Leaflet No.

The Republic of the Union of Myanmar
Ministry of Natural Resources and Environmental Conservation

Study on Natural Durability and Chemical Composition of Sapwood and Heartwood from the Eight Kinds of Trial Teak

Lwin Lwin Aung, Assistant Research Officer
Forest Department

March, 2026

Contents

List of Tables ii
List of Figures iii
Abstract iv
စာတမ်းအကျဉ်း..v

1. Introduction..1
2. Objectives 1
3. Literature Review..1
4. Material and Methods 3
5. Results and Discussion 10
   5.1. Phytochemical Test..10
   5.2. Antioxidant Test Activity 13
   5.3 Moisture Content 16
   5.4. Evaluation of Termite Resistance 18
   5.5. Total Phenolic Compound (TPC) Content Measurement Test Activity..19
   5.6 GC/MS Test 20
6. Conclusion 34
7. Acknowledgement 34
8. References..35

List of Tables

		Pages
Table 1	Visual rating for termite resistance	6
Table 2	Durability Classification of the Timber Based on Weight Loss	7
Table 3	Results of Phytochemical compound in sapwood & heartwood of four provenience trial	12
Table 4	Results of Phytochemical compound in sapwood & heartwood of four provenience trial	13
Table 5	% Inhibition & IC_{50} of Ascorbic Acid	14
Table 6	Results of Antioxidant Activity in sapwood & heartwood of eight provenance trial	14
Table 7	Results of Moisture Content in Bottom, Middle & Top	17
Table 8	Results of Evaluation of Termite Resistance in Bottom, Middle & Top	18
Table 9	Results of Total Phenolic Compound (TPC) test in sapwood & heartwood	19
Table 10	Results of GC/MS in sapwood & heartwood from Kanbalu	21
Table 11	Results of GC/MS in sapwood & heartwood from Oktwin	23
Table 12	Results of GC/MS in sapwood & heartwood from Phyu	24
Table 13	Results of GC/MS in sapwood & heartwood from Nattalin	26
Table 14	Results of GC/MS in sapwood & heartwood from Paukkaung	27
Table 15	Results of GC/MS in sapwood & heartwood from Taungoo	29
Table 16	Results of GC/MS in sapwood & heartwood from Bago	31
Table 17	Results of GC/MS in sapwood & heartwood from Thabeikgyin	33

List of Figures

		Pages
Figure 1	Making the Reagent for the Phytochemical Analyzing	4
Figure 2	Sample Preparation	5
Figure 3	Incubation at 37°C for 30 min.	5
Figure 4	96 Well reaction plates	5
Figure 5	Weight of specimen	6
Figure 6	Oven dried at 60 °C overnight	6
Figure 7	Sample preparation	7
Figure 8	Specimen store plastic bag	7
Figure 9	Testing the evaluation of termite resistance	8
Figure 10	Gallic acid standard curve	9
Figure 11	Sample preparation	9
Figure 12	96 well reaction plates before & after incubation	9
Figure 13	Making the reagent for the GC/MS Analyzing	10
Figure 14	Results of Antioxidant Activity in sapwood & heartwood	16
Figure 15	Results of Moisture Content in Bottom, Middle & Top	17
Figure 16	Results of Evaluation of Termite Resistance in Bottom, Middle & Top	19
Figure 17	Results of Total Phenolic Compound (TPC) test in sapwood & heartwood	20

.

"Study on Natural Durability and Chemical Composition of Sapwood and Heartwood from the Eight Kinds of Trial Teak"

Lwin Lwin Aung, Assistant Research Officer

Forest Department

Abstract

In this study, the experiment was performed for the 15 years old teak from the eight different trial plantations to know if there are differences or not based on the natural durability of teak and the composition of bioactive compounds of teak and their advanced potential utilization. According to the experiment procedure, the sample was collected from each of eight trial teak plantations, Ngalaik Reserved Forest No.9, Ottara Thiri Township, Naypyitaw, 2007. For the termite test of weight loss and the moisture content test, the sample was prepared by dividing it into three parts as top parts, middle parts, and bottom parts, and then, for the test, it was used and followed by ASTM standard D-3345-08. For the chemical tests, the sample was spread as a sapwood sample block and a heartwood sample block to check their kinds of phytochemical compounds, kinds of antioxidant compounds and their content, and the Total Phenolic Compound content test. GC-MS test was also performed to check the bioactive compounds and their content in detail, like the differences based on the sapwood and heartwood. Based on the facts of the result, the moisture content of Kanbalu sample block is the highest in all 3 parts. Then, the lowest moisture content of the sample is in the bottom part, Bago; in the middle part, Taungoo; and in the top part, Thabeikkyin. In the termite test result, it was a moderate durability class in all sample blocks. In the phytochemical checking process, there were included alkaloids, Glycosids, Polyphenol, Saponin and Tanins in all trial blocks. There was a significant fact of included terpene phytochemical in the heartwood of Bago only. In the antioxidant activity, the value of sapwood extract of the eight trial sample blocks is 171.625 µg/ml, and the value of heartwood extract of the eight trial sample blocks is 154.125 µg/ml; therefore, the antioxidant properties of sapwood are greater than those of the sapwood of the eight trial sample blocks. Then, among the total phenolic compound content of eight trail sample blocks, the TPC content of Paukkhaung is highest in both sapwood and heartwood. When comparing the TPC content of heartwood and sapwood, the TPC content of sapwood is higher than the TPC content of heartwood in the sample of Kanbalu, Oaktwin, Paukkhaung and Thabeikkyin. In the GCMS test using ethanol extract, there are 20 compounds contained in sapwood and heartwood of teak from eight trials. Among them, the content of 9-Octadecenoic acid(Z)-, methyl ester, and 9, 12-Octadecadienoic acid (ZZ) is included as the highest, and in Oaktwin sapwood and Taungoo sapwood samples, it is the highest (80.91% - peak area), the second most abundant compound is Nattalin sapwood (80.91%- peak area). Those compounds included high antioxidant activities like anti-inflammatory properties and anti-cancer properties.

Keywords: *Antioxidant Activity, Natural Durability, Termite Resistance*

မတူညီသည့်မူရင်းဒေသ(၈)မျိုး မှ စိုက်ခင်းကျွန်းများ၏ အနှစ်သားနှင့်အကာသား အတွင်းပါဝင်သောဓါတုဒြပ်ပေါင်းအမျိုးအစားများနှင့် သဘာဝအလျောက်ကြာရှည်ခံနိုင်မှုတို့ကို လေ့လာခြင်း

လွင်လွင်အောင်၊ လက်ထောက်သုတေသနအရာရှိ၊ သစ်တောသုတေသနဌာနခွဲ

စာတမ်းအကျဉ်း

ဤစာတမ်းတွင်၂၀၀၇ခုနှစ်၊ နေပြည်တော်ကောင်စီနယ်မြေဥတ္တရသီရိမြို့နယ်၊ ငလိုက်ကြိုးဝိုင်းအကွက်အမှတ်(၉)တွင် တည်ထောင်ထားသော အနယ်နယ်ကျွန်းစမ်းသပ် စိုက်ကွက်မှစိုက်ခင်းကျွန်းဒေသ(၈)ခုမှဒေသတစ်ခုလျှင်ပင်ကြပ်တိုင်(၁)ပင်စီစုဆောင်းရယူခဲ့ပါသည်။ (၁၅) နှစ် သားစိုက်ခင်းကျွန်းတို့၏**သဘာဝအလျောက်ကြာရှည်ခံနိုင်မှု(အရင်း၊ အလယ်၊ အဖျား ပိုင်း)**နှင့် **ဓာတုဒြပ်ပေါင်းပါဝင်မှု (အကာသားနှင့်အနှစ်သား)**အချက်များအပေါ်မူတည်ပြီး ဆက်စပ် အသုံးချနိုင်မှုတို့ကိုသိရှိနိုင်စေရန်အတွက်ဆောင်ရွက်ခဲ့ခြင်းဖြစ်ပါသည်။ ဤသုတေသနတွင်သစ်လုံး တစ်လုံး ၏ အရင်း၊ အလယ်၊ အဖျားပိုင်း အပိုင်း (၃)ပိုင်းခွဲ၍ သစ်တို့၏အစိုဓါတ် ပါဝင် မှုမှာ အရင်း ပိုင်းတွင် ပဲခူး၊ အလယ်ပိုင်း တောင်ငူနှင့် အဖျားပိုင်းတွင် သပိတ်ကျင်းမြို့နယ် တို့သည် အနည်းဆုံးဖြစ်ကြောင်းတွေ့ရပြီး၊ ခြစားမှုဒဏ်ခံနိုင်စွမ်းကိုမြေမြှုပ်စမ်းသပ်နည်းတွင် မြို့နယ် (၈)ခုလုံး၏ (အရင်း၊လယ်နှင့်အဖျားပိုင်း) အပိုင်း(၃)ပိုင်းလုံးသည် အသင့်အတင့်ကြာ ရှည်ခံ သော အုပ်စုတွင်သာဖြစ်ကြောင်းတွေ့ရှိခဲ့ရသည်။ ဓာတုဂုဏ်သတ္တိ အော်ဂဲနစ်ဒြပ်ပေါင်း ပါဝင် မှု (phytochemical) အမျိုးအစားများမှာ Alkaloids၊ Glycosids၊ Polyphenol၊ Saponin နှင့် Tannins Phytochemical (၅)မျိုးပါဝင်နေပြီး၊ Terpene ဓါတုဒြပ်ပေါင်းမှာ ပဲခူး (အနှစ် သား) တွင်သာ ပါဝင်မှုရှိကြောင်းတွေ့ရှိရပါသည်။ ဓါတ်တိုးဆန့်ကျင်နိုင်စွမ်းဂုဏ်သတ္တိတွင် မြို့နယ် (၈)ခု မှ စိုက်ခင်းကျွန်းသစ်များ၏ အကာသား Extracts နမူနာတန်ဘိုးမှာ(171.625 μg/ml)၊ အနှစ် သား (154.125 μg/ml) ဖြစ်ပြီး အနှစ်သားထက် အကာသားနမူနာမှာ ဓာတ်တိုး ဆန့်ကျင် နိုင်မှု ဂုဏ်သတ္တိပိုမိုများပြားကြောင်းတွေ့ရှိခဲ့ရပြီး၊Total Phenolic Compound (TPC) ပါဝင်မှု မှာ ကန့်ဘလူ၊ အုတ်တွင်း၊ ပေါက်ခေါင်းနှင့်သပိတ်ကျင်းမြို့နယ်များတွင် အနှစ်သားထက် အကာ သား နမူနာတွင်(TPC)ပါဝင်မှုမှာအများဆုံးဖြစ်ကြောင်းတွေ့ရှိရပါသည်။Crude Extract အား GC-MS ဓာတ်ခွဲကိရိယာအသုံးပြုစမ်းသပ်ခဲ့ရာတွင် မြို့နယ် (၈) ခုလုံး၏ Extract နမူနာ အားလုံးတွင် compound (၂၀)မျိုးပါဝင်နေပြီး ပမာဏအများဆုံး ပါဝင်သော compound (၂)မျိုးမှာ 9, 12-Octadecadienoic acid (ZZ) နှင့် 9-Octadecenoic acid(Z)-, methyl ester တို့ဖြစ်ကြသည်။ အဆိုပါ compound (၂) မျိုးမှာ anti-cancer နှင့် anti-inflammatory properties ကဲ့သို့ဓါတ်တိုး ဆန့်ကျင်နိုင်စွမ်းဂုဏ်သတ္တိမြင့်မားစွာရှိကြောင်း တွေ့ရပြီးငင်း compound (၂)မျိုးပါဝင်မှု အများဆုံး မြို့နယ်မှာအုတ်တွင်းအကာသားနှင့်တောင်ငူ အကာသား (80.91% - peak area)၊ ဒုတိယ နတ်တလင်းအကာသား (80.91 % - peak area) နှင့် တတိယ ကန့်ဘလူအကာသား (79.79 %-peak area) တို့ဖြစ်သည်။

Study on Natural Durability and Chemical Composition of Sapwood and Heartwood from the Eight Kinds of Trial Teak

1. Introduction

Burmese Teak, a highly valued hardwood, is known for its natural qualities and sustainable management practices in Myanmar. It is a dense, fine-grained wood with a smooth texture and a distinctive golden hue. The natural oils in the wood make it exceptionally durable and resistant to water, pests, and decay, then, it is versatile. (usvintagewood.com/Burmese-teak/). According to the assessment of sustainable management of teak, Myanmar government started the plantation project without destroying the existing ecological characteristics in Myanmar. In Myanmar, the annual total plantation target for 1990-2010 has been fixed at around 361,807 ha of which commercial plantations constitute about 205,550 ha, representing 57 % of the total plantations (Soe, 2009 and FD, 2010). Because there are many benefit of forest plantations like, (1) decreasing the deforestation without effecting to the sustainable production of wood to supply the industry, (2) environmental management like carbon restoration, ecosystem restoration and soil and water conservation. (3) Rural development and job creation. Therefore the forest plantation establishing include as the essential role in community. Especially, teak plantation was concentrated to fulfill the requirements of economic.

Thus, this research aims to know the detail properties of teak timber like the chemical properties of sapwood and heartwood in different parts of timber (top, middle and bottom) from different trial. In this study, comparison in the moisture content differences in different part of timber collected from different trials, content of phenolic compound in heartwood (which support to against termite) in different part of timber collected from different trials and another supportive chemical compounds in teak timber, were studied.

2. Objectives

- To study the nature of plantation teak in difference part of timber form eight provenance trials.
- To compare the moisture content and phenolic content which protect form termite defense in difference part of timber from eight provenance trials.
- To compare the chemical properties of sapwood and heartwood of plantation teak in different trials.
- To suggest the utilization potential of plantation teak based on result of this study.

3. Literature Review

3.1. History of Myanmar Plantation Teak

In Myanmar, the forest cover consists mainly of natural forests, about 45 % of which are teak bearing forests. With a view to enriching the stocking inn the natural teak bearing forests in Myanmar, teak plantations had been established in Paletwa area of the Chin State in about the year 1700 (FAO, 1956). The first attempt at teak plantations by Taungya method, which is world renowned today (Soe, 2009), was made in 1856 at Tharyawady in the Bago Division. After the establishment of the plantations in Tharyawady Forest Division in 1856, plantation forestry continued and a total of 310 ha had been attained by 1867-68, and a relatively large area of 1,370 ha was reached by 1876. Teak plantations established up to1906 totaled about 24,282 ha (Myint et al., 1999). Starting from early Special Teak Plantations were formed in the areas with degraded forests and poor stocking of teak and other valuable commercial species (Gyi, 1972). As of 22000, 293,782 ha of teak plantations had been established which of 41% of total plantations. In early 1998, the Forest Department launched a special teak plantation program, which incorporates new features such as adoption of 40-year rotation, and management participation of interested and relevant communities. The adoption of a definite 40-year rotation reflects a significant deviation from the old concepts and final harvest will be made by clear cutting at the end of the rotation (Min and Lwin, 2004).

3.2. Natural Durability of Teak

The high natural durability of teak is an important characteristic that has been attributed to various compounds identified in the extractives of teak (Rudman *et al.* 1958; Lukmandaru *et al.*2009). Several studies concerning the effect of the extractives content on the natural durability of teak have been published (Rudman *et al.* 1967, Lukmandaru *et al.* 2015). Quinones and their derivatives in the extractives of teak have been reported to defend against termite and fungal attack (Sumthong *et al.* 2006; Thulasidas *et al.* 2007; Niamké 2011). The high decay resistance of teak heartwood is postulated to be due to a synergistic effect of the decay active ethanol extracts and caoutchouc (Sandermann 1964; Yamamoto *et al.* 1998).
Dimensional stability determines the use and variability of wood and is one of the important natural durability features of wood (Devi 2004; Pandey 2009). The dimensional stability could be related to the concentration of extractable substances in the wood (Kokutse 2004; Hernandez 2007; Roger *et al.* 2014). A dimensionally stable wood is one that shows small changes in size due to the changes in moisture.

3.3. Fact of Moisture Content of Teak

Wood has a special ability. It's hygroscopic, which means it can absorb and release moisture from the air around it. If the air is humid, wood will soak up the moisture. If the air is dry, wood will release some of the moisture back into the air. Wood always has a little bit of water inside it, and it's constantly adjusting to the environment! Moisture plays a crucial role in how wood behaves. If wood isn't properly seasoned, the moisture inside can cause the problems such as warping, cracking, weakness and shrinkage etc…. (HTSM, 1985, Genuine Timber)

Moisture content is critically important for teak wood, as it significantly impacts the wood's stability, strength, and resistance to decay. Properly managed moisture content ensures the wood remains dimensionally stable, preventing warping, cracking, or swelling, and also enhances its durability and resistance to fungal attacks. Moisture content is so important for teak wood due to the following facts;
Moisture Fluctuations: Changes in humidity cause wood to expand or contract. If the moisture content is not controlled, these changes can lead to warping, cracking, or swelling.
Equilibrium Moisture Content (EMC)**:** Wood reaches a point of equilibrium with the surrounding air moisture (EMC). Ensuring wood reaches EMC before use minimizes dimensional changes.
Dimensional Stability in Teak: Teak, known for its natural oils, is more resistant to moisture fluctuations than many other woods, but proper moisture management is still crucial for optimal performance.
Moisture and Strength: Moisture content affects the strength and stiffness of wood. Generally, as moisture content decreases, strength and stiffness increase.
Decay Resistance: High moisture content can make wood susceptible to fungal decay. (Harsha Timber & Saw Mills, 03, March, 2025)

3.4. Heartwood and Sapwood Proportion of Teak Wood

Heartwood initiation in teak trees start at the age of 4-5 years (Bhat, 1998). The amount of heartwood varies considerably with age, site and growth rate, and between families, genera and species (Hillis, 1987). The sapwood proportion decreased with age and stabilises at maturity, thereafter maintaining a constant width with the proportion of heartwood(Hillis, 1987). In teak, heartwood percentage increased with growth rate of trees with increasing diameter at breast height (DBH). The effect of growth rate on the heartwood-sapwood ratio seemed to decline with increasing age, resulting in negligible differences between fast and slowly-grown mature trees aged 55-65 years (Bhat, 1998). The heartwood proportion in teak depends not only on the age, but also on the ecological zones in which the tree grows as observed by Kokutse et al. (2004) for teak in the range of 40-45 years. In a study on 35- yr-old home-garden teak at two locations in India, Thulasidas and Bhat (2009) reported no significant difference in the heartwood-sapwood proportion, even though the large diameter logs had a proportionately higher heartwood percentage than small diameter logs. Sapwood yield from short-rotation plantations is considerably higher, adversely affecting the durability of timber unless the material is adequately treated with environmentally-friendly preservatives. With higher penetrability, sapwood is easier to treat with preservatives than the refractory heartwood. However, the transition zone, which is very light in color, is often quite difficult to treat due to low liquid permeability. A high proportion of sapwood is a real concern for outdoor furniture. (Walter Kollert, Michael Klein, 2017).

3.5. Chemical Composition of heartwood and sapwood of Teak

Teak wood has chemical compounds that can be used for pharmaceutical and textile industries, in addition, this compounds are related to resistance to bio deterioration, color and modification processes. A variety of plant materials are natural sources of antioxidants due to the phytochemicals such as alkaloids, flavonoids, phenolic, and terpenoids they contain. Medicinal plants mainly with documented and popular traditional use in folk medicines for the treatment of oxidative and other related diseases could be a good source for novel and effective antioxidants. Teak wood has chemical compounds that can be used for pharmaceutical and textile industries, in addition, this compounds are related to resistance to bio deterioration, color and modification processes. The acetic acid (10%) and levoglucosan (26.65%) were the most abundant compound in the sapwood and heartwood, respectively. The high acetic acid content enhances the use of teak wood to production of artificial essences for perfumery, paints, dyes. While levoglucosan can be used in the manufacture of epoxy resins, ant parasitic and insecticides. The organic compounds identified include 2-methylanthraquinone as one of the main component responsible for the resistance of the teak wood to biological factors (fungi and termites). The syringyl (S)/guaiacyl (G) ratio of heartwood and sapwood was 0.51 and 0.50, respectively. (Vinícius Resende de Castro,Paula Gabriella Surdi, Nov 2022, article no 18441).

4. Material and Methods

4.1 Phytochemical Test Activity

To know the phytochemical composition of sapwood and heartwood of eight provenances, the experiment was follow by the Harborne JB method. According to the Harborne JB method, Alkaloids content was measured using Dragendroff's and Wagner's Reagent and the content of Saponins was measured by Distilled Water, Shake (sipping) test. Tannin content was determined by 10% $FeCl_3$, (Dil.) H_2SO_4 reagent, then, Flavonoids content was measured with a small amount of magnesium and HCl reagent and then,10% Lead acetate test material was used for Glycosides content measurement. Acetic Anhydride,(Conc.) H_2SO_4 (2 Drops), Chloroform + Acetic Anhydride + Conc.HCl (2 Drops) test materials was utilized to measure the content of Steroid and Terpene. The Phenolic content was determined using 10 % $FeCl_3$ reagent. And the polyphenol content was determined using 1 % $K_3Fe(CN)_6$, 1 % $FeCl_3$ reagent, the Lipophenol content was determined using 0.5 N KOH reagent. Reducing sugar content was also tested using Benedict's solution test kit.

Figure 1. Making the Reagent for the Phytochemical Analyzing

4.2. DPPH Radical Scavenging Assay Protocol

Chemicals and materials; Reagents and chemical used in this experiment were of the highest analytical grade.

DPPH radical scavenging assay; The **antioxidant activity** of the different concentration of extracts were determined by the DPPH radical scavenging assay according to Lee *et al*. Briefly, the reaction mixture containing 5 µL of test sample with different concentration (diluted with DMSO) and 95 µL of DPPH (0.3 mM) dissolved in methanol, was taken in a 96-well micro-titer plate and incubated at 37 ˚C for 30 min in the dark. The absorbance was measured at 517 nm by using 96 well microplate reader (SPECTROstar Nano microplate reader (BMG, Labtech, Germany)). Ascorbic acid was used as a standard. Percent Radical Scavenging Activity (% Inhibition) was calculated by using the following formula:

Inhibition (%) = [1 - (Oven Dry Test Compound / Oven Dry Control)]× 100

Results were expressed as Mean ± Standard Error Mean (SEM) of three independent experiments for each test samples. IC_{50} of the samples was calculated by Microsoft Excel 2010.

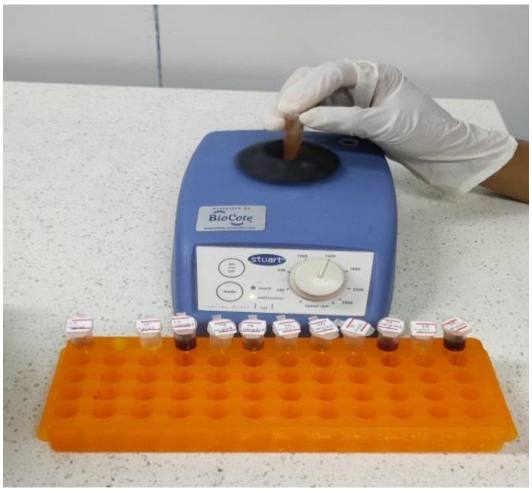

Figure 2. Sample Preparation

Figure 3. Incubation at 37 ˚C for 30 min

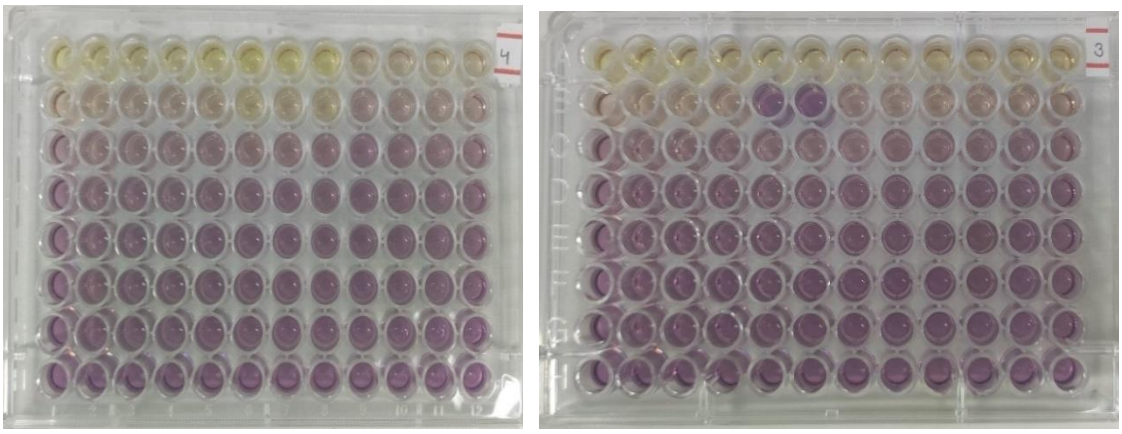

Figure 4. 96 well reaction plates

4.3 Moisture Content Test Activity

The MC of the samples was determined by using an oven-dry method. Oven used for the test are usually electrically heated. To assess the teak wood properties, the sample were cut from the top, middle and bottom parts to get detail data's; 240 samples measuring 20×20×20mm for each region was used to determine the MC.

The MC of the samples was determined by using an oven-dry method.

- The initial weight of each moisture content sample in air -dry condition was weighed and recorded as initial weight.
- After that, the samples were oven-dried at 103 ± 2° C to obtain the constant weight and the oven dried samples were weighed and recorded.
- The M.C of each sample at air dry and green conditions were calculated by using the following equation.

$$MC\ (\%) = \frac{I.wt\ -\ O.D\ wt}{O.D\ wt} \times 100$$

where,

M.C = Moisture Content of Sample
I.wt = Initial Weight of Sample
O.D wt = Oven Dry Weight

Figure 5. Weight of specimen

Figure 6. Oven dried at 60 °C overnight

4.3.1 Evaluation of Termite Resistance

In the tropics, termites, particularly the subterranean species, pose a serious threat to timbers. The accelerated laboratory test was used. The test blocks (20mm x 20mm x20 mm) were oven dried at 60 °C overnight and weighed. The weights were recorded as initial weight W1.

A test site at FRI, highly susceptible to subterranean termites was chosen for study. The design of the field test procedure is as follows: a ditch of consistently 15-20 cm depth is dug to partly layer with residues from coconut fibers and susceptible wood veneers (to bait and aggregate termites). Wood blocks were then placed about this depth above the residue layer and additional amounts of residues added to conceal the blocks, and the ground covered with topsoil. The blocks (5 replications) were kept together according to species to aid identification of the specimens at the end of the test.

After 16 weeks, the specimens were removed from the tested sites and cleaned up. The ground was unearthed, the blocks carefully retrieved, weighed immediately to determine the final wet weight and then oven dried at 60°C in the oven by the same way of determination of initial mass and the final oven dry weight was marked as W2.

The test blocks were also rated according to an arbitrary 0-5 visual scale as: 0 = sound, l = surface, 2= light attack, 3= moderate attack with bore holes, 4= heavy/severe attack and 5= completely destroyed. The grading of termite resistance was estimated by mass loss of specimen and visual observation. The grading by the mass loss of the specimen was corrected by visual observation according to table.

Visual Rating	Rate
No attack (sound)	0
Surface attack	1
Slightly attack	2
Moderately attack	3
Severe attack	4
(completely destroyed)	5

Table 1. Visual rating for termite resistance
Source: American Wood Preservers' Association (AWPA) Rating

Durability Class	Average loss in dry weight (%)
Very Durable	Nil- or negligible
Durable	Up to 5%
Moderately Durable	5-10%
Non-Durable	10-30%
Perishable	Over 30%

Table. 2. Durability Classification of Timber based on Weight Loss
Source: W. P. K. Findlay (1985)

4.3.2. Method of Analysis

To estimate the calculated oven dry weight of each test block, the average initial moisture content (MC) of the MC-sample was used.

Then, the average initial MCs of MC-blocks were calculated based on the average initial air-dry M.C. The calculated oven dry weight of each test sample was calculated by using the following formula.

$$\text{C.O.D.Wt} = \frac{\text{I. Wt} \times 100}{(100 + \text{M.C } \%)}$$

Where, C.O.D.Wt = Calculated Oven Dry Weight of the Sample

To determine the weight loss percent of each of the test samples the following formula was used.

$$\text{Wt. Loss } (\%) = \frac{(\text{C.O.D .Wt} - \text{F.O.D Wt})}{\text{C.O.D. Wt}} \times 100$$

where, C.O.D Wt = Calculated Oven Dry Weight
F.O.D Wt = Final Oven Dry Weight

Figure 7. Sample Preparation Figure 8. Specimen store Plastic Bag

Figure 9. Testing the Evaluation of Termite Resistance

4.4. Total Phenolic Compound (TPC) Content Measurement Test Activity

Measurement of Phenolic Content - The total phenolic content was determined by using the Folin-Ciocalteau method. The extracts were dissolved at 1 mg/mL and diluted with methanol solvent. To each sample (100 µL), 450 µL of Folin–Ciocalteu (1.0 N) was add and stirred vigorously on a vortex mixer. After 5 minutes, 450 µL of sodium carbonate (Na_2CO_3) (0.075 mg/mL) were added and incubate the mixture for an hour at 37˚C . After that, the absorbance was measured at 765 nm and converted to the phenolic content using calibration curve. Different concentration of Gallic acid (50,100,150,200,250,300 and 3500 mg/l) were used for calibration curve of phenolic compound. The total phenolic content was expressed in milligrams per gram of sample (mg GAE/g) and calculated as gallic acid equivalents (GAE).
The total phenolic content was calculated as gallic acid equivalent (GAE) by the following equation:

$$T = C \times V/M$$

T = total phenolic content in mg g^{-1} of the extracts as GAE, (T= mg (GAE)/g of ext)
C = concentration of gallic acid established from the calibration curve in mg ml^{-1},
V = volume of the extract solution in ml and
M = weight of the extract in g .
Data are expressed as mean ± SD of three replicates.

T = cv/m

T = mg (TPC)/g of ext.

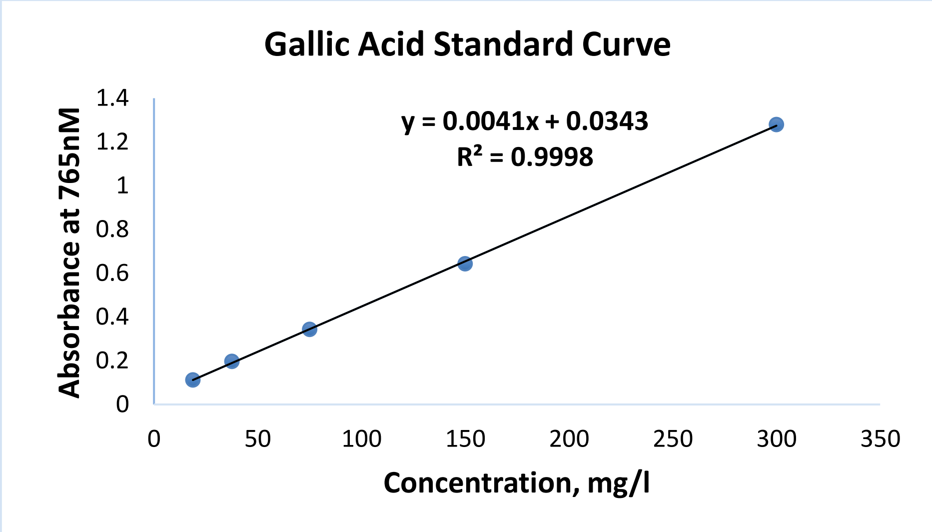

Figure 10. Gallic acid standard curve

Figure 11. Sample Preparation

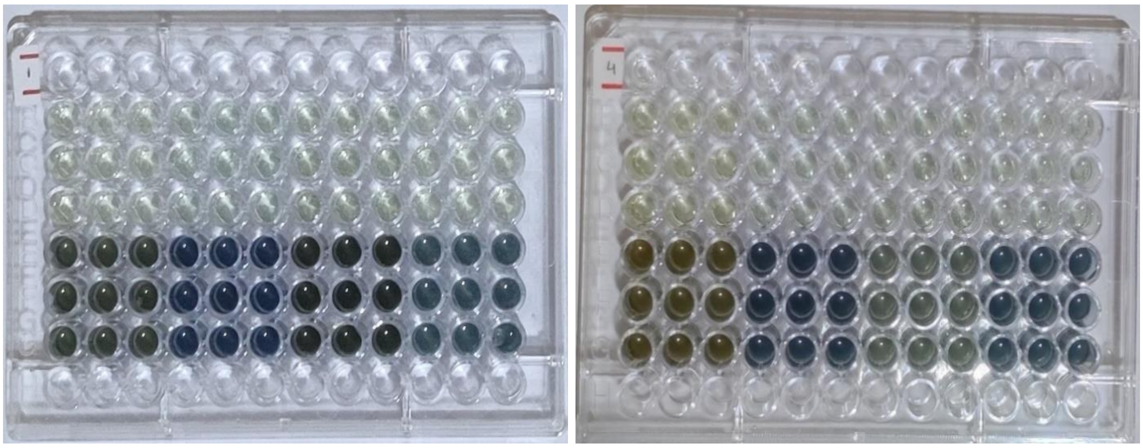

Figure 12. 96 well reaction plates before and after incubation

4.5. GC/MS Test Activity

The analysis was carried out by Perkin–Elmer GC Clarus 690 system. The chromatographic conditions were AOC-20i auto-sampler capillary column (30 × 0.25 µm ID × 0.25 µm df) with column flow rate of 1.0 ml/min. The mass spectrometry conditions were an EI (Electronic ionization) ionization source with electron bombardment energy of 70 eV, ion source temperature of 200 °C, Helium was the carrier gas at 1 mL/min flow rate in split mode and then at a split ratio of 10:1. The temperature of GC injector was adjusted to 250 °C, the initial oven temperature at 100 °C for 2 min and the heating rate was 200 °C for 5 min and then increased the temperature at 280°C for 9 min and analysis the composition of compound. The mass of the samples was subjected by Electron Multiple-Perkin-Elmer mass-detector. The peaks of the compounds, obtained after scanning of the samples, were identified based on the Turbo-Mass ver-5.2 software. The yield of the relative percentage amount was obtained dividing the area of each peak by the total area. The result are shown in the following table.

Figure 13. Making the Reagent for the GC/MS Analyzing

5. Results and Discussion

5.1. Phytochemical Test

Phytochemical analysis is the process of identifying, quantifying, and characterizing the phytochemicals within a plant. This analysis is emphasize for understanding the potential medicinal or nutritional value of plant, as well as for quality control and standardization of plant-based products and along with the search for bioactive constituents that may be helpful production of therapeutic drugs. In the current study the phytochemical analysis of HCl, EtOH, D/w and Petether extracts of Sapwood and heartwood of *Tectona grandis* from eight proveniences is carried out as show in table (3 to 4). Alkaloids, Glycoside, Polyphenol, Saponin and Tannins were detected in all extract of heart wood and sapwood of teak from eight proveniences. Terpene phytochemical compound was found only in the heartwood of Bago provenance test block.

Alkaloids play an essential role in both human medicine and in an organism's natural defense. In plants, alkaloids protect plants from predators and regulate their growth. Therapeutically, alkaloids are particularly well known as ana-esthetics, cardio protective, and anti-inflammatory agents.

Glycosides perform a variety of biological functions, including pest control, growth regulation, and plant development. Glycosides are important in medicine and pharmacology due to their medicinal properties to treat heart failure and arrhythmias etc..

Polyphenol are secondary metabolites of plants and are generally involved in defense against ultraviolet radiation or aggression by pathogens and may also contribute to the bitterness, astringency of the food. Polyphenols provide a significant protection against development of several chronic diseases such as cardiovascular diseases (CVDs), cancer, diabetes, infections, aging, asthma etc.

Saponin are important in human and animal nutrition. Saponin have significant activity to kill protozoans and mollusk's, to have an effect on cold blooded animals, also to have the analgesic, anti-nociceptive, antioxidant activity, to impair the digestion of protein, to cause hypoglycemia and to act as antifungal and antiviral agents.

Tannins possess antiviral, antibacterial, and antitumor activity. Tannins found in the plants can effectively improve the quality of meat and milk, and enhance the oxidative stability of the product.

Terpene (Terpenoids) have a wide range of medicinal uses. It have the potential to serve as anticancer and antidiabetic reagents and then anti-inflammatory, antioxidant, antiseptic, antiplasmodial, astringent, digestive, diuretic ect…

No	Test	Extr-act	Test Reagent	Preferen-ces	Observation							
					Kanbalu (Sapwood)	Kanbalu (Heartwood)	Oaktwin (Sapwood)	Oaktwin (Heartwood)	Phyu (Sapwood)	Phyu (Heartwood)	Nattalin (Sapwood)	Nattalin (Heartwood)
1.	Alkaloids	1% HCl	Wagner's Reagent	Orange PPT	+	+	+	+	+	+	+	+
			Dragendroff's Reagent	Brown PPT	+	+	+	+	+	+	+	+
2.	Flavonoid	EtOH	Small Pieces of Mg Ribbon, HCl (Conc:)	No pink color solution	-	-	-	-	-	-	-	-
3.	Glycoside	D/W	10 % Lead Acetate	White PPT	+	+	+	+	+	+	+	+
4.	Polyphe-nol	EtOH	1% $FeCl_3$, 1% $K_3Fe(CN)_6$, (1 ml)	Greenish blue color solution	+	+	+	+	+	+	+	+
5.	Phenolic	D/W	10 % Ferric Chloride Solution	No dark color solution	-	-	-	-	-	-	-	-
6.	Reducing Sugar	D/W	Benedict's solution	No-brick red color solution	-	-	-	-	-	-	-	-
7.	Saponin	D/W	Shaken vigorously	Froth	+	+	+	+	+	+	+	+
8.	Steroid	EtOH	Acetic Anhydride , (Conc.) H_2SO_4 , $CHCl_3$	No green color solution	-	-	-	-	-	-	-	-
9.	Tannins	EtOH	10% $FeCl_3$, (Dil.) H_2SO_4	Brown color	+	+	+	+	+	+	+	+
10.	Terpene	Pet-ether	Chloroform + Acetic Anhydride + Conc.HCl	No pink color solution	-	-	-	-	-	-	-	-

Table 3. Results of Phytochemical Commpound in sapwood and heartwood of four provenience trial

No	Test	Extr-act	Test Reagent	Preferen-ces	Observation							
					Paukkaung (Sapwood)	Paukkaung (Heartwood)	Taungoo (Sapwood)	Taungoo (Heartwood)	Bago (Sapwood)	Bago (Heartwood)	Thabeikgyin(Sapwood)	Thabeikgyin(Heartwood)
1.	Alkaloids	1% HCl	Wagner's Reagent	Orange PPT	+	+	+	+	+	+	+	+
			Dragendroff 's Reagent	Brown PPT	+	+	+	+	+	+	+	+
2.	Flavonoid	EtOH	Small Pieces of Mg Ribbon, HCl (Conc:)	No pink color solution	-	-	-	-	-	-	-	-
3.	Glycoside	D/W	10 % Lead Acetate	White PPT	+	+	+	+	+	+	+	+
4.	Polyphe-nol	EtOH	1% $FeCl_3$, 1% $K_3Fe(CN)_6$,(1ml)	Greenish blue color solution	+	+	+	+	+	+	+	+
5.	Phenolic	D/W	10 % Ferric Chloride Solution	No dark green color sol:	-	-	-	-	-	-	-	-
6.	Reducing Sugar	D/W	Benedict's solution	No-brick red color solution	-	-	-	-	-	-	-	-
7.	Saponin	D/W	Shaken vigorously	Froth	+	+	+	+	+	+	+	+
8.	Steroid	EtOH	Acetic Anhy dride,(Conc. H_2SO_4 $CH Cl_3$	No green color solution	-	-	-	-	-	-	-	-
9.	Tannins	EtOH	10% $FeCl_3$, (Dil. H_2SO_4	Brown color	+	+	+	+	+	+	+	+
10.	Terpene	Pet-ether	Chloroform + Acetic Anhydride + Conc.HCl	No pink color solution	-	-	-	-	-	+	-	-

Table 4. Results of Phytochemical Commpound in sapwood and heartwood of four provenience trial

5.2. Antioxidant Test Activity

Antioxidant activity of plants is largely attributed to the presence of bioactive compounds in them. In the present study, the antioxidant activities of sapwood and heartwood of teak from different trial were determined by DPPH radical scavenging assay using ascorbic acid as a reference antioxidant standard. The values are expressed as milligrams of ascorbic acid equivalents per gram sample. The calculated IC_{50} values for the teak extract were found in the range of 139 -267µg/ml of heartwood extract and range of 141-287 µg/ml of sapwood extract, indicating good antioxidant potential of the teak extracts. In this study, the average antioxidant activities of the sapwood extract (171.625µg/ml) were larger than the heartwood extract of teak from different trial (154.125µg/ml). This result tend to the antioxidant activity is more abundance in the sapwood than the heartwood at all growing regions. Thus antioxidant activity is more detected in the sapwood than the heartwood of the teak. And according to the overall result, the antioxidant activity level is depend on the sample concentration rate, the more sample concentration rate the more abundance antioxidant activity at both of sapwood and heartwood at all regions. Among the sapwood of teak from eight trials, the most abundance antioxidant activity is Nattalin region's sample and the antioxidant activity is less in Thabeikgyin region's sample. And then in all of the heartwood sample of teak from eight trials, Bago region's sample is least abundance antioxidant activity and the most abundance antioxidant activity is Oaktwin region's sample.

Sample (Concen-tration µg/ml)	**500**	**250**	**125**	**62.5**	**31.25**	**15.625**	**IC_{50} (µg/ml) ± SEM**	**Method**
% Inhibition ± SEM	99.82 ± 0.15	100.83 ± 0.97	100.55 ± 0.13	99.03 ± 0.77	88.04 ± 3.27	27.00 ± 2.55	20.32 ± 0.71	DPPH Radical Scavenging Assay

Table 5. % Inhibition and IC_{50} of Ascorbic acid

No	**Met-hod**	**Prov e-nanc e**	**Speci-es (Extr-act)**	**Sample Concentration (µg/ml)**							**IC_{50} (µg/ml) ± SEM**
				500	**250**	**125**	**62.5**	**31.25**	**15.625**	**7.8125**	
1.	DPPH Radical Scavenging Activity (% Inhibition ±SEM)	Kan-balu	Heart-wood	89.87 ± 1.54	75.30 ± 3.22	47.03 ± 3.28	26.02 ± 0.56	23.06 ± 4.16	4.55 ± 0.88	0.58 ± 0.18	150.17 ± 9.85
			Sap-wood	81.12 ± 1.94	62.89 ± 0.70	36.11 ± 1.09	19.37 ± 0.91	12.84 ± 2.82	6.71 ± 2.35	1.36 ± 2.65	176.80 ± 1.75
2.		Ok-twin	Heart-wood	76.02 ± 4.49	44.77 ± 2.34	22.25 ± 3.43	13.74 ± 1.66	13.14 ± 0.84	7.38 ± 1.38	5.60 ± 1.74	267.30 ± 11.33

			Sap-wood	78.38 ± 1.83	64.39 ± 3.80	40.51 ± 2.24	26.39 ± 1.63	14.91 ± 2.55	6.75 ± 2.06	6.15 ± 0.22	187.67 ± 5.22
3.		Phyu	Heart-wood	44.90 ± 2.96	38.99 ± 1.45	15.04 ± 0.80	12.24 ± 1.58	3.56 ± 4.16	0	0	>500
			Sap-wood	37.87 ± 4.93	30.59 ± 2.99	9.59 ± 1.88	5.95 ± 3.29	0.29 ± 0.70	0	0	>500
4.		Natta-lin	Heart-wood	77.97 ± 9.00	67.43 ± 6.06	37.16 ± 4.88	18.89 ± 0.68	7.07 ± 0.94	0.45 ± 0.20	0.133 ± 0.66	151.92 ± 13.99
			Sap-wood	67.15 ± 0.97	45.70 ± 0.85	20.95 ± 1.15	5.29 ± 1.22	0	0	0	287.20 ± 6.98
5.	DPPH Radical Scavenging Activity (% Inhibition ±SEM)	Pauk-kaung	Heart-wood	74.99 ± 4.40	63.80 ± 0.89	34.01 ± 5.35	19.62 ± 2.17	19.76 ± 13.70	6.53 ± 6.31	0	187.28 ± 8.02
			Sap-wood	86.65 ± 0.80	68.34 ± 1.46	48.64 ± 2.73	28.85 ± 1.90	15.85 ± 0.63	6.35 ± 0.43	5.15 ± 1.73	143.12 ± 4.03
6.		Taungoo	Heart wood	85.22 ± 2.49	74.03 ± 3.90	38.50 ± 3.88	18.80 ± 1.17	8.96 ± 0.67	6.14 ± 2.14	1.99 ± 4.33	164.76 ± 8.33
			Sap-wood	80.47 ± 1.58	58.64 ± 1.34	39.37 ± 1.51	18.76 ± 2.18	8.60 ± 1.00	2.16 ± 0.46	0.03 ± 0.92	183.57 ± 5.82
7.		Bago	Heart-wood	87.38 ± 0.09	74.40 ± 2.22	45.09 ± 2.72	32.19 ± 7.14	19.37 ± 1.46	12.70 ± 4.89	5.76 ± 0.53	139.76 ± 8.00
			Sap-wood	70.79 ± 0.48	47.93 ± 1.49	26.53 ± 1.84	12.01 ± 2.48	2.94 ± 2.38	2.16 ± 1.48	2.62 ± 2.90	256.48 ± 5.69
8.		Tha-beik-gyin	Heart-wood	86.43 ± 2.60	64.72 ± 1.59	35.90 ± 2.64	25.11 ± 9.79	9.78 ± 1.40	4.08 ± 1.71	2.03 ± 0.36	175.00 ± 6.68

			Sap-wood	83.39 ± 1.65	63.69 ± 3.25	45.96 ± 2.35	25.54 ± 1.67	17.83 ± 2.34	11.66 ± 4.47	6.74 ± 2.36	141.11 ± 9.05

Table 6. Results of Antioxidant activity in sapwood and heartwood of eight provenience trial

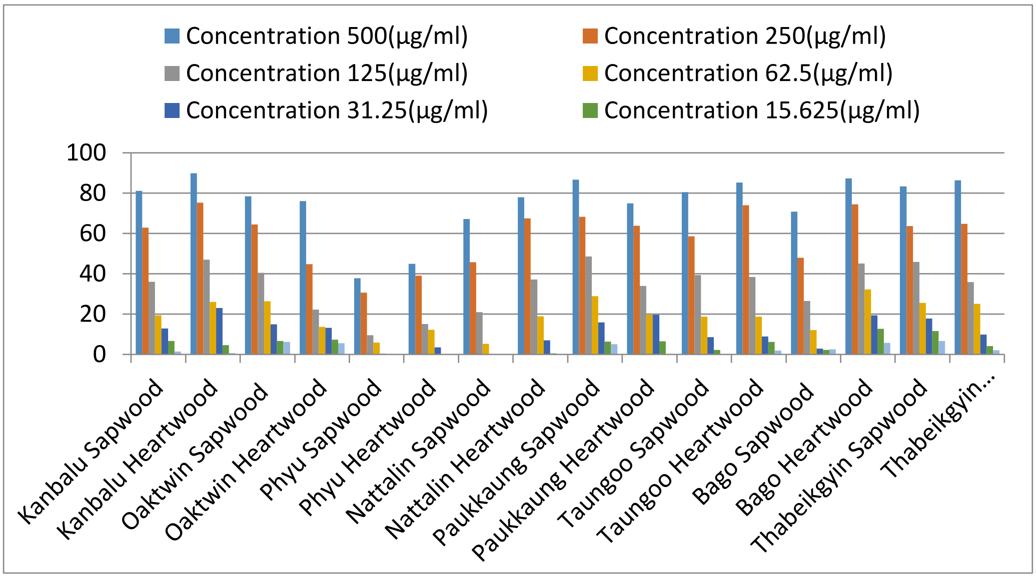

Figure 14. Results of Antioxidant activity in sapwood and heartwood

5.3 Moisture Content

Moisture content of wood plays an important role in the utilization of wood. Because the moisture content found in cell walls could affect density, strength, and dimensions of wood. In the present study, the highest average moisture content of 15-year-old the bottom part of teak wood was 15.71% (Kanbalu), lowest average moisture content of 15-year-old the bottom part of teak wood was 13.52% (Bago). In the middle part of 15-year-old teak wood, the highest average moisture content is 15.93% (Kanbalu) and the lowest moisture content is 13.14% (Taungoo). In the top part of 15-year-old teak wood, the highest average moisture content is 15.20% (Kanbalu) and the lowest moisture content is 13.16% (Thabeikgyin). According to the overall checking result of this moisture content test, Kabalu trial teak have the peak moisture content than others. This fact will help in utilizing too much. In fact, the lowest average moisture content teak of Bago, Taungoo and Thabeikgyin was suitable to use without doing special drying treatment, since there is not too high significant moisture content. (Zen et al.2019).

No	Prove-nances	Sample Size	Moisture Content (%)											
			Bottom				Middle				Top			
			Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
1.	Kanbalu	(20x 20x 20) mm	14.81	16.96	15.71	0.63	14.70	16.78	15.93	0.54	14.53	15.97	15.20	0.56
2.	Oaktwin		14.78	16.33	15.61	0.45	13.11	15.42	13.92	0.75	13.84	16.24	15.11	0.74
3.	Phyu		13.03	15.09	14.30	0.72	12.45	14.60	13.32	0.79	12.53	14.62	13.71	0.58
4.	Nattalin		13.30	14.70	13.77	0.39	13.88	15.35	14.52	0.48	13.64	14.94	14.18	0.41
5.	Pauk-kaung		14.26	15.90	15.23	0.55	13.68	14.87	14.48	0.37	13.14	14.62	13.89	0.51
6.	Taungoo		13.62	15.66	14.89	0.57	12.64	14.41	13.14	0.55	13.19	15.14	14.07	0.60
7.	Bago		13.33	13.77	13.52	0.13	13.48	14.8	14.28	0.33	12.55	14.72	13.75	0.61
8.	Thabeik-gyin		13.03	15.05	14.01	0.60	12.95	14.14	13.59	0.43	12.61	13.97	13.16	0.44

Table 7. Results of Moisture Content in Bottom, Middle & Top of eight provenience trial

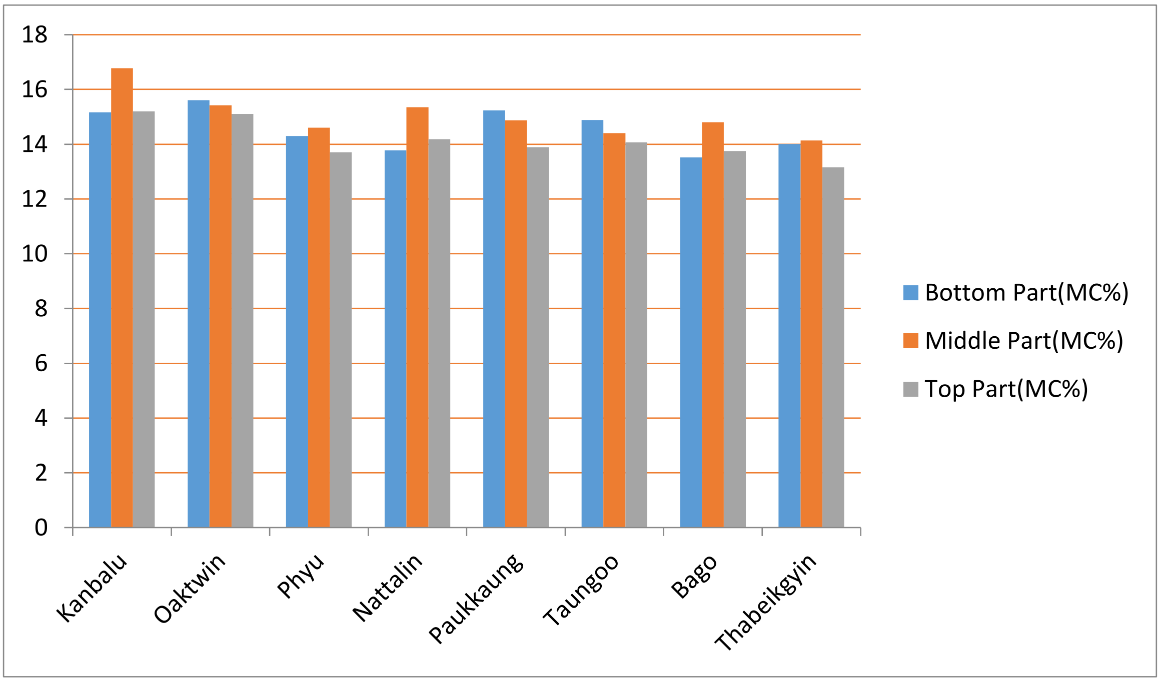

Figure 15. Results of Moisture Content in Bottom, Middle & Top

5.4. Evaluation of Termite Resistance

The percentage weight losses in the test blocks provide a measure of the relative decay resistance. The mean weight losses of the test blocks exposed to the selected termite are given in Table 8. In the present study, the sample was divided by 3 parts as Bottom, Middle and Top for the 15 year-old-teak wood form 8 trials. The analysis revealed not large differences between the three parts of wood sample in the percentage of weight loss caused by decay termite and the mean weight loss was less than 10% , in detail it was around 5% at all parts and trial. But according to the descending the results, Bago, Taungoo and Natalin sample block was the durable class and in Kabalu sample block, the bottom part is durable class but the middle and top part are moderated durable class. And the left regions, Tabaikkyin, Oaktwin, Phyu and Paukkaung, trial sample block were moderately durable class. By the deciding based on the weight loss test, the wood quality of Bago teak are the best (Exact 5% Avg Weight Loss) and second is Taungoo (5.1-5.3% Avg Weight Loss) and the third is Natalin (5.3 – 5.4% Avg Weight Loss). Paukkaung trial sample block is the highest weight loss percentage among all trial block, it is 5.7 - 5.9 % Avg Weight loss.

Specimen Block		**Avg Initial Wt**	**Avg Oven Dry Wt**	**Avg COD Wt**	**Avg MC (%)**	**Avg Wt Loss (%)**	**Durability Class**
Bago	Bottom	5.058	3.927	4.134	22.36	5.007	Durable (Class II)
	Middle	6.05	4.694	4.942	22.41	5.0182	
	Top	6.449	4.999	5.2653	22.48	5.0505	
Taungoo	Bottom	5.3	4.094	4.3175	22.7547	5.1	
	Middle	5.059	3.91	4.1227	22.71	5.1592	
	Top	6.114	4.7	4.9658	23.12	5.35	
Natalin	Bottom	5.565	4.274	4.517	23.198	5.379	
	Middle	5.227	4.01	23.27	4.2399	5.42	
	Top	4.922	3.775	3.9918	23.3	5.4311	
Kanbalu	Bottom	5.38	4.12	4.359	23.42	5.48	
	Middle	5.582	4.27	4.5198	23.5	5.52	Moderate durable (Class III)
	Top	4.826	3.69	3.9067	23.53	5.5468	
Tabaikkyin	Bottom	5.089	6.5	4.1186	23.5600	5.5500	
	Middle	5.744	4.41	4.67	23.22	5.567	
	Top	5.098	3.808	4.1215	23.69	5.6168	
Oaktwin	Bottom	5.215	3.979	4.2165	23.69	5.6207	
	Middle	4.695	3.58	3.7942	23.74	5.6454	
	Top	5.877	4.48	4.7483	23.77	5.6504	
Phyu	Bottom	5.172	3.94	4.1775	23.81	5.675	
	Middle	5.057	3.851	4.0828	23.8600	5.7019	
	Top	5.159	3.925	4.163	23.91	5.717	
Paukkaung	Bottom	4.59	3.49	3.7028	23.9600	5.7470	
	Middle	5.591	4.23	4.5095	23.98	5.7545	
	Top	4.656	3.521	3.743	24.37	5.931	

Table 8. Results of Evaluation of Termite Resistance in Bottom, Middle & Top

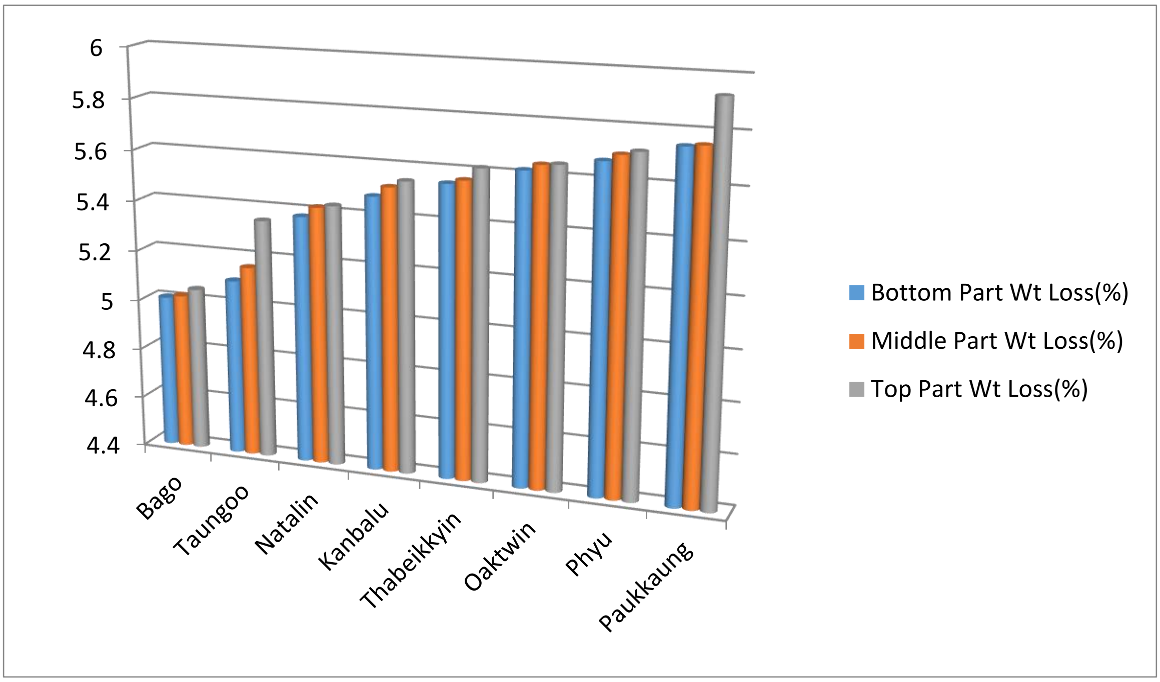

Figure 16. Results of Evaluation of Termite Resistance in Bottom, Middle & Top

5.5. Total Phenolic Compound (TPC) Content Measurement Test Activity

The high natural durability of teak is an important characteristic that has been attributed to various compounds identified in the extractives of teak (Rudman *et al.* 1958; Lukmandaru *et al.*2009). Quinones and their derivatives in the extractives of teak have been reported to defend against termite and fungal attack (Sumthong *et al.* 2006; Thulasidas *et al.* 2007; Niamké 2011). Quinone is the one of the sub-phenolic compound. Phenolic compounds are important plant constituents with redox properties, thus imparting antioxidant activity since hydroxyl groups in these compounds are responsible for facilitating free radical scavenging [25]. They are believed to account for a major portion of the antioxidant capacity in many plants [26]. The total phenolic content of the heartwood varied from 62.20 ± 0.84 mg (GAE)/g of extract, it is the highest TPC of Paukkaung among the eight trial of heartwood sample and also in the sapwood sample Paukkaung sample block is highest TPC (63.82 ± 11.23 mg (GAE)/g of extract). In TPC test, when comparing the sapwood and heart wood, the average TPC detected in the heartwood is more than the sapwood. But in some trial condition, the TPC of sapwood is larger than the heartwood , such as the sample block of Kanbalu, Oaktwin, Paukkaung and Thabeikgyin. The antioxidant activity of the teak wood extracts and their respective total phenolic contents were positively correlated. The results suggested that the phenolic compounds contributed significantly to the antioxidant capacity of medicinal plants.

No	Gallic Acid Standard Calibration Curve	Provenance		Observation (mg GAE/G of Extract) Mean ± SD
1.	y = 00041 x + 0.0343 R^2 = 0.998	Kanbalu	Heartwood	44.88 ± 2.93
			Sapwood	49.27 ±1.22
2.		Oktwin	Heartwood	34.63 ± 0.65

			Sapwood	43.82 ± 1.15
3.		Phyu	Heartwood	49.02 ± 0.65
			Sapwood	48.29 ± 0.98
4.		Nattalin	Heartwood	51.06 ± 2.54
			Sapwood	37.01 ± 1.60
5.		Paukkaung	Heartwood	62.20 ± 0.84
			Sapwood	63.82 ± 11.23
6.		Taungoo	Heartwood	48.13 ± 2.55
			Sapwood	38.29 ± 0.24
7.		Bago	Heartwood	47.07 ± 0.00
			Sapwood	30.81 ± 0.75
8.		Thabeikgyin	Heartwood	43.82 ± 0.86
			Sapwood	46.50 ± 0.99

Table 9. Results of Total Phenolic Compound (TPC) Test in sapwood and heartwood

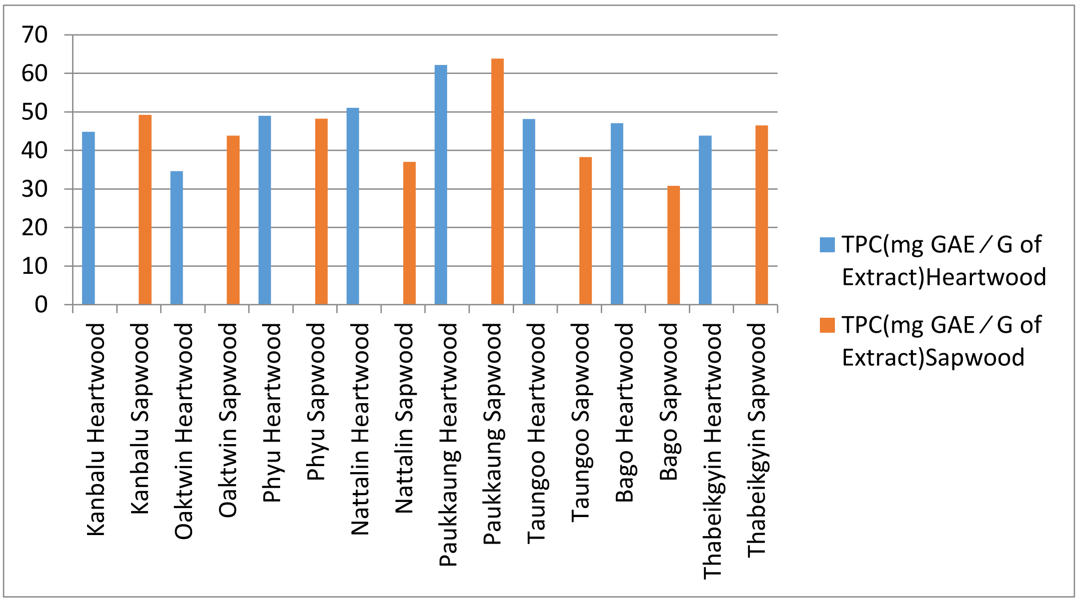

Figure 17. Results of Total Phenolic Compound (TPC) Test in sapwood and heartwood

5.6 GC/MS Test

The bioactive compounds were identified based on retention time, MS fragment ions generated and the percentage of these bioactive compounds was evaluated from the total peak area.From the analysis result, the GCMS test by using ethanol extract, there are respectively 20 compounds contained in sapwood and heartwood of teak from eight trials such as (1) Toluene, (2) 2-Pentanone, 4-hydroxy-4-methyl- , (3) Tetradecanem, (4) Heneicosane, (5) Hexadecanoic acid, methyl ester, (6) 9,12-Octadecadienoic acid(Z,Z), methyl ester, (7) 9-Octadecenoic acid(Z)-, methyl esterm (8) 8-Octadecenoic acid, methyl ester,(E)-, (9) 9-Octadecenoic acid, methyl ester,(E)-, (10) Oleoyl chloride, (11) Methyl stearate, (12) 6-Octadecenoic acid, methyl ester,(Z)-, (13) Cis-11-Eicosenoic acid, methyl ester, (14) Diisooctyl phthalate, (15) .gamma.-Sitosterol, (16) .gamma.-Sitosterol, (17) Squalene, (18) Stigmasterol, (19) Ergost-25-ene-3,5,6-triol, (3.beta., 5.alpha.,6beta)-, (20) .gamma.-Sitostenone. 4 trials of take sample such as Nattalin, Paukkaung, Bago and Thabeikgyin, contained 20 kinds of compounds in both sapwood and heartwood. However, in the Heartwood of Kanbalu and Oktwin were found, there is only 19 kinds of compounds and Phyu’s heartwood and Taungoo Heartwood contained only 18 kinds of compound. The top two major compounds were 9, 12-Octadecadienoic acid (ZZ) and 9-Octadecenoic acid(Z)-, methyl ester in this experiment trial**.** These compounds have great potential antioxidant, anti-cancer, and anti-inflammatory properties and have been detected that justifies the traditional application and predicts the possibility of discovery of new drugs. Considering the biological activities of compounds present in *teak* supports the medicinal application of these plants**.**(J. Biomed. Pharmaceut. Sci., 5 (4) (2018), pp. 23-29). Other compounds present in this experiment comparatively in fewer amounts. Not all the compounds were found as common in all sapwood and heartwood of all trial, there is a little difference in containing list of compounds. All of the heartwood and sapwood contained 9-Octadecenoic acid(Z)-, methyl ester compound as the most abundance. Among them, the content of 9-Octadecenoic acid(Z)-, methyl ester in Oaktwin sapwood and Taungoo sapwood sample is the highest (80.91% - peak area), the second highest abundant compound is Nattalin sapwood (80.91%- peak area) and the third one is Kanbalu sapwood (79.79%-peak area). But the sapwood of Thabeikgyin sample contained 9,12-Octadecadienoic acid(Z,Z), methyl ester (88.96% -peak area) as the most abundance compound. Moreover, in the trial of Phyu sample block, the most abundance compound is 9-Octadecenoic acid(Z)-, methyl ester (E)-(70.26% - peak area) in heartwood sample and 8-Octadecenoic acid(Z)-, methyl ester,(E) - (62.81% - peak area) in sapwood sample. However that two kinds of compound is the same molecular formula and the same connectivity of atoms, it is just differ in the three-dimensional arrangement of their atoms in space and its some properties. 9-Octadecenoic acid(Z)-, methyl ester (80.91) , the formula ($C_{19}H_{36}O_2$) is almost colorless and odorless, it cannot be soluble in pure water but alcohol. It can be used in perfuming agents, skin repairing agents, detergent agents, crystal retardant for agrochemicals, solvent for emulsifiable concentrate of agrochemicals and raw material for spin finishes and oiling agent for textile.

No	Prove-nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
1.	Kan-balu	Heart-wood	3.132	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.32
			26.197	➢ tau-Muurolol	$C_{15}H_{26}O$	222	1.29
			26.370	➢ Bicyclo(4,4,0)dec-1-ene, 2-isopropyl -5-methyl-9-methylene-	$C_{15}H_{24}$	204	0.29
			26.697	➢ .alpha.-Cadinol	$C_{15}H_{26}O$	222	1.87
			34.283	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.72
			36.440	➢ 4a-Methyl-1-methy lene-1,2,3,4, 4a, 9, 10, 10a-octahydrophe nanthrene	$C_{16}H_{20}$	212	0.55
			36.781	➢ 1,4-Naphthalenedi one, 2-hydroxy-3-(3-methyl-2-butenyl)	$C_{15}H_{14}O_3$	242	1.02
			36.995	➢ 4a-Methyl-1-methyl ene-1,2,3,4,4a,9,10,10 a–octa hydrophenan threne	$C_{16}H_{20}$	212	0.42
			37.118	➢ 2H-Naphtho(2,3-b) pyran -5,10-dione,2,2-dimethyl	$C_{15}H_{12}O_3$	240	0.24
			37.927	➢ 9,12-Octadecadienoic acid(Z,Z),methyl ester	$C_{19}H_{34}O_2$	294	6.37

			38.079	➢	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296	76.78
			38.537	➢	Methyl stearate	$C_{19}H_{38}O_2$	298	6.16
			41.734	➢	Cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.36
			42.638	➢	2H-Furo(2,3-b)indole, 3, 3a,8,8a-tetrahydro -2,3-di methyl-	$C_{12}H_{15}NO$	189	0.48
			45.828	➢	Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.24
			47.856	➢	.gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.39
			49.776	➢	.psi..,.psi.-Carotene, 7,7’ ,8,8’,11, 11’,12,12,15,15’ -decahydro-	$C_{40}H_{66}$	546	0.56
			51.264	➢	Stigmasta-7,25-dien-3-ol, 3.beta.,5alpha..)-	$C_{29}H_{48}O$	412	0.26
			51.355	➢	Stigmast-4-en-3-one	$C_{29}H_{48}O$	412	0.31
	Kan-balu	Sap-wood	3.117	➢	2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.31
			18.103	➢	Tetradecane	$C_{14}H_{30}$	198	0.34
			23.918	➢	Heneicosane	$C_{21}H_{44}$	296	0.19
			34.276	➢	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	1.09
			37.924	➢	9,12-Octadecadienoic acid(Z,Z),methyl ester	$C_{19}H_{34}O_2$	294	7.36
			38.087	➢	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296	79.79
			38.531	➢	Methyl stearate	$C_{19}H_{38}O_2$	298	3.57
			38.675	➢	6- Octadecenoic acid, methyl ester(Z)-	$C_{19}H_{36}O_2$	296	0.16
			41.725	➢	Cis-13-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.39
			45.818	➢	Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	1.50
			47.856	➢	.gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.23
			49.774	➢	Squalene	$C_{30}H_{50}$	410	1.06
			50.355	➢	9,19-Cycloergost-24 (28) -en-3-ol,4,14-di methyl-, acetate,(3, beta. ,	$C_{32}H_{52}O_2$	468	0.19
			50.865	➢	24(S)-Ethyl-3.alpha, 5. alpha.-cyclocholest-22 (E)-en-6-one	$C_{29}H_{46}O$	410	0.59
			50.946	➢	Pseduosarsassappogenin-5-en methyl ether	$C_{29}H_{48}O_4$	460	0.24
			51.265	➢	Stigmasta-7,25-dien-3-ol, (3.beta.,5.alpha.)	$C_{29}H_{48}O$	412	0.37
			51.330	➢	Stigmasta-7,25-dien-3-ol, (3.beta.,5.alpha.)	$C_{29}H_{48}O$	412	0.22
			52.348	➢	24-Methylenecycloar tan-3-one	$C_{31}H_{50}O$	438	0.21

			52.961	➢ .gamma.-Sitostenone	$C_{29}H_{48}O$	412	1.90
			53.130	➢ 2-Butanone,4-(2,6,6-tri methyl-2-cyclo hexen-1-yl)-,(R)-	$C_{13}H_{22}O$	194	0.31

Table 10. Results of GC/MS Test in sapwood and heartwood from Kanbalu provenience trial

No	Prove nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
2.	Ok-twin	Heart-wood	2.285	➢ Toluene	C_7H_8	92	0.18
			3.111	➢ 2-Pentanone, 4-hydr oxy-4-methyl-	$C_6H_{12}O_2$	116	0.56
			18.107	➢ Tetradecane	$C_{14}H_{30}$	198	0.30
			34.275	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.34
			36.781	➢ 1,4-Naphthalenedione ,2-hydroxy-3-(3-methyl -2-butenyl)	$C_{15}H_{14}O_3$	242	0.44
			37.918	➢ 9,12-Octadecadienoic acid (Z,Z),methyl ester	$C_{19}H_{34}O_2$	294	6.41
			38.059	➢ 9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296	74.10
			38.531	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	4.77
			41.727	➢ Cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.49
			45.826	➢ Bis(2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$	390	0.18
			47.872	➢ .gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.35
			47.979	➢ .gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.23
			49.781	➢ Squalene	$C_{30}H_{50}$	410	7.32
			50.165	➢ Stigmast-7-en-3-ol, (3.beta.,5alpha..,24S)-	$C_{29}H_{50}O$	414	0.25
			50.384	➢ 2-Isopropenyl-4,4,7a-trimethyl-2,4,5,6,7,7a-hexahydro-benzofura	$C_{14}H_{22}O_2$	222	0.31
			50.861	➢ 24(S)-Ethyl-3,alpha., 5. alpha.,cyclochholest-22E)-en-6-one	$C_{29}H_{48}O$	410	0.62
			51.279	➢ Stigmasta-7,25-dien-3-ol,(3.beta., 5.alpha.)	$C_{29}H_{48}O$	412	0.84
			51.350	➢ Stigmasta-7,25-dien-3-ol, (3.beta.,5.alpha.)	$C_{29}H_{48}O$	412	0.69
			52.350	➢ 24-Methylenecycloar tan-3-one	$C_{31}H_{50}O$	438	0.24
			52.965	➢ .gamma.-Sitostenone	$C_{29}H_{48}O$	412	1.37
	Ok-twin	Sap-wood	2.289	➢ Toluene	C_7H_8	92	0.14

			3.115	➢ 2-Pentanone, 4-hydr oxy-4-methyl-	$C_6H_{12}O_2$	116	0.57
			18.101	➢ Tetradecane	$C_{14}H_{30}$	198	0.13
			30.958	➢ Heneicosane	$C_{21}H_{44}$	296	0.21
			34.277	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.43
			37.916	➢ 9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	6.55
			38.053	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	81.90
			38.320	➢ 8-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.03
			38.360	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.01
			38.455	➢ Oleoyl chloride	$C_{18}H_{33}ClO$	300	0.29
			38.525	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	3.87
			38.715	➢ 6-Octadecenoic acid, methyl ester,(Z)-	$C_{19}H_{36}O_2$	296	0.18
			41.723	➢ Cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.42
			45.814	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	1.86
			47.873	➢ .gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.46
			47.974	➢ .gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.43
			49.765	➢ Squalene	$C_{30}H_{50}$	410	0.63
			51.272	➢ Stigmasterol	$C_{29}H_{48}O$	412	0.55
			51.355	➢ Ergost-25-ene-3,5,6-triol ,(3.beta.,5.alpha.,6beta)-	$C_{28}H_{48}O_3$	412	0.49
			52.952	➢ .gamma.-Sitostenone	$C_{29}H_{48}O$	412	0.84

Table 11. Results of GC/MS Test in sapwood and heartwood from Oktwin provenience trial

No	Prove-nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
3.	Phyu	Heart-wood	2.020	➢ Octanoic acid, 7-oxo-	$C_8H_{14}O_3$	158	0.03
			2.284	➢ Toluene	C_7H_8	92	0.05
			3.112	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.16
			18.097	➢ Tetradecane	$C_{14}H_{30}$	198	0.07
			34.276	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	5.66
			35.983	➢ cis-10-Heptadecenoic acid, methyl ester	$C_{18}H_{34}O_2$	282	0.06
			36.488	➢ Heptadecenoic acid, methyl ester	$C_{18}H_{36}O_2$	284	0.09
			36.767	➢ 1,4-Naphthalenedi one, 2-hydroxy-3-(3-methyl-2-butenyl)-	$C_{15}H_{14}O_3$	242	0.65

			37.114	➢	2H-Napptho(2,3-b) pyran-5,10-dione,2,2-dimethyl-	$C_{15}H_{12}O_3$	240	0.09
			37.929	➢	9,12-Octadecadienoic acid(Z,Z),methyl ester	$C_{19}H_{34}O_2$	294	8.42
			38.144	➢	9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	70.26
			38.360	➢	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296	1.67
			38.537	➢	Octadecanoic acid, methyl ester	$C_{19}H_{38}O_2$	298	10.22
			38.805	➢	9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.19
			38.875	➢	17-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	0.13
			41.722	➢	cis-13-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.27
			44.644	➢	9-Octadecenoic acid, 1,2,3-propanetriyl ester , (E,E,E)-	$C_{57}H_{104}O_6$	884	0.07
			49.768	➢	Squalene	$C_{30}H_{50}$	410	1.91
	Phyu	Sap-wood	3.119	➢	2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.22
			34.288	➢	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	3.70
			35.805	➢	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	1.15
			37.930	➢	9,12-Octadecadienoic acid(Z,Z),methyl ester	$C_{19}H_{34}O_2$	294	7.82
			38.115	➢	8-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	62.81
			38.165	➢	cis-13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	6.73
			38.334	➢	9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	2.07
			38.395	➢	6-Octadecenoic acid, methyl ester(Z)-	$C_{19}H_{36}O_2$	296	0.58
			38.430	➢	cis-13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	1.31
			38.537	➢	Octadecanoic acid, methyl ester	$C_{19}H_{38}O_2$	298	7.56
			38.710	➢	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296	0.55
			38.795	➢	9-Hexadecanoic acid, methyl ester(Z)-	$C_{17}H_{32}O_2$	268	0.17
			39.201	➢	trans, trans -9,12-Octadecadienoic acid, propyl ester	$C_{21}H_{38}O_2$	322	0.79

			39.302	➢ (E)-9-Octadecenoic acid ethyl ester	$C_{20}H_{38}O_2$	310	0.76
			39.789	➢ Octadecenoic acid ethyl ester	$C_{20}H_{40}O_2$	312	0.41
			41.047	➢ 9,12-Octadecadienoic acid, ethyl ester	$C_{20}H_{36}O_2$	308	0.69
			41.726	➢ cis-13-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.24
			43.267	➢ Eicosanoic acid, ethyl ester	$C_{22}H_{44}O_2$	340	0.16
			45.818	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.58
			49.771	➢ Squalene	$C_{30}H_{50}$	410	1.70

Table 12. Results of GC/MS Test in sapwood and heartwood from Phyu provenience trial

No	Prove-nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
4.	Natta-lin	Heart-wood	2.302	➢ Toluene	C_7H_8	92	0.10
			3.129	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.27
			18.112	➢ Tetradecane	$C_{14}H_{30}$	198	0.17
			34.279	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.74
			35.818	➢ Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	0.13
			36.225	➢ 2,4,6-cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl) -4-(1	$C_{15}H_{18}O_2$	230	0.16
			36.453	➢ 4a-Methyl-1-methyl ene-1,2,3,4,4a,9,10,10 a –octahydrophenan hrene	$C_{16}H_{20}$	212	0.71
			36.776	➢ 1,4-Naphthalenedione ,2-hydroxy-3-(3-methyl -2-butenyl)-	$C_{15}H_{14}O_3$	242	1.06
			37.010	➢ 2H-Nappthо(2,3-b) pyran-5,10-dione,2,2-dimethyl-	$C_{15}H_{12}O_3$	240	0.59
			37.125	➢ 9,12-Octadecadienoic acid(Z,Z),methyl ester	$C_{19}H_{34}O_2$	294	0.37
			37.931	➢ 9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$	296	8.04
			38.103	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	78.26
			38.155	➢ cis-13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	0.14
			38.327	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.12

			38.434	➢ 10-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	0.12
			43.267	➢ Eicosanoic acid, ethyl ester	$C_{22}H_{44}O_2$	340	0.16
			45.818	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.58
			49.771	➢ Squalene	$C_{30}H_{50}$	410	1.70
	Natta-lin	Sapwood	2.296	➢ Toluene	C_7H_8	92	0.20
			3.123	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.56
			18.115	➢ Tetradecane	$C_{14}H_{30}$	198	0.55
			23.936	➢ Heneicosane	$C_{21}H_{44}$	296	0.31
			29.972	➢ (E)-4-(3-hydroxyprop-1-en-1-yl)-2-methoxyphenol	$C_{10}H_{12}O_3$	180	1.03
			30.130	➢ Benzene,(1-ethyldecy1)-	$C_{18}H_{30}$	246	0.30
			30.967	➢ Heneicosane	$C_{21}H_{44}$	296	0.22
			34.290	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.50
			35.823	➢ Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	0.24
			37.927	➢ 9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	6.64
			38.065	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	80.91
			38.433	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.20
			38.539	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	4.68
			39.208	➢ 9,12-Octadecadienoic acid(Z,Z), ethyl ester	$C_{20}H_{36}O_2$	308	0.26
			39.304	➢ Ethyl Oleate	$C_{20}H_{38}O_2$	310	0.19
			41.738	➢ cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.44
			45.826	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	1.11
			47.870	➢ .gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.33
			49.777	➢ Squalene	$C_{30}H_{50}$	410	1.13
			50.276	➢ Stigmast-8(14)-en-3.beta.-ol	$C_{29}H_{50}O$	414	0.18

Table 13. Results of GC/MS Test in sapwood and heartwood from Nattalin provenience trial

No	Prove nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
5.	Paukk aung	Heart-wood	3.121	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.07
			34.260	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	11.19

			35.973	➢ cis-10-Heptadecenoic acid, methyl ester	$C_{18}H_{34}O_2$	282	0.10
			36.498	➢ Heptadecenoic acid, methyl ester	$C_{18}H_{36}O_2$	284	0.14
			36.804	➢ 1,4-Naphthalenedione, 2-hydroxy-3-(3-methyl-2-butenyl)-	$C_{15}H_{14}O_3$	242	0.63
			38.285	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	75.36
			38.573	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	7.91
			39.077	➢ 9-Octadecenoic acid,(E)-	$C_{18}H_{34}O_2$	282	1.54
			39.420	➢ Oxiraneoctanoic acid, 3-octyl-, methyl ester, trans-	$C_{19}H_{36}O_3$	312	0.45
			39.730	➢ 8,11-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294	0.42
			39.907	➢ cis-10-Nonadecenoic acid, methyl ester	$C_{20}H_{38}O_2$	310	0.08
			41.735	➢ cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.44
			44.659	➢ Glycidyl oleate	$C_{21}H_{38}O_3$	338	0.19
			44.891	➢ Glycidyl palmitate	$C_{19}H_{36}O_3$	312	0.10
			47.850	➢ .gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.08
			48.124	➢ 9-Octadecadienoic acid (Z)-,2,3-dihydroxypropyl ester	$C_{21}H_{40}O_4$	356	0.27
			49.782	➢ Squalene	$C_{30}H_{50}$	410	0.51
			50.361	➢ 9,19-Cyclolanosstan-3-ol, 24-methylene-, (3.beta.)-	$C_{31}H_{52}O$	440	0.24
			52.343	➢ 24-Methylenecycloartan-3-one	$C_{31}H_{50}O$	438	0.13
			52.956	➢ .gamma.-Sitosterol	$C_{29}H_{48}O$	412	0.14
	Pauk-kaung	Sapwood	34.289	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	10.71
			35.802	➢ Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	0.30
			37.939	➢ 9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	6.29
			38.183	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	61.79
			38.360	➢ 9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294	1.91
			38.426	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	1.62
			38.539	➢ Methyl stearate	$C_{19}H_{38}O_2$	2998	10.23
			38.940	➢ 9-Octadecenoic acid(Z)-, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.99

			39.040	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	0.97
			39.095	➢ 9-Octadecenoic acid(Z)-, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.44
			39.195	➢ 9,12-Octadecadienoic acid(Z,Z), ethyl ester	$C_{20}H_{36}O_2$	308	0.89
			39.294	➢ (E)-9-Octadecenoic acid ethyl ester	$C_{20}H_{38}O_2$	310	0.77
			39.435	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	0.44
			39.550	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	o.26
			39..645	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.27
			39.783	➢ Octadecenoic acid, ethyl ester	$C_{20}H_{40}O_2$	312	0.39
			41.722	➢ cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.22
			49.767	➢ Squalene	$C_{30}H_{50}$	410	0.41
			52.350	➢ Tricyclo(20.8.0.0(7,16)tri accontane,1(22),7(16)-di epoxy-	$C_{30}H_{52}O_2$	444	0.32
			52.468	➢ 9-Octadecenoic acid, 1,2, 3-propanetriyl ester, (E,E,E)-	$C_{57}H_{104}O_6$	884	0.80

Table 14. Results of GC/MS Test in sapwood and heartwood from Paukkaung provenience trial

No	Prove-nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
6.	Taung -oo	Heart-wood	2.285	➢ Toluene	C_7H_8	92	0.18
			3.111	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.56
			18.107	➢ Tetradecane	$C_{14}H_{30}$	198	0.30
			34.275	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.34
			36.781	➢ 1,4-Naphthalenedione, 2-hydroxy-3-(3-methyl-2-butenyl)	$C_{15}H_{14}O_3$	242	0.44
			37.918	➢ 9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	6.41
			38.059	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	74.10
			38.531	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	4.77
			41.727	➢ Cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.49
			51.350	➢ Stigmasta-7,25-dien-3-ol,(3.beta.,5.alpha.)-	$C_{29}H_{48}O$	412	0.69

			52.350	➢	24-Methylenecycloartan-3-one	$C_{31}H_{50}O$	438	0.24
			45.826	➢	Bis(2-ethylhexyl)phthalat	$C_{24}H_{38}O_4$	390	0.18
			47.872	➢	.gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.35
			47.979	➢	.gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.23
			49.781	➢	Squalene	$C_{30}H_{50}$	410	7.32
			50.165	➢	Stigmast-7-en-3-ol, (3.beta.,5alpha..,24S)-	$C_{29}H_{50}O$	414	0.25
			50.384	➢	2-Isopropenyl-4,4,7a-trimethyl-2,4,5,6,7,7a-hexahhydro-benzofuran-	$C_{14}H_{22}O_2$	222	0.31
			50.861	➢	24(S)-Ethyl-3,alpha. ,5.alpha.,cyclochholest-22E)-en-6-one	$C_{29}H_{48}O$	410	0.62
	Taung -oo	Sapwood	2.289	➢	Toluene	C_7H_8	92	0.14
			3.115	➢	2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.57
			18.101	➢	Tetradecane	$C_{14}H_{30}$	198	0.13
			30.958	➢	Heneicosane	$C_{21}H_{44}$	296	0.21
			34.277	➢	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	0.43
			37.916	➢	9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	6.55
			38.053	➢	9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	81.90
			38.320	➢	8-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.03
			38.360	➢	9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.01
			38.455	➢	Oleoyl chloride	$C_{18}H_{33}ClO$	300	0.29
			38.525	➢	Methyl stearate	$C_{19}H_{38}O_2$	298	3.87
			38.715	➢	6-Octadecenoic acid, methyl ester,(Z)-	$C_{19}H_{36}O_2$	296	0.18
			41.723	➢	Cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.42
			45.814	➢	Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	1.86
			47.873	➢	.gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.46
			47.974	➢	.gamma.-Sitosterol	$C_{29}H_{50}O$	414	0.43
			49.765	➢	Squalene	$C_{30}H_{50}$	410	0.63
			51.355	➢	Ergost-25-ene-3,5,6-tri ol,(3.beta.,5.alpha.,6beta)	$C_{28}H_{48}O_3$	412	0.49
			52.952	➢	.gamma.-Sitostenone	$C_{29}H_{48}O$	412	0.84

Table 15. Results of GC/MS Test in sapwood and heartwood from Taungoo provenience trial

No	Prove-nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
7.	Bago	Heart-wood	3.117	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.06
			33.778	➢ 9-Hexadecanoic acid, methyl ester,(Z)-	$C_{17}H_{32}O_2$	268	0.09
			34.095	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	7.40
			34.319	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	11.65
			35.988	➢ cis-10-Heptadecenoic acid, methyl ester	$C_{18}H_{34}O_2$	282	0.06
			38.197	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	63.77
			38.390	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	1.90
			38.544	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	8.70
			39.089	➢ 9-Octadecenoic acid,(E)-	$C_{18}H_{34}O_2$	282	1.59
			39.400	➢ 11-Octadecadienoic acid, methyl ester	$C_{19}H_{36}O_2$	296	0.12
			41.719	➢ cis-11-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.34
			43.907	➢ Oleoyl chloride	$C_{18}H_{33}ClO$	300	0.07
			44..655	➢ Glycidyl oleate	$C_{21}H_{38}O_3$	338	1.51
			44.860	➢ 1,4-Dioxaspiro(4,5) deca ne,2-(hydroxyl methyl)-	$C_9H_{16}O_3$	172	0.29
			45.040	➢ Glycidyl palmitate	$C_{19}H_{36}O_3$	312	0.09
			45.813	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.06
			49.773	➢ Squalene	$C_{30}H_{50}$	410	0.29
			51.738	➢ 9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E,E,E)-	$C_{57}H_{104}O_6$	884	0.97
			51.890	➢ E,E,Z-1,3,12-Nonadeca triene-5,14-diol	$C_{19}H_{34}O_2$	294	0.89
			52.050	➢ E,E,Z-1,3,12-Nonadeca triene-5,14-diol	$C_{19}H_{34}O_2$	294	0.15
	Bago	Sapwood	3.121	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.14
			33.780	➢ 9-Hexadecanoic acid, methyl ester,(Z)-	$C_{17}H_{32}O_2$	268	0.10
			34.303	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	10.42
			35.989	➢ cis-10-Heptadecenoic acid, methyl ester	$C_{18}H_{34}O_2$	282	0.06
			37.933	➢ 9,12-Octadecadienoic acid(Z,Z), ethyl ester	$C_{19}H_{34}O_2$	294	6.67
			38.145	➢ 9-Octadecenoic acid, methyl ester(E)-	$C_{19}H_{36}O_2$	296	64.35

			38.320	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	0.06
			38.444	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{36}O_2$	296	0.08
			38.542	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	11.72
			39.125	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	0.56
			39.205	➢ 6-Octadecenoic acid, methyl ester,(Z)-	$C_{19}H_{36}O_2$	296	0.13
			39.250	➢ 11-Octadecadienoic acid, methyl ester(Z)-	$C_{19}H_{36}O_2$	296	0.13
			39.340	➢ 6-Octadecenoic acid, methyl ester,(Z)-	$C_{19}H_{36}O_2$	296	0.05
			41.726	➢ cis-13-Eicosenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.18
			44.654	➢ Glycidyl oleate	$C_{21}H_{38}O_3$	338	0.26
			45.814	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.08
			51.700	➢ Elaidic acid, isopropyl ester	$C_{21}H_{40}O_2$	324	0.05
			52.072	➢ 9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E,E,E)-	$C_{57}H_{104}O_6$	884	1.66
			52.207	➢ E,E,Z-1,3,12-Nonadeca triene-5,14-diol	$C_{19}H_{34}O_2$	294	2.96
			53.530	➢ Oleic acid, 3-(octadecy loxy) propyl ester	$C_{39}H_{76}O_3$	592	0.33

Table 16. Results of GC/MS Test in sapwood and heartwood from Bago provenience trial

No	Prove-nance	Species (Ethanol Extract)	RT	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
8.	Thabei kgyin	Heart-wood	3.110	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.25
			18.101	➢ Tetradecane	$C_{14}H_{30}$	198	0.24
			34.275	➢ Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	1.92
			35.800	➢ Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	0.14
			36.776	➢ 1,4-Naphthalenedione, 2-hydroxy-3-(3-methyl-2-butenyl)-	$C_{15}H_{14}O_3$	242	0.42
			37.929	➢ 9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	7.55
			38.105	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	66.63
			38.292	➢ 9-Octadecenoic acid, methyl ester(E)-	$C_{19}H_{36}O_2$	296	2.89
			38.421	➢ 9-Octadecenoic acid(Z)-, methyl ester	$C_{19}H_{36}O_2$	296	1.55

			38.532	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	10.46
			38.760	➢ 9-Octadecenoic acid, methyl ester(E)-	$C_{19}H_{36}O_2$	296	0.58
			38.855	➢ 6-Octadecenoic acid, methyl ester,(Z)-	$C_{19}H_{36}O_2$	296	0.80
			38.970	➢ 15-Tetradcosenoic acid, methyl ester(Z)-	$C_{25}H_{48}O_2$	380	0.18
			39.000	➢ 1-Octen-3-0l,trifluoroacetate	$C_{10}H_{15}F_3O_2$	224	0.09
			41.720	➢ cis-13-Eicossenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.29
			45.819	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.09
			49.776	➢ Squalene	$C_{30}H_{50}$	410	5.60
			53.200	➢ 9-Octadecenoic acid(Z)-, 2-hydroxy-1,3,-propanedily ester	$C_{39}H_{72}O_5$	620	0.14
			53.467	➢ 9-Octadecenoic acid(Z)-, 2-hydroxy-1,3,-propanedily ester	$C_{39}H_{72}O_5$	620	0.13
			54.745	➢ 9-Octadecenoic acid(Z)-, 2-hydroxy-1,3,-propanedily ester	$C_{39}H_{72}O_5$	620	0.08
	Thabei kgyin	Sapwood	3.120	➢ 2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	0.17
			23.929	➢ Heptadecane	$C_{17}H_{36}$	240	0.10
			26.725	➢ 1H-Benzocyclohhepten-9-ol,2,4a-,beta.,5,6,7,8, 9, 9a-.beta.-octahhydro	$C_{19}H_{34}O_2$		0.17
			30.966	➢ Heneicosane	$C_{15}H_{26}O$	222	0.12
			34.264	➢ Hexadecanoic acid, methyl ester	$C_{21}H_{44}$	296	2.15
			35.811	➢ Hexadecanoic acid, ethyl ester	$C_{17}H_{34}O_2$	270	0.46
			37.939	➢ 9,12-Octadecadienoic acid(Z,Z), methyl ester	$C_{19}H_{34}O_2$	294	88.96
			38.148	➢ 9-Octadecenoic acid, methyl ester,(E)-	$C_{19}H_{38}O_2$	298	77.59
			38.537	➢ Methyl stearate	$C_{19}H_{38}O_2$	298	6.91
			38.795	➢ 6-Octadecenoic acid, methyl ester,(Z)-	$C_{19}H_{36}O_2$	296	0.18
			38.915	➢ Triolein	$C_{57}H_{104}O_6$	884	0.14
			39.205	➢ trans, trans -9,12-Octa decadienoic acid, propyl ester	$C_{21}H_{38}O_2$	322	0.69
			39.306	➢ (E)-9-Octadecanoic acid, ethyl ester	$C_{20}H_{38}O_2$	310	0.54
			39.794	➢ Octadecanoic acid, ethyl ester	$C_{20}H_{40}O_2$	312	0.14

			39.965	➢ 3,4-Dihydro-2-(2-hydro xyethhyl)-1-methyl-3-oxo-4-oxaphenanthrene	$C_{16}H_{14}O_3$	254	0.19
			41.048	➢ 9,12-Octadecadienoic acid, ethyl ester	$C_{20}H_{36}O_2$	308	0.14
			41.730	➢ cis-11-Eicossenoic acid, methyl ester	$C_{21}H_{40}O_2$	324	0.47
			42.452	➢ 1,1-Biphenyl,4,2,3,4-ttetramethoxy-6-methyl-	$C_{17}H_{20}O_4$	288	0.21
			45.822	➢ Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	0.51
			49.772	➢ Squalene	$C_{30}H_{50}$	410	0.15

Table 17. Results of GC/MS Test in sapwood and heartwood from Thabeikgyin provenience trial

6. Conclusion

In this study of research, the six kinds of tests were performed to know about the natural durability and chemical composition of sapwood and heartwood of eight trial teaks: Bago, Taungoo, Nattalin, Kanbalu, Tabaikkyin, Oaktwin, Phyu and Paukkaung regions. All of the tests are phytochemical tests, antioxidant tests and GCMS tests performed to know the kinds of bioactive compounds and contents of compounds and their potential utilization and moisture content tests, weight loss tests and total phenolic compound content measurement tests were performed to know the natural durability and its physical performances. For some of the tests, the experiments were performed by dividing three parts of the sample block (bottom, middle and top) of sapwood and heartwood of the teak sample. According to the facts based on the experiments, the 15-year-old teak from eight trials can be moderately resistant to pests and natural environmental effects because it was included in the durable class and moderate durable class in the weight loss test activity. In moisture content calculation, there was no significant difference between each trial. There is an almost stable range of moisture content for general usage; all of the mean moisture contents are between 13% and 15%, and the lowest moisture content was Bago region's sample, which is 13.52%. Continuously, the Bago region's sample was one of the durable classes in this study, along with Taungoo and Nattalin. However, the Kanbalu sample was included in two classes; the bottom part is in the durable class, and the middle part and top part are in the moderately durable class. By checking the result of the GCMS test, there is a difference in the number of included chemical compounds in sapwood and heartwood; the included kinds of compounds are fewer in heartwood than in sapwood. And there is a relation in antioxidant properties and content of phenolic compounds due to the kind of included compound. The higher the antioxidant activity, the higher the total phenolic compound content. This study can indicate the potential utilization of physical and chemical properties of teak by checking the results of the tests.

7. Acknowledgement

Firstly, I would like to acknowledge the financial supportive of the Ministry of Natural Resources and Environmental Conservation and Forestry. And I would like to express my thankful person, Dr. Thaung Naing Oo, (Director General, Forest Department, Ministry of Natural Resources and Environmental Conservation and Forestry).

I am extremely thanking to Dr. Thinn Myat New (Professor and Head), Department of Chemistry, University of Mandalay and Dr. The Su Moe (Professor), Department of Biotechnology Research Medical Biotechnology Laboratory, Kyaukse District, Mandalay Region, Myanmar. I also thank U Soe Tint (Retired), Director of Forest Research Institute, Yezin and the laboratory representative persons. Moreover I would like to say thanks to the all person (FRI Team) who give support deal with this research.

8. References

Creffield, J. W., 1994. A field method for determining the above- ground resistance of wood and wood products to attack by subterranean termites.

Cho Cho Win, Lwin Lwin Aung (2016), Investigation on the Decay and Termite Resistance of Five Wood Species from Tanintharyi Region

Dietrich Meier, J.Puls, H.Leithoff, M.Haup (2003- Europen Journal of Wood & Wood Products), Heartwood Extractive and Natural Durability of Plantation Grown Teakwood.

Daw Khin May Lwin, Study on Utilization of Plantation Teak Pre-project CFC/ ITTO 73 FT PPD 68/03 Rev.2(1).

Daw Cho Cho Win, et.al, 2009 - Investigation on Natural Durability and Drying Behavior of Plantation Teak at Different Ages, Forest Research Institute, Myanmar.

Gardner S., Sidisunthorn P. &Anusarnsunthorn V. 2000. A field guide to Forest Trees of Northern Thailand. Kobfai Publishing Project. Bangkok. Thailand.

Geoffrey Daniel, Nasko terziv, Ulrich J.Wolfsmayr (2008) -Natural Durability and Anatomical Features of Teak (*Tectona grandis*) from Plantations in Costa Rica.

Ghani A. (1998). Medicinal plants of Bangladesh: chemical constituents and uses. 1st ed. Asiatic Society of Bangladesh, pp. 155-156.

https://www.intechopen.com/books/phenolic-compounds-biological-activity/phenolic-compounds-functional-properties-impact-of-processing-and-bioavailability.

Igor Otavio Minatel, Cristine Vanz Borges, Maria Izabela Ferreira, Hector Alonzo Gomez Gomez, Chung-Yen Oliver Chen and Giuseppina Pace Pereira Lima ; Phenolic Compounds: Functional Properties, Impact of Processing and Bioavailability

Johnson et al, 1982. The Accelerated field simulator.

Johnson et al, 1983. Natural Durability study in an accelerated field simulator- A Novel Approach.

Khare CP. (2007). Indian Medicinal Plants: an Illustrated Dictionary. Springer-Verlag, New York, USA, pp. 199-201. Khera.

Kokutse A.D.,Stokes A.,Bailleres H.Kokou K. 2005- Evaluation of Natural Durability of Teak Wood in Plantation in Tago , West Africa.

Mankowski, M. E., B. Boyd, B. Hassan, and G. T. Kirker. 2016. GC-MS Characterizations of Termiticidal Heartwood Extractives from Wood Species Utilized in Pakistan.

Meyer, L.1; Brischke, C.1; Pilgård, A.2,3 (Moisture performance based wood durability testing.)

Nobuyukit ANAKA, Tadao HAMAZAKI , Tosporn VACHARANGKURA, (1998) Distribution, Growth and Site Requirement of Teak.

Reticulitermes flavipes (Kollar); Natural durability of tropical and native woods against termite damage.

S.Sakanphet, S.Midgley & M.Diecters, (2019)Teak (*Tectona grandis*) silviculture and research: applications for smallholders in Lao PDR.

T.C. Scheffer, J.J. Morrell; Natural Durability of Wood: A Worldwide Checklist of Species".

Vinícius Resende de Castro; Heartwood and Sapwood of *Tectona grandis* wood characterized by CG/MS-PY.

Walter Koller, Michael Kleine,(2017 - IUFRO) - Analysis Evaluation and Future Potential of Teak Resources.