. E., & Matsuura, K. (2012). Asexual queen succession in the subterranean termite Recticulitermes virginicus. *Proceeding of The Royal Society,* 279, 813-819.

Veeresham, C. (2012). Natural products derived from plants as a source of drugs. *Journal of Advanced Pharmaceutical Technology & Research, 3(4),* 200-201.

Vipin, K., Arun, G. K., & Gupta, R. (2011). Antimicribial activity of *Sesbania Grandiflora (L.) PERS. International Research Journal Of Pharmacy,* 2(7), 85-87.

Wan, H., & Kim, M. G. (2006). Impregnation of southern pine wood and strands with low molecular weight phenol-formaldehyde resins for stabilization of oriented. *Journal of Wood and Fibre Science.* 38(2), 314-324.

Wagh, V. D., Wagh, K. V., Tandale, Y. N., & Salve, S. A. (2009). Phytochemical, pharmacological and phytopharmaceutics aspects of *Sesbania Grandiflora* (Hadga) : A review. *Journal of Pharmacy Research,* 2(5), 889-892.

William, L. H. (1996). Borate wood protection compounds: a review of research and commercial use. *Borate Wood-Protection Compounds,* 27(4), 46-51.

Wu, J., Su, X., Kong, X., Liu, M., & Xing, L. (2013). Multiple Male and Female Reproductive Stratergies and the Presence of a Polyandric Mating System in the Termite Reticulitermes Labralis (Isoptera: Rhinitermitidae). *Sociobiology, 60*(4), 459-465.

APPENDIX A

Mortality test/Non Choice test

Table A1: Descriptive statistics for mortality test

	N	Minimum	Maximum	Mean	Std. Deviation
Blank	3	1.00	1.00	1.0000	.00000
Extractive	3	1.00	2.00	1.3333	.57735
Chemical	3	.00	.00	.0000	.00000
Valid N (listwise)	3				

Post Hoc Tests

Table A2: Multiple comparisons dependent variable mortality test for Tukey HSD

(I) Treatments	(J) Treatments	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Commercial preservatives	Extractives preservatives	-1.33333*	.27217	.006	-2.1684	-.4983
	Control	-1.00000*	.27217	.024	-1.8351	-.1649
Extractives preservatives	Commercial preservatives	1.33333*	.27217	.006	.4983	2.1684
	Control	.33333	.27217	.483	-.5017	1.1684
Control	Commercial preservatives	1.00000*	.27217	.024	.1649	1.8351
	Extractives preservatives	-.33333	.27217	.483	-1.1684	.5017

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Table A3: Value mortality test for Tukey HSD

Treatments	N	Subset for alpha = 0.05	
		1	2
Commercial preservatives	3	.0000	
Control	3		1.0000
Extractives preservatives	3		1.3333
Sig.		1.000	.483

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000

Wood decay/Choice test

Table A4: Anova value for decay wood

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	608.600	2	304.300	24.550	.001
Within Groups	74.370	6	12.395		
Total	682.970	8			

Post Hoc Tests

Table A5: Multiple comparison dependent value decay wood for Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Commercial	Extractive	-3.60000	2.87460	.469	-12.4201	5.2201
	control	-18.96333*	2.87460	.001	-27.7834	-10.1433
Extractive	Commercial	3.60000	2.87460	.469	-5.2201	12.4201
	Control	-15.36333*	2.87460	.004	-24.1834	-6.5433
Control	Commercial	18.96333*	2.87460	.001	10.1433	27.7834
	Extractive	15.36333*	2.87460	.004	6.5433	24.1834

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Table A6: Value of decay woof for Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
Commercial	3	9.3967	
Extractive	3	12.9967	
Control	3		28.3600
Sig.		.469	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000

Physical properties of wood test

Water absorption for 2 hours

Table A7: Anova value for water absorption for 2 hours

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1668.077	2	834.039	1.322	.334
Within Groups	3785.147	6	630.858		
Total	5453.225	8			

Post Hoc Tests

Table A8: Multiple comparison dependent variable water absorption for 2 hours for Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Commercial preservative	Extractive	-2.62667	20.50785	.991	-65.5504	60.2970
	Control	27.47667	20.50785	.426	-35.4470	90.4004
Extractive	Commercial preservative	2.62667	20.50785	.991	-60.2970	65.5504
	control	30.10333	20.50785	.369	-32.8204	93.0270
Control	Commercial preservative	-27.47667	20.50785	.426	-90.4004	35.4470
	Extractive	-30.10333	20.50785	.369	-93.0270	32.8204

Homogeneous Subsets

Table A9: Value water absorption for 2 hours for Tukey HSD

Treatment	N	Subset for alpha = 0.05
		1
Control	3	49.9467
Commercial preservative	3	77.4233
Extractive	3	80.0500
Sig.		.369

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Water absorption for 24 hours

Table A10: Anova value for water absorption for 24 hours

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	888.018	2	444.009	1.179	.370
Within Groups	2259.485	6	376.581		
Total	3147.503	8			

Post Hoc Tests

Table A11: Multiple comparison dependent variable water absorption for 24 hours for Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Commercial preservative	Extractive	2.89667	15.84468	.982	-45.7192	51.5125
	control	22.37000	15.84468	.393	-26.2458	70.9858
Extractive	Commercial preservative	-2.89667	15.84468	.982	-51.5125	45.7192
	Control	19.47333	15.84468	.481	-29.1425	68.0892
Control	Commercial preservative	-22.37000	15.84468	.393	-70.9858	26.2458
	Extractive	-19.47333	15.84468	.481	-68.0892	29.1425

Homogeneous Subsets

Table A12: Value water absorption for 24 hours for Tukey HSD

Treatment	N	Subset for alpha = 0.05
		1
Control	3	96.9567
Extractive	3	116.4300
Commercial preservative	3	119.3267
Sig.		.393

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Vernier caliper for 2 hours

Table A13: Anova value for Vernier caliper for 2 hours

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.776	2	.888	.277	.767
Within Groups	19.220	6	3.203		
Total	20.996	8			

Post Hoc Tests

Table A14: Multiple comparison dependent variable vernier caliper for 2 hours for Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Commercial preservative	Extractive	-.49333	1.46135	.940	-4.9772	3.9905
	Control	-1.08667	1.46135	.748	-5.5705	3.3972
Extractive	Commercial preservative	.49333	1.46135	.940	-3.9905	4.9772
	Control	-.59333	1.46135	.914	-5.0772	3.8905
Control	commercial preservative	1.08667	1.46135	.748	-3.3972	5.5705
	Extractive	.59333	1.46135	.914	-3.8905	5.0772

Homogeneous Subsets

Table A15: Value Vernier caliper for 2 hours for Tukey HSD

Treatment	N	Subset for alpha = 0.05
		1
Commercial preservative	3	3.1767
Extractive	3	3.6700
Control	3	4.2633
Sig.		.748

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Vernier caliper for 24 hours

Table A16: Anova value Vernier caliper for 24 hours

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.771	2	1.885	.403	.685
Within Groups	28.089	6	4.682		
Total	31.860	8			

Post Hoc Tests

Table A17: Multiple comparison dependent variable vernier caliper for Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Commercial preservative	Extractive	-.64333	1.76665	.930	-6.0639	4.7772
	Control	-1.57667	1.76665	.664	-6.9972	3.8439
Extractive	Commercial preservative	.64333	1.76665	.930	-4.7772	6.0639
	Control	-.93333	1.76665	.861	-6.3539	4.4872
Control	Commercial preservative	1.57667	1.76665	.664	-3.8439	6.9972
	Extractive	.93333	1.76665	.861	-4.4872	6.3539

Homogeneous Subsets

Table A18: Value Vernier caliper for 24 hours for Tukey HSD

Treatment	N	Subset for alpha = 0.05
		1
Commercial preservative	3	3.2933
Extractive	3	3.9367
Control	3	4.8700
Sig.		.664

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000

APPENDIX B

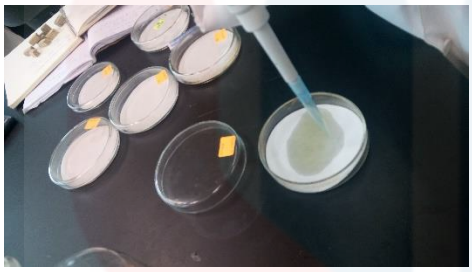

Figure B1: Preparation dilution on mortality test

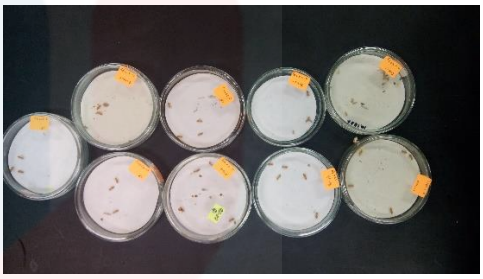

Figure B2: 9 petri dish were prepared for the termites mortality test

Figure B3: 3 replicate for the extractives preservatives

Figure B4: 3 replicates for the control specimen

Figure B5: 3 replicates for the commercial perservatives

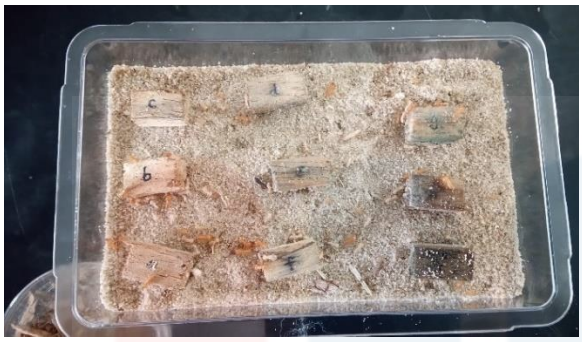

Figure B6: Test arena for wood decay

Figure B7: One of the wood being decayed on control specimen

Figure B8: Commercial preservatives on test arena

Figure B9: Extractives preservatives on test arena

Figure B10: Control specimen on test arena

Figure B11: Imprgenated wood being soaking for 2 and 24 hours

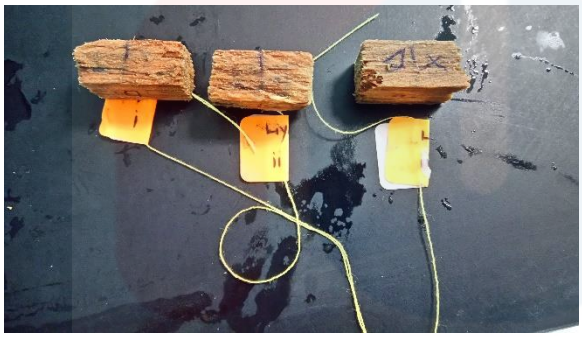

Figure B12: Physical properties of impregnated wood was observed