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Study on the Durability and Utilization Potential of Economic Important Species, Tamalan (*Dalbergia oliveri* Gamble ex Prain)

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Abstract

Dalvergia oliveri, one of the commercial wood in Myanmar and used for furniture, handicraft and others in South East Asia due to its graceful appearance and known as Burmese Rosewood. As we known, it has natural extracts and includes antifungicide and antitermiticide properties to be very durable and very resistant wood. In this research paper, we performed to prove and learn about the termite resistance, to test about decay resistance of Tamalan wood and to know about the included chemical compound and its usage. For the testing of termite resistance, we used under-ground method and for the testing of decay resistance, we performed with Agar Block Tech at Laboratory by using white rot fungi. After 16 weeks of placing the tested block at under-ground and agar media, we took the records and calculate the weight loss by fungal attach and decay attach for both tests. There is only 0.0402 % and 0.0812% of weight loss in tests and we find out it was very durable and resistant wood. And then, in this research work, the extract solutions of the wood of *Dalvergia oliveri* were checked in a qualitative test of phenolic compound by Acid Property Test, Color with $FeCl_3$ and Ellagic Acid Test respectively. All testings were shown that *Dalvergia oliveri* present phenolic compound. Moreover, determination of total content of phenolic compound, we checked out with a UV spectrophotometer using the Folin-Ciocalteau reagent at 765 nm by gallic acid equivalent standard. It was 100.02 mg gallic acid equivalent (GAE) per 100 g. Since the antimicrobial (kills microorganisms or stops their growth) and antioxidant (damage the cells of organisms) activities of the extracts were positively associated with the total phenolic contents of the extract, we find out, the present of phenolic compound is higher the resistance to termite and decay of Tamalan wood is higher. Thus, we found out and known that the *Dalvergia oliveri* was class 1 (very durable and resistance) cause of the presence of phenolic compound in the wood.

Keywords: *Dalvergia oliveri* Gamble ex Prain (Rose Wood), Decay Resistance, Termite Resistance, Phenolic Compound, Natural Durability

စီးပွားရေးအရ အရေးပါသော တမလန်းသစ်၏ ကြာရှည်ခံနိုင်မှုနှင့် အသုံးချနိုင်မှု အလား အလာကို လေ့လာခြင်း

လွင်လွင်အောင်၊ လက်ထောက်သုတေသနအရာရှိ
သစ်တောသုတေသနဌာန၊ သစ်တောဦးစီးဌာန

စာတမ်းအကျဉ်း

တမလန်းသစ်သည် မြန်မာနိုင်ငံတွင် စီးပွါးရေးအရ အရေးပါသော သစ်တစ်မျိုးဖြစ်ပြီး ဈေးကွက်တွင် Burmese Rosewood ဟူ၍ လူသိများပါသည်။ ဤသုတေသနတွင် တမလန်းသစ်၏ ခြစားခံနိုင်မှု၊ သစ်ဆွေးမှိုဒဏ်ခံနိုင်မှုတို့ကို စမ်းသပ်ပြီး ပါဝင်သောဓါတု ဒြပ်ပေါင်း များ၏ ဆက်စပ်အသုံးချနိုင်မှုတို့ကို သိရှိနိုင်ရန် ဆောင်ရွက်ခဲ့ခြင်းဖြစ်ပါသည်။ ခြစားမှုဒဏ် ခံနိုင်စွမ်းကို မြေမြှုပ်စမ်းသပ်နည်းဖြင့်လည်းကောင်း၊ သစ်ဆွေးမှိုဒဏ်ခံနိုင်စွမ်းကို ဓါတ်ခွဲခန်း အတွင်း Agar Block နည်းဖြင့် စမ်းသပ်ခဲ့ပါသည်။ သစ်နမူနာများသည် သစ်ဆွေးမှို စမ်းသပ် ချက်တွင် မူလ အလေးချိန်မှ ၀.၀၄၀၂%နှင့် ခြစားမှုဒဏ်ခံနိုင်စွမ်း စမ်းသပ်ချက်တွင် ၀.၀၈၁၂%သာ လျော့ကျ ပြီး အလွန်ကြာရှည်ခံသောသစ်မျိုး ဖြစ်ကြောင်း တွေ့ရှိရပါသည်။ ဓါတုဒြပ်ပေါင်း များပါဝင် မှုကို စမ်းသပ်ခဲ့ရာတွင် Acid Property စမ်းသပ်ချက်၊ $FeCl_3$ အရောင် ပြစမ်းသပ်ချက် နှင့် Ellagic Acid စမ်းသပ်ချက်ရလဒ်များအရ တမလန်းထုတ်နုတ်ပစ္စည်း ဖျော်ရည် (Extract Solution) တွင် Phenolic Compound များ ပါဝင်နေကြောင်း တွေ့ရှိ ရပါသည်။ တမလန်းသစ်၏ Total Phenolic ဒြပ်ပေါင်းပါဝင်မှုကို Folin-Ciocalteau ဓါတ်စမ်းပစ္စည်းကိုအသုံးပြု၍ UV Spectrophotometer (Wavelength 765 nm) ဖြင့် Gallic Acid ကို Standard Solution အဖြစ် အသုံးပြု၍ တိုင်းတာခဲ့ပါသည်။ ဤသုတေသနပြုချက်အရ တမလန်းသစ်၏ Total Phenolic Compound ပါဝင်မှုပမာဏမှာ 100.02 mg ၊ Gallic Acid Equivalent (GAE) per 100g ဖြစ်ကြောင်းတွေ့ရှိရပါသည်။ အင်းဆက်ပိုးမွှားများကို ပျက်စီးစေနိုင်သော Antioxidant ဂုဏ်သတ္တိနှင့် အဏုဇီဝသက်ရှိ သတ္တဝါ (Microorganism) များကို သေစေနိုင်ခြင်းနှင့် ၎င်းတို့၏ ကြီးထွားမှုများကို ရပ်တန့်စေခြင်း (Antimicrobial) ဂုဏ်သတ္တိများသည် သစ်သားအတွင်း Phenolic Compound ပါဝင်မှုရာခိုင်နှုန်းအပေါ်တွင် မူတည် ဆက်စပ် ပတ်သက်နေကြောင်း သိရှိရပါသည်။ အဆိုပါ Phenolic Compound ပါဝင်မှု ရာခိုင်နှုန်းများ လေလေ သစ်၏ ဆွေးမြေ့မှုဒဏ်၊ ခြစားခံရမှုဒဏ် မြင့်မားလေလေဖြစ်ကြောင်း

တွေ့ရှိခဲ့ရပါသည်။ ထို့ကြောင့် တမလန်း သစ်သည်အလွန်ကြာရှည်ခံသော အုပ်စုအဆင့်(၁) ဖြစ်နေရခြင်းမှာ သစ်သားအတွင်း Phenolic Compound များစွာပါဝင်မှုရှိနေခြင်းကြောင့် ဖြစ်ကြောင်း သိရှိခဲ့ရပါသည်။

Study on the Durability and Utilization Potential of Economic Important Species, Tamalan (*Dalbergia oliveri* Gamble ex Prain)

1. Introduction

Dalbergia oliveri Gamble ex Prain, Tamalan in Myanmar, is a member of the family Fabaceae, and it is one of the most economically important and lesser known timber species in Myanmar. Nowadays, it has become well known over the world as Burmese redwood, rosewoods, or Tamalan; and Hongmu in China all for its hardness and utilization in building and making furniture. In Myanmar, Pyinkado wood is more scarce due to over-exploitation and Tamalan becomes one of the timbers replaceable for Pyinkado and other hardwood.

Rosewood (Hongmu) is an informal term referring to a group of hardwood species that are red in color and widely used in furniture processing in China. Rosewood has been used in furniture manufacturing since at least the tenth century, during the late Ming and early Qing dynasties (Xu & Li 2003).

Because of an unprecedented boom in the popularity of reproduction of Qing and Ming dynasty furniture in China, demand for Hongmu wood is unsustainable on forests throughout Mekong region and worldwide. Chinese demand for Tamalan is clearly driving illegal logging and timber smuggling in Myanmar and posing a real threat to governance, the rule of law and the viability Myanmar's dwindling forests. Convention on International Trade in Endangered Species (CITES) is a multilateral environmental agreement under the United Nations, with over 170 national signatories, including Myanmar and China (Environmental Investigation Agency (EIA) 2014).

According to Myanmar Forest Department, confiscated timber of Tamalan (*D. oliveri*) is more than 2000 cubic tons in 2008 – 2009, and it becomes up to about 4500 cubic tons in 2013 – 14 (Nyi Nyi Kyaw 2014).

As illegal logging is increased, Myanmar needs to safeguard its forests from rampant and growing Chinese demand for valuable Hongmu species. The Myanmar Government sought the Convention on International Trade in Endangered Species (CITES) Appendix III protection for its at-risk Hongmu species, *D. oliveri / bariensis* (Tamalan) and *Pterocarpus macrocarpus* (Padauk). *Dalbergia oliveri* could be protected by a CITES Appendix III listing for Tamalan and Padauk species before CoP17 to protect them (Environmental Investigation Agency (EIA) 2014).

D. oliveri Gamble ex Prain, Tamalan, is found in Myanmar, Thailand, Laos, Cambodia, and Vietnam. It is also known as Neang Nuon in Cambodian, Mai Ching Chan in Thai, Mai Kham Phii in Laos and Cam Lai or Trac Lai in Vietnam. It has been threatened by habitat loss and over-harvesting for its valuable red lumber. This tree is valuable for ornamental work including wood turning and furniture. The lumber is sold under the names Burmese Rosewood, Laos Rosewood, and Asian Rosewood. The sapwood is yellowish-white and the heartwood is dark brown and very hard and heavy (Wikipedia 2018).

D. oliveri Gamble ex Prain is a deciduous tree with an open, spreading crown. It can grow 15 – 30 meters tall. The bole is straight and 60 – 90 cm in diameter. The species occurs within a restricted area of distribution and has been overexploited for its beautiful red wood.

It has been classified as Vulnerable in the IUCN Red List of Threatened Species (2011). In 2012 the classification was raised to Endangered (Fern 2014).

The wood of *D. oliveri* Gamble ex Prain is diffuse-porous (Meier 2018). It is close-grained, hard, heavy, and resistant to the attacks of termites. It has an attractive veined structure and is easy to polish. It is often used for making quality furniture, luxury cabinets, art and handicrafts etc, as well as the handles of agricultural implements (Fern 2014).

According to the Wood Database (Meier 2018), average dried weight of the wood is 940 kg/m^3, specific gravity 0.78 – 0.94, and Janka hardness 2710 lb_f. Its radial shrinkage is ~2%, tangential ~5%, and volumetric ~7% respectively.

As Tamalan is one of the economically important timber species, more plantations are required for reforestation together with other timber species as well as for improvement of forest and the coverage of the forest. It can also serve in reducing carbon dioxide emission from deforestation and degradation of Myanmar forests.

A little knowledge of morphology and anatomy was found so far, according to available literature in Myanmar. A brief description of morphological and anatomical characteristics of *D. oliveri* Gamble was given by Thein Kywe and Kyaw Soe (1983). Pluempanupat et al. (2013) firstly reported that *D. oliveri* extracts contained isoflavonoids and they were mosquitocidal, and effective against both larvae and pupae of *Aedes aegypti*. However, chemical compounds extracted from Tamalan timber from the forest of Myanmar which might be potentially useful as fungicides and termiticides were not tested yet and the utilization potential of the compound of the wood was not recorded yet.

According to the checklist of Kress et al. (2003), the *Dalbergia* contains 28 trees, 5 small trees and 10 shrubs in Myanmar. Among them *Dalbergia oliveri, D. cultrata,* (Yindaik), *D. fusca* (Yinsat), *D. collettii* (Madama), *D. ovata* (Madama), and *D. lanceolaria* (Thitpagan) are traded species.

Most *Dalbergia* species are widely used timber trees, and are valuable because of their decorative and fragrant wood (Chopra *et al.*, 1980). Some of the timber producing *Dalbergia* species is famous for their fragrant wood and are termed as rosewood. Although some other genera of legume family also produce fragrant woods, the most desired rosewoods are *D. nigra* and *D. latifolia*. Most of the phytochemical works found on *Dalbergia* species are on the heartwood. Several phytoconstituents like isoflavonoids, neoflavonoids, glycosides, cinnamylphenols, quinones, and furans have been isolated from different species. *Dalbergia oliveri* is most valued not only for the durability of its timber but also for its resistance to attack by insects and micro-organisms. They have provided a large number of neoflavonoid and isoflavonoid derivatives (Rohit Kumar Bijauliya et al, 2017). Previous research has demonstrated that the presence of phenolic compounds is positively correlated with durability.

Moreover, *Dalbergia* species are well known for its medicinal properties. Many species are used in traditional system of medicines all over the world in the treatment of various ailments like diarrhea, leucoderma, dyspepsia, dysentery, syphilis, gonorrhea, stomach ache, leprosy, eye diseases, scabies, pain, and ringworm (Pooley et al., 1993; Ghani, 1999; Khare, 2007; Kazembe et al., 2012). Traditionally, they are also used for their analgesic, antimicrobial, aphrodisiac, anthelmintic, antipyretic, anti-inflammatory, and larvicidal activities (Nadkarni 1954; Kirtikar et al., 1991). In the present work, the wood of

Dalbergia oliveri was selected for evaluation of antioxidant activity and total phenolic content because it is rich sources of phenolic compounds which possess antioxidant properties. Based on the content of phenols in the *Dalbergia oliveri* then conducted research trials on the antioxidant activity of it by using DPPH.

In this research, the timber of *D. oliveri* Gamble ex Prain is taken from Office of the Forest Department, Patheingyi Township. The timber is known to be seized by the office. Its durability, chemical extracts which might be resistant to termites and fungi will be tested and its potential utility also be described.

The objectives of this study are

- To study the natural durability of *Dalbergia oliveri* Gamble ex Prain, (Tamalan) by evaluating the resistance to decay and termite tests.
- To express completely the information dealing with the durability by studying the compound substances contained in Tamalan.
- To give the message that Tamalan is going to extinct and to use effectively the Tamalan timber without wasting.

2. Literature Review

Dalbergia oliveri Gamble ex Prain was threatened by habitat loss and over-harvesting for its valuable red lumber. It grew in tree form to 15 – 30 meters in height. The fruit was a green pod containing one to two seeds which turned brown to black when ripe. Its synonym was *D. laccifera* Laness. and *D. prazeri* Prain (Wikipedia 2018).

The wood was valuable for ornamental work, including wood turning and furniture. The sapwood was yellowish-white with dark brown heartwood. The heartwood was very hard and heavy. The lumber was sold under the names Burmese rosewood, Laos rosewood, and Asian rosewood (Wikipedia 2018).

Thirty-three timber species were included in the timber species of the 2000 China National Hongmu Standard, six of which were found in Myanmar and were captured in China's import data under its dedicated Hongmu Customs Code (HS Code: 44039930). These included *D. oliveri* or *D. bariensis*, Tamalan which was also known as Burmese rosewood and Burma Blackwood (*D. cultrate*) (Environmental Investigation Agency (EIA) 2014).

The Environmental Investigation Agency (EIA) warned that Myanmar tree species Tamalan and Padauk were disappearing at an extremely rapid pace as Chinese traders had begun targeting their high-value wood, and the species could be logged to extinction in Myanmar within as little as three years (Vrieze 2018).

Lee Kong Chian Natural History Museum (2018) described that common name of *D. oliveri* was Tamalan tree and an attractive and shady road side tree. Its status was cultivated only in Singapore. It was native to Myanmar and Thailand, introduced to many tropical countries. It was a tree that could reach 20 meters high. It had a spreading crown and simple pinnate leaves were arranged alternately along the twigs. Leaflets were 13 – 17, 1.8 – 3 x 1.2 – 1.8 cm, alternately arranged, with a terminal leaflet. Flowers were bisexual, small, 7 – 10 mm long, in small bunches, lilac in the bud, fading pink then white. The fruits were thin, flat pods, 5 – 9 x 1.5 cm, with one, occasionally 2 or 3 seeds. The pods did not split open with maturity.

Thein Kywe and Kyaw Soe (1983) described that D. *oliveri* was a medium size tree attaining a height of 18 – 24 meters and a girth of 1.5 – 1.8 meter. It was commonly found in dry deciduous and Indaing forests from Pegu Yoma Northwards in Myanmar. The bark was blackish bright yellow, 8 – 10 mm thick, outer dead bark persistent over the whole of the trunk and larger branches, rough, irregularly shallow furrowed; scaly plates separated by shallow fissures. The pod was oblong or strap shaped, 6.2 – 7.8 cm long, 1.6 – 1.8 cm wide, usually thin or flat, 1 – 4 seeded indehiscent, not thickened. It flowered from March to April and it fruited from April to May. Its sapwood was white or yellowish white; narrow, heartwood ranges from shades of lemon pink or red scarlet to reddish brown with distinctly darker lines, lustrous when first exposed, but soon becoming dull; pleasant odor, without distinct taste, very heavy (sp.gr. approx. 1.00); straight grained or slightly inter-locked grained, medium coarse textured, very hard and strong. The wood was diffuse-porous.

Pluempanupat et al. (2013) reported to show *Dalbergia oliveri* extracts and isoflavonoids there in were mosquitocidal, and effective against both larvae and pupae of *Aedes aegypti*. They stated that the potential of *Dalbergia oliveri* in dengue fever vector controlled by evaluating various extracts as larvicides and growth disruptors of *Aedes aegypti* L. under laboratory conditions. Highest larvicidal effect was obtained, with dichloromethane and hexane extracts. Dichloromethane extract, being most active, was subjected to sequential chemical separation to obtain series of isoflavonoids. Three compounds (+)-medicarpin, formononetin and (±)-violanone were identified as active larvicides of *A. aegypti*.\

Deal with the preservation of Tamalan timber, D. *oliveri* was reported to be listed as a vulnerable, protected species in the Burma Forest Act (Oldfield, 1988). Until recently, Myanmar was reported to be one of the only remaining countries in the world that has set no prohibitions to the export of logs (Woods & Canby, 2011). The policy and legal framework in the country was regarded as insufficient for the prohibition of illegal logging and export of wood (Forest Trends, 2013). However, it was reported that a log export ban is going to come into force on the 31st of March 2014 (ITTO, 2014). Also mention at Non-CITES timber species from South East Asia (Leguminosae)potentially warranting further protection by UNEP World Conservation Monitoring Centre, the D. *oliveri* database is still weak in data collection to supply them from Myanmar. According to ITTO (2002, 2003, 2004), the demand for D. *oliveri* from Myanmar increased in the early 2000s. No trade reported in the ITTO annual reviews of 2006-2012, but Wenbin and Xiufang (2013) reported that significant quantities of D. oliveri was imported from Myanmar to Yunnan (China) in 2012.

2.1 Moisture Content Performance on Decay Resistance

The risk of decay in wood products can vary widely with moisture availability, soil condition, and climate. Decay resistance can vary according to the position in the heartwood from which an item of wood is taken. In some species, the resistance of the outer heartwood increases markedly from the upper to the lower trunk. Radial differences in resistance can vary significantly, notably in the larger trees, with the lowest resistance occurring in the innermost wood (Zabel and Morrell 1992).

Rating scale of EN 252 (1990)

Rating	Description	Definition
0	Sound	No evidence of decay, discoloration, softening or weakening caused by microorganisms.
1	Slight attack	Limited evidence of decay, no significant softening or weakening up to 1 mm depth.
2	Moderate attacks	Significant evidence of decay, with areas of decay (softened or weakened wood) from 2 to 3 mm depth.
3	Severe attacks	Strong evidence of decay, extensive softening and weakening, typical fungal decay at large areas from 3 to 5 mm depth or more.
4	Failure	Sample breaks after a bending test.

2.2 Botanical Description

Darlbergia oliveri is a large tree that grows up to 30 m in height (Dy Phon 2000) and 90 cm in diameter (Tan Dung 1996). The color of its bark is gray. The branches are stout and slightly pubescent. Leaves are pinnate compound with 13 to 17 leaflets and occasionally with 9-11 or 19-21 leaflets. The leaflets arrange alternately. Inflorescence is corymbose-piniculate, axillary or nearly terminal. Inflorescence is 10-20 cm long and 7.5-15 cm wide. The flower is white in color and the inner part is purple in color. The fruit is flat with 6-7 cm long and 1.7 cm wide, consisting of 1 seed, but sometimes the pod contains 2 or 3 seeds.

2.3 Uses and products

The wood of *Darlbergia oliveri* is hard and beautiful. The color of heart wood is dark red and sapwood is white. The heartwood is very hard and heavy. The lumber is sold under the names **Burmese rosewood**, **Laos rosewood**, **Asian rosewood**. It is used for ornamental purpose, such as for making good quality furniture, arts, musical instruments, agricultural implements and other decorations (Dy Phon 2000; Sam *et al.* 2004). Most Dalbergia species are widely used timber trees, and are valuable because of their decorative and fragrant wood (Choi et al., 2009).

2.4 Ethnomedicinal uses

Many species are widely used in the treatment of various diseases all over the world. Sanjib Saha et al., (2013) described a comprehensive list of the different species used, along with their routes of administration and traditional uses.

Table 2. Ethnomedicinal uses of various species of genus *Dalbergia*

Botanical Name) Traditional	Part Used (Route of Administration	Medicinal Uses (References)
Dalbergia lanceolaria L.f.	Leaves, bark and seeds (oral)	A decoction of the bark is used in dyspepsia, leaves are used in leprosy and allied obstinate skin diseases. Seed oil is used in rheumatism and cutaneous diseases (Khare, 2007).

Dalbergia latifolia Roxb.	Bark and whole plant (oral)	Bark is used in body pain, and the whole plant is used in diarrhea, dyspepsia, leprosy and obesity. The whole plant is also used as stomachic, anthelmintic and bitter tonic (Ghani, 1999; Khare, 2007). In Senegal, stem and root bark are used in the treatment of diarrhea with baobab or tamarind fruits. Smoke of burnt roots is inhaled in colds, bronchitis and headache. Smoke of burnt stems is inhaled to treat rheumatism in Sudan.
Dalbergia melanoxylon Guill. & Perr.	Leaves, stem and root bark (oral, topical)	In Senegal, stem and root bark are used in the treatment of diarrhea with baobab or tamarind fruits. Smoke of burnt roots is inhaled in colds, bronchitis and headache. Smoke of burnt stems is inhaled to treat rheumatism in Sudan. A decoction of the roots is used as anthelmintic and aphrodisiac, and applied in the treatment of gonorrhea, stomach-ache and abdominal pain. A decoction of bark is used in healing wounds. The leaf decoction is used in the relief of joint pain, and leaf sap is taken to treat inflammation in the mouth and throat (Bolza et al., 1972; Neuwinger et al., 2000)
Dalbergia nitidula Welw. ex Baker	Leaves (topical), roots (oral, topical) and bark (oral)	Chewed leaves are applied to treat snakebites and leaves are rubbed on abscesses. Powdered root soaked in warm water is gargled to treat toothache and root decoction and infusion is used in the treatment of malaria and cough. In Zimbabwe, bark is used to treat wounds and ulcers (Kazembe et al., 2012).
Dalbergia obovata E.Mey.	Roots (infusion) and bark (topical)	A root infusion is used in the treatment of stomachache and toothache (Louppe et al., 2008). Bark is applied to treat sore mouths in babies (Pooley et al., 1993).
Dalbergia odorifera T.C.Chen	Heartwood (oral)	Heartwood is used in Chinese traditional medicine in the treatment of ischemia, blood stagnation syndrome swelling, rheumatic pain, epigastria, traumatic injuries and necrosis (Kang et al., 2005; Hou et

		al., 2011)
Dalbergia sissoides Graham	Roots (oral)	Anti-inflammatory (Khare, 2007).
Dalbergia sissoo Roxb.	Leaves, Bark, wood, roots and whole plant (oral)	Leaf juice is used for eye ailments, and wood is used in the treatment of blood disorders, burning sensations, scabies, stomach problems, scalding urine, epistaxis, hemorrhage, eye and nose disorders, syphilis and bleeding piles (Kirtikar et al., 1993). Bark and wood are applied as expectorant, astringent, anthelmintic, aphrodisiac, antipyretic and used in diseases of the blood, dyspepsia and dysentery (Kirtikar et al., 1975). Extract of wood rasping is very useful in leprosy, and roots are used as astringent (Ghani, 1998). Decoction of leaves is also prescribed in acute gonorrhea, and the whole plant is used in ancient Yunani preparations and in the treatment of skin diseases and gonorrhea (Kirtikar et al., 1975; Nadkarni, 1954).
Dalbergia spinosa Roxb.	Fruits, leaves and stem barks (oral)	Fruits are used as a tonic and antipyretic. Leaves and stem bark are applied as febrifuge and anthelmintic (Naskar, 2004)
Dalbergia stipulacea Roxb.	Roots and leaves (oral)	Roots and leaves are used in the treatment of gonorrhea and aphthae (Yusuf et al., 1994)
Dalbergia sympathetic Nimmo	Bark (topical), leaves and aerial parts (oral)	Paste of bark is used in the treatment of pimples. Leaves are used as an alterative, and aerial parts as spasmolytic, CNS active and hypothermic (Khare, 2007).
Dalbergia volubilis Roxb.	Leaves, roots and aerial parts (oral)	Decoction of leaves is used as anti-inflammatory and antiarthritic, applied in aphthae, and also used in sore-throat as gargle. Juice of roots is used in gonorrhea. Aerial parts are applied as diuretics (Ghani, 1998, Khare, 2007).

2.5 Phenolic Compounds

Phenolics or phenols are a class of chemical compounds consisting of a hydroxyl group (-OH) bonded directly to an aromatic hydrocarbon group. Phenolic compounds are classified as simple phenols or polyphenols based on the number of phenol units in the molecule (Ei Ei Phyo, 2012). Phenols have higher acidities due to the aromatic ring's tight coupling with the oxygen and a relatively loose bond between the oxygen and hydrogen (Medicinal plant of Myanmar). Phenol can also be classified on the basis of their number of phenol groups. They can ,therefore, be called simple phenols or monophenols, with only one phenolic group, or di (bi), tri and oligophenols, with two, three or several phenolic groups respectively. A potential source of antioxidant and antimicrobial agents and could be used as a natural antioxidant and preservative in food and non-food systems(By Igor Otavio Minatel, Cristine Vanz Borges, Maria Izabela Ferreira, Hector Alonzo Gomez Gomez, Chung-Yen Oliver Chen and Giuseppina Pace Pereira Lima). Phenolic and polyphenolic compounds, in isolate or associated with vitamins, such as carotenoids, vitamin E, and vitamin C, are reducing agents that protect human body's specific tissues against oxidative stress.The largest and best studied natural phenol is the flavonoid which include several compounds, among them flavonoid, flavones, flavan-3 ol, flavanone, anthocyanidin and isoflavonoid (Jeffery. B. Harbone) phenolic compounds, known as secondary metabolites, that are not directly involved in normal growth, development and reproduction of the plant. Secondary metabolites from plants possess important biological and pharmacological activities, such as anti-oxidative, anti-allergic, antibiotic, hypoglycemic and anti-carcinogenic (Borneo *et al*., 2008). In plants, the phenolics can be found linked to the cell membranes/walls or can be free. Plant phenolics are generally involved in defense against ultraviolet radiation or aggression by pathogens, parasites and predators, as well as contributing to plants' colors. A number of phytochemical types, including isoflavonoids, neoflavonoids, glycosides, cinnamylphenols, quinones, furans, steroids, and other miscellaneous compounds have been isolated from various species of the *Dalbergia* genus. The highest investigated plant part is the heartwood while most of the reported compounds are phenolic compounds.

According to the experiment by T.C. Scheffer , J.J. Morrell, Dalbergia oliveri (Trade name_ Chingchan, Tamalan) was shown the durability is class 1 in the area of Australia at field test and also termite resistance also class 1. (Anuwongse and Cholprasert 1976, Tewari 1978).

3. Materials and Methods

3.1. Materials

In this study, the timber of *D. oliveri* Gamble ex Prain is taken from the Office of the Forest Department, Patheingyi Township. The timber is known to be seized by the office. The wood samples were authenticated at Anatomy Section of Forest Research Institute (FRI), Yezin.

3.2. Sample Preparation

Sample preparation was carried out at Saw-mill of FRI. For decay test, (12.5mm x 12.5mm x 25mm) blocks and for termite resistance evaluations, (20mmx20mmx20mm) blocks were prepared. Ten replications were prepared for each test. These boards were free from knots, drying defects and without visible evidence of fungus infection.

Figure 3.1 Sample Preparation

3.3 Preparation of Extract

The collected wood samples were chopped into small pieces by using a knife and then allowed to air dry in the well ventilated room at temperature 40 ± 2°C for about three weeks. These airs dried samples were used throughout the experiment.

Figure 3.2 150 ml of 0.3 % HCl in Methanol Extraction

3.4 Laboratory Decay Test

In order to provide rapid evaluation of the relative durability of the species, laboratory tests of the relative decay resistance were carried out. The agar - block test was used in this research. The white rot fungi (*Coriolus versicolor*) were used in this study since these fungi are common to hardwood. The fungus specimen was cultured on Potatoes- Dextrose Agar (PDA) media.

The procedure took for the fungus culturing was as follows:-

a) 200g of peeled, diced potatoes, 20 g of dextrose and 15 g of agar were dissolved in 1000 ml of distilled water in a flask and heated till boil.
b) The media were distributed into the test tubes, approximately 20 ml in each tube.
c) The test tubes were plugged with cotton and sterilized in autoclave sterilizer for 20 minutes at 105 ˚C and 15 psi pressure. It was necessary to sterilize the media before using in order to kill bacteria or fungal spores which will possibly present in the media or in the glassware.
d) The test tubes were taken out from the autoclave sterilizer and cooled to room temperature.
e) The fungus inoculums were cut and placed on the media. After 3 to 5 days, the fungus grew well, with mycelium. These were ready for decay test.
f) Each test sample block was weighed and it was designated as the initial weight (I. Wt).

g) After that, all the test samples were exposed to fungal attack by placing them over the fungus mycelium in the test tubes. Tiny chips of glass- rod were placed between bamboo samples and the fungus in order to prevent the direct contact between them.
h) The test tube was placed at ordinary room temperature and incubated for 16 weeks.
i) After completion of the incubation period, the test blocks were taken out and attached mycelium was carefully cleaned.
j) The test blocks were oven dried at 103 ± 2° C until the constant weights were obtained and then, the oven-dry weights were recorded as final oven dry weight (FOD Wt) to calculate the weight loss percentages of the test blocks.

Figure 3.3 Laboratory Decay Test (Fungus Test)

3.5. 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 (3.1).

Table 3.1 Visual rating for termite resistance

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

Source: American Wood Preservers' Association (AWPA) Rating

Table 3.2 Durability Classification of Timber based on Weight Loss

Durability Class	Life of Test Stake in the field		Average loss in dry weight (%)
	England	Tropics	
Very Durable	Over 25 yr.	Over 10 yr.	Nil- or negligible
Durable	15 - 20 yr.	5 -10 yr.	Up to 5%
Moderately Durable	10 - 15yr	(Not given)	5-10%
Non-Durable	5- 10 yr.	2 - 5 yr.	10-30%
Perishable	Less than 5 yr.	Less than 2yr	Over 30%

Source: W. P. K. Findlay (1985)

3.6 Method of Analysis

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

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

where,

M.C = moisture content of the sample
I.wt = initial weight of the sample
O.D.wt = Oven Dry weight of the sample

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.

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

where,

C.O.D wt = calculated oven dry weight
F.O.D wt = final oven dry weight

3.7 Qualitative Tests for phenol

Extraction Procedure

About 300 g of air dried wood samples percolated with 95% methanol (500 ml) at room temperature for about two months. The extract was filtered with filter paper. Then the filtrate was evaporated at room temperature to get concentrated crude extract. Totally (35.8 g) of methanol extract was obtained. 10 g of methanol crude extract was re-extracted with 100 ml 0.3% HCl in methanol. The mixture was centrifuged at 5000 rpm for 30 minutes. The supernatant was decanted to a small beaker. The extraction procedure was repeated two times. The supernatant was poured into the same container. It was evaporated to dryness and 20 ml of distilled water was added to dissolve the residue. This extract contains the phenols.

3.8 Tests for Phenols

3.8.1 Group Test

The extract solution of *Darlbergia oliveri* was tested with blue litmus paper. This blue litmus paper turns red.

3.8.2 Color with $FeCl_3$

1ml of extract solution was taken and a few drops of very dilute solution of ferric chloride were added. The color changes to brown which indicates the presence of phenolic compound. The reaction takes place as follows.

$$\underset{\text{(Phenol)}}{6C_6H_5OH} + FeCl_3 \longrightarrow 3H^+ + \underset{\text{(Brown)}}{[Fe(OC_6H_5)_6]^{3-}} + 3HCl$$

3.8.3 Liebermann's Test

A small amount of extract solution and a few crystals of sodium nitrite were taken in a dry test tube and heated gently for a minute. It was cooled and 0.5 ml conc: H_2SO_4 was added to his mixture HNO_2 formed in the reaction reacts with phenol. A deep green color was developed. The mixture was diluted with distilled water. The solution turns red. Then excess of dilute NaOH solution was added the mixture becomes blue. During these reactions, transformation of one type of phenol to other forms takes place as follows.

$$\text{Phenol} \xrightarrow{\text{HNO2}} \underset{\text{(deep green)}}{\text{p-nitrophenol}} \xrightarrow{C_6H_5OH} \underset{\text{(red)}}{\text{Indophenol}} \xrightarrow{\text{NaOH}} \underset{\text{(blue)}}{\text{Indophenol anion}}$$



Figure 3.4 Quantitative Phenol Test with UV- 1800, SHIMADZU, UV spectrophotometer

3.8.4 Preparation and Determination of Standard Ethyl Gallate

10 mg of the standard ethyl gallate was taken in a test tube. 100 ml of distilled water was added to the standard compound. 1 ml of this standard solution was taken in another test tube. The volume of this solution was made up to 10 ml with distilled water. The solution was taken by micro-pipette into a series of test tubes 20 µl, 40 µl, 60 µl, 80 µl, 100 µl respectively. The volume was made up to 1.6 ml with distilled water in each test tube. Then 100 µl of Folin-Ciocalteau reagent and 300 µl of standard Na_2CO_3 (20%) solution were added. After each solution was heated in the water bath at 40 °C for 30 minutes, the absorbances of the solutions were measured with a UV spectrophotometer at 765 nm with respect to the blank solution. The calibration curve of standard ethyl gallate is shown in figure (3.5).

Table 3.3 The Results of Absorbances of Standard Ethyl Gallate Solution

No	Sample ID	Type	Concentration (µg/ml)	Absorbance
1.	STD 1	Standard	2.00	0.163
2.	STD 2	Standard	4.00	0.193
3.	STD 3	Standard	6.00	0.255
4.	STD 4	Standard	8.00	0.302
5.	STD 5	Standard	10.00	0.349

Standard Curve

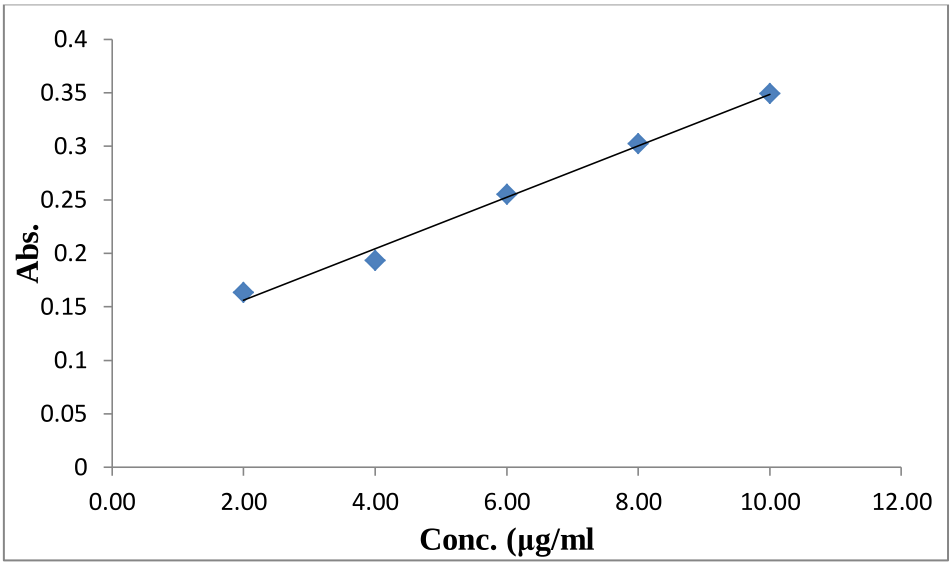

Figure 3.5 Determination of Total Phenolic Content of the Wood of *Dalbergia oliveri*

The total phenolic content of the wood extract of *Darlbergia oliveri* was measured with the Folin -Ciocalteau reagent. Firstly, 2 µl of extract solution was taken in a test tube. It was made up to 1.6 ml with distilled water. 100 µl of Folin -Ciocalteau reagent was mixed, then 300 µl of standard Na_2CO_3 (20%) solution was added.

The mixture was heated in a water bath at 40 °C for 30 minutes and then cooled in an ice bath. The absorbance of this prepared sample solution was measured at 765 nm by using UV spectrophotometer. The results are shown in Table (3.4).The total phenolic content of the extract was expressed as ethyl gallate equivalent (GAE) mg / g dry weight.

Table 3.4 Results of Absorbances and Concentration of Extract Solution(Sample Table)

No	Sample ID	Type	Concentration (µg/ml)	Absorbance
1.	Tamalan- 1	Unknown	9.99	0.348
2.	Tamalan- 2	Unknown	10.05	0.349

Calculation

The total phenolic content of the wood extract of *Darlbergia oliveri* was calculated from the standard curve prepared from different concentrations of ethyl gallate in which the same spectrophotometric procedure was followed for the working standard.

By using the resulted data,

2 µl of diluted extract solution contain   10,02µg of phenolic compounds.

2 ml of diluted extract solution contains   10.02 mg of phenolic compounds.

20 ml of diluted extract solution contains   = ?

$$= \frac{20\ ml \times 10.02\ mg}{2ml}$$

$$= 100.02\ mg$$

The total phenolic content of the wood extract of

Darlbergia oliveri = 100.02 mg (ethyl gallate equivalent) / g

4.Results and Discussion

4.1. Moisture content of tested species

The average moisture content of tested species is shown in table 4.1. According to this table, the mean moisture content of Tamalan is 17.14% and the minimum and maximum moisture contents are 14.96 % and 20.41 %.

According to the measurement of the moisture content of the tested Tamalan, the average moisture content is 17.14 %, thus, we can assume and observe the content of moisture is less in our tested Tamalan.

Table 4.1 Moisture content of tested species

Sample No.	Initial Weight	Oven Dry Weight	Moisture Content MC (%)	Average (%)
T-1	8.089	6.718	20.41	17.14
T-2	7.846	6.751	16.22	
T-3	8.758	7.420	18.03	
T-4	7.808	6.792	14.96	
T-5	8.779	7.589	15.68	
T-6	8.501	7.250	17.26	
T-7	8.395	7.137	17.63	
T-8	8.584	7.350	16.79	
T-9	9.018	7.609	18.52	
T-10	8.740	7.539	15.93	

4.2. Decay Resistance of Tested Species

The results of the experiments were evaluated as a mean weight loss percent. The average weight loss in dry weight percent of Tested Species was shown in table (4.2). According to the Natural Durability Classification (Findlay, 1958), the natural durability of the tested species is also given in Table (4.2).

Table 4.2 The average weight losses in Tested Species by fungus

Sample no.	Initial Wt	After 4 months Wt	COD Wt	Wt Loss (%)	Durability Class
T-1	5.417	5.0011	5.4	0.0738	**Very durable (Class I)**
T-2	5.221	4.8921	5.12	0.0445	
T-3	4.608	4.1284	4.6	0.1025	
T-4	5.3	4.9103	5.3	0.0735	
T-5	5.358	4.8	5.356	0.1038	
T-6	5.51	5.1	5.5	0.0727	
T-7	5.133	4.7659	5.132	0.0713	
T-8	5.218	4.7481	5.21	0.0886	
T-9	5.285	4.73	5.284	0.1048	
T-10	5.22	4.8002	5.2	0.0768	
Average				0.0812	

According to this table, it was found that the average weight loss in dry weight percent of Tamalan is 0.0812 %. Therefore, it lies in Very Durable class, Durability Class I. The decay resistance of testing species was shown in figure 4.2. It can be seen clearly that Tamalan is the lowest in weight losses among the tested species.

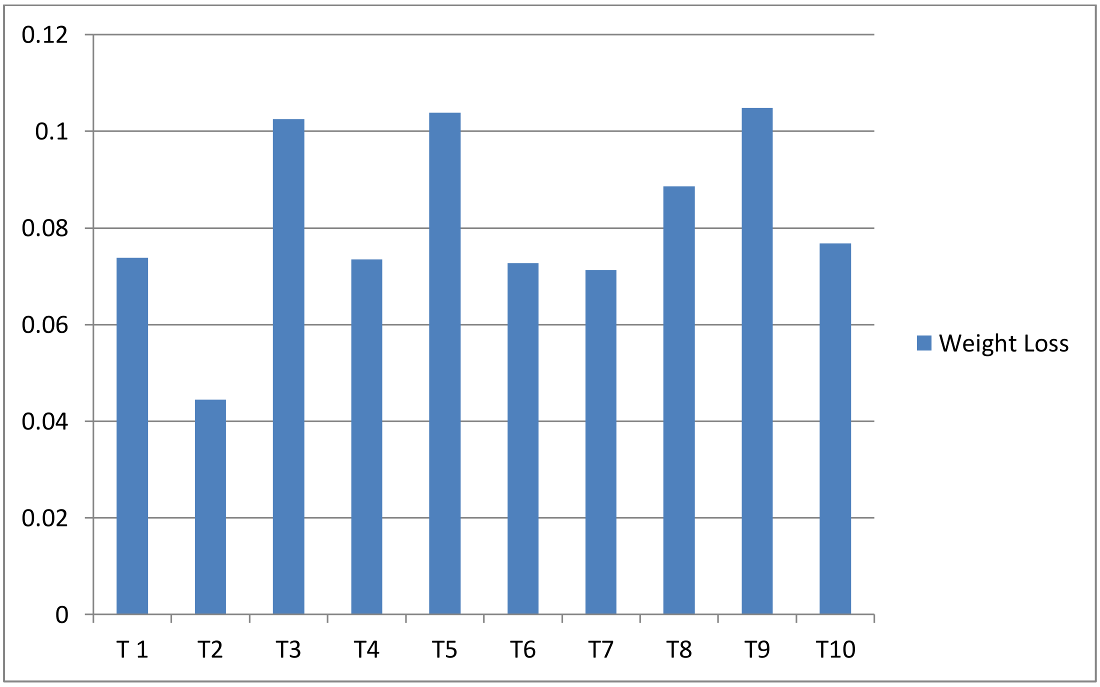

Figure 4.1 The average weight losses in Tested Species by fungus

4.3. Termite Resistance of Tested Species

The resistance to subterranean termites of testing wood samples was shown in Table (4.3). The visual rating of test samples and weight losses are also presented in this table.

Table 4.3 The visual rating and average weight losses of Tested Species

Sample no.	Initial Wt	After 4 months Wt	COD Wt	Wt Loss (%)	Durability Class
T-1	8.38	7.8923	8.089	0.0243	**Very durable (Class I)**
T-2	8.243	7.4621	7.846	0.0489	
T-3	8.253	7.8547	8.058	0.0252	
T-4	8.282	7.329	7.808	0.0613	
T-5	8.335	7.9901	8.279	0.0348	
T-6	8.017	7.1196	7.501	0.0508	
T-7	8.683	7.9651	8.395	0.0512	
T-8	8.513	7.9984	8.384	0.0459	
T-9	8.219	7.8002	8.018	0.0271	
T-10	8.46	7.8796	8.14	0.0319	
Average				0.0402	

According to this table, it can be seen that a visual rating of Tamalan is Zero and weight loss percentage of it is found to be 0.0402. Therefore, Tamalan is found to be termite resistant, while the same result was found for Tamalan (visual rating: 0, weight loss: 0.0402) and it is to be termite resistant.

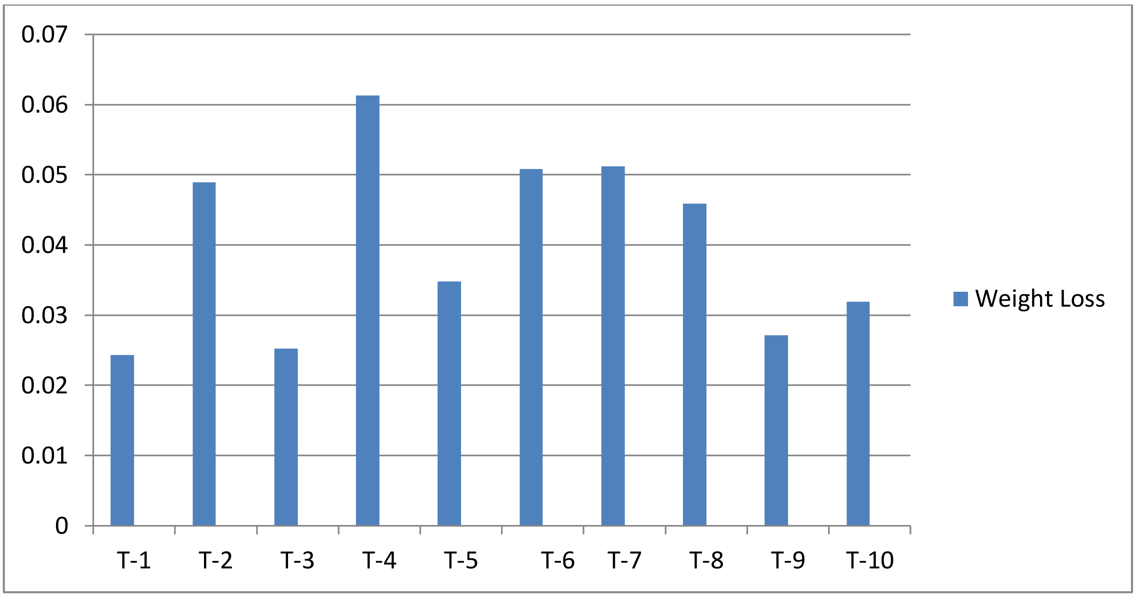

Figure 4.2 The visual rating and average weight losses of Tested Species

Table 4.4 Values of Standard Deviation of the Tested Specimens

SSpecies	**Moisture Content**				**Lab Decay Test**				**Termite Test**				**Durability Class**
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	
Ta-ma-lan	14.96	20.41	17.14	1.59	0.04	0.10	0.08	0.009	0.02	0.06	0.04	0.004	**Very Durable Class**

4.4 Qualitative Tests for phenol

The extract obtained from the wood of *Darlbergia oliveri* with 0.3 %HCl in methanol and distilled water was examined by using the special qualitative tests of phenol. The resulted data are tabulated in table (4.5).

Table 4.5 The Results of Qualitative Test for Phenol

No	**Experiment**	**Observation**	**Inference**
1.	Acid Property Test	The Blue litmus paper turns red	Phenol may be present
2.	Color with $FeCl_3$	Brown color was observed	Phenol is present
3.	Ellagic Acid Test	Muddy or nigger brown precipitate was appeared	Phenol is present

From these results, it was observed that the extract of the selected sample, which consists of phenolic compounds which exhibited the antioxidant activity.

4.5 Quantitative Determination of Total Phenolic Content

The total phenolic content of the wood of *Darlbergia oliveri* was carried out by spectrohphotometric method using the Folin-Ciocalteu reagent. The absorbances of prepared sample solutions ((2 µl with ml distilled water) were measured by UV- visible spectrophotometer at 765 nm with respect to the blank solution for two times. The results are described in Table (4.1 and 4.2). From these results, the amount of total phenolic content by analyzing samples was obtained by using the standard graph. The total phenolic content of the wood of *Darlbergia oliveri*. was expressed as gallic acid equivalent and it was found as 100.02 mg ethyl gallate equivalent per gram.

5. Conclusion

In this research, **"Study on the Durability and Utilization Potential of Economic Important Species, Tamalan (*Dalbergia oliveri* Gamble ex Prain)'',** it tested mainly for durability and resistance of termite of Tamalan wood by decay and termites tests based on field tests and laboratory tests. Since, Tamalan is very durability class mentioned all researchers, this research was tested by using simple and significant way of differing initial weight and after testing weight on both of decay tests and termite testes. In both tests, weight loss is nearly zero percentage. This results show that it is a very durable class on both testes of decay and termite testes. In decay testings, the common fungus for hardwood; white rot fungi were used. In termite testings, to find out the present of phenolic compound in the wood, it carried out by 3 types of testing; Acid Property Test, Color with $FeCl_3$ and Ellagic Acid Test. Moreover, the total phenolic content of the wood extract obtained from the selected samples could be evaluated by UV spectrophotometer using the Folin-Ciocalteau reagent at 765 nm. It was found that the total phenolic contents of *Darlbergia oliveri* is 100.02 mg gallic acid equivalent per 100 g. The result data of the current work showed that the selected sample had the considerable amount of the total amount of phenolic compounds. Since the antimicrobial (kills microorganisms or stops their growth) and antioxidant (damage the cells of organisms) activities of the extracts were positively associated with the total phenolic contents of the extract, the presence of phenolic compound in the wood is a main fact for the most durable and resistant of Tamalan. So it can be concluded that higher proportions of phenol confer higher resistance of the wood. And the content of MC also influence on the durability and resistance of the wood. Since, the result of the MC amount of testing was the least amount (17.14%) under 30 %, it also one of the facts to support Tamalan wood to be very durable and resistant (class 1). And evaluation of natural termite resistance in native and tropical species is becoming increasingly important in the wood preservation industry, because there has been a greater focus on reducing the potential leaching of chemical treatments out of the wood and into the environment.

6. References

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

Choi CW, Choi YH, Cha MR, Kim YS, Yon GH, Kim YK, Choi SU, Kim YH and Ryu SY. (2009). Antitumor components isolated from the heartwood extract of Dalbergia odorifera. Journal of the Korean Society for Applied Biological Chemistry 52, 375-379.

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

Desch, H.E., (Revised by J.M. Dinwoodie) 1981.

Environmental Investigation Agency (EIA). 2014. Myanmar's Rosewood Crisis. Why key species and forests must be protected through CITES. London, UK. (ukinfo@eia-international.org) (www.eia-international.org)

Fern, Ken. 2014. Useful Tropical Plants Database 2014 by Ken Fern.

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

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

https://doi.org/10.1016/j.indcrop.2012.09.006Get rights and content

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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.

Johnson G. C. and J. D. Thornton, 1991. An Australian Test of wood preservatives, II. The condition after 25 years exposure of stakes treated with waterborne preservatives.

Kazembe T, Munyarari E, Charumbira I. (2012). Use of traditional herbal medicines to cure malaria. Bulletin of Environment, Pharmacology and Life Sciences 1, 63-85.

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

Khin Maung Lwin(Dr) (FAME) and Dr. Myat Kay Thwe Lwin(Botanist): Medicinal plant list of Myanmar, Second Edition

Kiritikar KR, Basu BD. (1933). Indian Medicinal Plants. 2nd ed. Allahabadi: Lahit Mohon Basu 1, pp 818-819.

Lee Kong Chian Natural History Museum. 2018. Faculty of Science, National University of Singapore. 2018.

Lenz et al., 1992. An improved field method for assessing the resistance of wood and non-woody materials attacked by subterranean termites.

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)

Nadkarni, K. M. (1954). Indian Materia Medica. 3rd ed. Bombay: Popular Book Depot 1, pp 432.

Nyi Nyi Kyaw. 2014. Myanmar Timber Trade and Rosewood Policies. Presentation to the International Workshop on Promoting Legal and Sustainable Trade and Investment of Forest Products, Myanmar Forest Department . 26 March 2014, Shanghai. In Rosewood Case Study, Analysis of rosewood (kg) data, based on seizure records in World WISE from 2005 to 2015.

Oldfield, S., Lusty, C. and MacKinven, A. (compilers). 1998. The World List of Threatened Trees. World Conservation Press, Cambridge, UK.

PANAYOTOU & ASHTON, 1992. Not by timber alone: economics and ecology for sustaining tropical forests. Island Press, Washington D.C.: 282 pp.

Pluempanupat, Sujittra; Nutchaya Kumrungsee, Wanchai Pluempanupat, Kotchamon Ngamkitpinyo, Warinthorn Chavasiri, Vasakorn Bullangpoti, Opender Koul. 2013. Laboratory evaluation of Dalbergia oliveri (Fabaceae: Fabales) extracts and isolated isoflavonoids on Aedes aegypti (Diptera: Culicidae) mosquitoes. Industrial Crops and Products. Vol. 44, January 2013, 653 – 658.

Pooley E. (1993). The Complete Field Guide to Trees of Natal, Zululand and Transkei, 1st edition. Natal Flora Publications Trust, Durban, South Africa.

Rao, Y.S. 1992. Forest news.Tigerpaper 4: 1-2.

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

Said, I.M. and Rozainah, Z. 1992.An updated list of wetland plant species of Peninsular Malaysia, with particular reference to those having socio-economic value.Asian Wetland Bureau.

Sanjib Saha1, Jamil A. Shilpi, Himangsu Mondal, Faroque Hossain, Md. Anisuzzman, Md. Mahadhi Hasan, Geoffrey A. Cordell (2013). Ethnomedicinal, phytochemical, and pharmacological profile of the genus Dalbergia L. (Fabaceae)

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

The Wood Database. 2018. Copyright © 2008-2018 Eric Meier.

Thein Kywe and Kyaw Soe. 1983. The Morphological and Anatomical Characteristics of (25) Commercial Burmese Timbers (Part 1). Leaflet No. 7/82-83. Forest Research Institute, Yezin. February 1983.

Van Steenis, C.G.G.J. 1948. Flora Malesiana. Flora Malesiana Foundation, Leiden.

Vrieze, Paul. 2018. Extinction Looms as Notorious Rosewood Loggers Set Sights on Burma Species, Group Warns. The Irrawaddy.

Whitmore, T.C. 1990. Comments on draft listing of tropical timbers of Peninsular Malaysia.

Wikipedia. 2018. A free encyclopedia. 2018. (https.//en.m.wikipedia.org)

Xu J.Y. and Li W.H. 2003. Identification of Rosewood. China Timber. 5: 8-11(in Chinese):In “Tropical Hardwood Flows in China: Case Studies of Rosewood and Okoumé ”. Huang Wenbin and Sun Xiufang. 2013.-"

Win Chit (2008): ဝင်းချစ်၏စာစုများ