

Subterranean Termite Durability of Three Inferior Wood Species Collected from Indonesian New Guinea Coated with Two Coating Systems

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Abstract

Wood is very susceptible material from termite attacks. A simple, cheapest method to prevent this attack is coating treatment. On this work, three inferior wood species collected from Manokwari – Papua Barat, namely Pulai (*Alstonia scholaris*), Binuang (*Octomeles sumatrana*), and Jambu (*Syzygium* sp.) were coated with two coating systems of oiled and water-based coatings. Coating was applied using paint brush on wood samples with dimensions, 50 cm long x 5 cm wide x 2.5 cm thick. Durability was conducting with grave yard test, where half-length of wood samples, coated and uncoated samples, were buried on the yard for the three consecutive months. Wood durability was evaluated using two variables, wood weight loss, and wood damage, respectively, and analyses into other variables like wood resistance class, level of resistance, degree of damage, and natural durability classes. The results indicated that both coated systems, oiled and water based, had an average of spreading rates from 0.005-0.015 g/cm². Weight loss of three inferior species of wood recorded from the control samples are 38.65%, 12.12%, and 6.14% for Pulai, Binuang and Jambu, respectively. Treatment with coating systems, weight loss could be prevented into 95.1%, 58.2% and 56.0% to control for Pulai, Binuang and Jambu, respectively. Wood resistance class of Pulai is IV for Susceptible (control) and fallen into Moderate – Resistance with coating systems, from Durable into Moderate Durable or shifting from degree of damage 3 into 2. Binuang species initially is Moderate Resistant (III) and improve into Resistant (II), and has natural durability from Non-Durable with degree damage of 3 into Very Durable with degree damage of zero. Jambu is similar to the Binuang, from Moderate resistant to Resistance and natural durability from Moderate Durable to Very Durable after being coated with two coating systems. It is summarized that coating systems available in the local market could protect wood from subterranean termites and these coating regimes could be applied into daily practices in our local environment or houses.

Keywords: wood durability; subterranean termite; inferior wood species; coating systems

Introduction

Wood is biological material available on earth produced by wooden plant that ecologically and environmentally sustainable for any utilizations. This renewable material has been usages from the beginning human civilization across the globe. It has natural characteristics like beauty in color, hardness, convertible and workable to any wood products. Since human civilization, wood has been utilized for construction of bridges, houses, huts, and others. However, one of main obstacle in wood life utilization or wood life service is organism attacks, mainly termite attacks (Subekti *et al.* 2018). Several treatment have been applied to protect wood in service, ranging from wood preservation with chemical, coating with coating system and wood barriers.

Recently, wood supplied from the natural forest is declining in volume, numbers of species, dimension, and quality (Wahyudi and Arifudin 2018). Sawn timber marketed and supplied for local used in Papua and Papua Barat province have been dominated by well-known species, Merbau (*Instia* sp.) and Matoa (*Pometia* sp.), respectively (Wahyudi *et al.* 2017). Two lesser known species which could be an alternative species of sawn timber in Papua and Papua Barat province are Lulu (*Celtis latifolia* Planch) and Jambu (*Syzygium* sp.) (Wahyudi *et al.* 2014).

Two inferior wood species of Pulai and Binuang, are enormous in nature, growing at any secondary forests or opened-lands near the local community gardens across low land areas in Indonesian New Guinea, Papua and Papua Barat Province. They are fast growing species, pioneer and dominant species at any secondary forests. These trees are naturally stand with an average of 60 cm up in diameter breath height (DBH) with 15 m height. Other wood species that have comparable attribute to the superior species are Jambu (*Syzygium* sp.) and Simpup (*Dillenia* sp.), as they have comparable machining properties to Matoa (*Pometia* sp.).

In Indonesian New Guinea, these wood species have not been utilized for construction purposes but they are used for pallet boards for cement boxes construction and due to their low density, and susceptible from wood organism, mainly subterranean termites. Today, these three wood species mainly used for packaging material, mainly due to their low density, where Pulai has density of 0.3 g/cm³, Binuang of 0.4 g/cm³ and Jambu of 0.63 g/cm³ (Wahyudi *et al.* 2014).

Wood durability is related to the resistance of timber against any attacks from destroyed organisms, mainly subterranean termites. In order to lengthen life service of wood or timber, wood preservation using chemicals that is toxic to environment was applied, but recently bio-natural agents have been explored and applied for timber preservation, as this is less toxic to surrounding nature (Hadi

et al. 2016). Another method to improve wood durability is coating treatment, where wood surfaces were layered or coated with substances, either oiled and water-based coating system (Krisdianto *et al.* 2018). Wood coating is aimed to provide a protective layer or barrier from the wood deteriorated agents including termites. Coating is one of several method to improve wood durability by protecting from fungi, termite attacks, and other physical and chemical causes (Kaborani *et al.* 2017; Pánek *et al.* 2019a; Pavlič *et al.* 2021).

Coating treatments are applicable in various ways in layering or polishing the surfaces of timber with hand sprayer, painted brush or the others (Rowell and Bongers 2015). These methods are technically achievable compared to the preservation ordinary methods, where toxic, corrosive substances and preservation installation are highly required. The simplest and cheapest coating treatment is to apply coating material or systems available on the market.

In daily uses, coating systems are divided into two categories, oiled and water based-coating systems (Pánek *et al.* 2019a). Oiled based coating systems is using oiled, mainly petroleum based for their liquid, while water based is water as the main solvent. Three oiled based coating systems were employed, ranging from paint, melamine, and varnish, respectively. Water based coating is acrylic based material. The main objective of this work, therefore, is to examine effectivity of four coating systems on wood durability against subterranean termite conducted with grave yard test.

Materials and Methods

Wood Sample Preparation

Wood samples of sawn timber were purchased from the local supplier in Manokwari town, each timber has dimension of 5 cm thick x 10 cm width x 400 cm long, and free from bark, split check, knot, and deformation. Sawn timber was cross cut with circular saw (Makita 8" 5008M) into two length, 5 cm thick x 10 cm width x 200 cm length, then further cross cut into 5 cm thick x 10 cm width x 100 cm length and four cross cut-

samples were obtained. Each sample was ripped to produce 16 sticks of 5 cm thick x 5 cm width x 100 cm length, then ripped into 2.5 cm thick x 5 cm width x 50 length and 32 sticks were collected and mixed randomly. Hand planer (Makita M1901B) and sand paper (Kinka 60-100) were used for preparing the final samples. Four sticks were selected for moisture content and wood density samples, 2 cm length x 2 cm width x 2 cm thick. 15 sticks were further cut for coating systems with grave-yard test.

Each coating system has 3 replicates, 3 control samples, and 4 treatment of coating, therefore, 15 samples, 2.5 cm thick x 5 cm width x 50 cm length, were used for each wood species.

Coating Treatment

Coating treatments were applied manually using 2 inches paint brush (Palazzo 50, 70 mm), to all surface of wood samples. Glue spreading rate (g/cm^2) was calculated by weighting the sample after and before coated. The coated samples were placed in opened air temperature for drying. Four coating systems were applied, which could be divided into two based characteristics, water and oil-based coating systems. Water based coating was Mowilex WS 503 (Mowilex, Indonesia). Three oil-based coating system are Melamine (Melanic 1200 clear base, PT. Nipsea Paint and Chemical, Jakarta), Varnish (Nipsea Paint and Chemical, Jakarta), and Wood and Metal Paint (Avian, Jakarta).

Grave Yard Test

Graveyard test is similar to in-ground testing, where 20 cm bottom section of the coated samples were buried into ground (30 cm wood samples above ground) and left in place for three months (Hadi *et al.*, 2016). Initial installment of wood sample for conducting graveyard test is illustrated in Figure 1. Grave tests were conducted at the back yard of Laboratory building Faculty of Forestry university of Papua Manokwari, using random design.



Figure 1 Instalment of the samples used for grave yard test.

Research Variables

This work has four variables, ranging from coated spreading rate (SR) expressed in g/cm^2 (Okahisa *et al.* 2019), weight loss (WL) in percent (%) (Hadi *et al.* 2016), level of wood resistance, and class of natural durability (Sornnuwat

1996), and rating system for visual classification (EN 252). These variables were calculated using the following equations: $\text{SR} = (W_i - W_o)/\text{WS}$ (g/cm^2), where W_i = weight of sample after been coated (g); W_o = weight sample prior being coated (g); WS = total surface of wood sample (cm^2). $\text{WL} =$

$(W_1 - W_2)/W_1 \times 100\%$ where W_1 = weight of sample prior the graveyard test (g); W_2 = weight of samples after the graveyard test (g).

Wood resistance levels are determined according to percent mass loss, listed in Table 1, whereas classification of natural durability of wood is determined with the visual rating and presented in Table 2.

Table 1. Wood resistance level based on the percent mass loss of wood

Class	Percent weight loss (%)	Level of resistance
I	0	Highly resistant
II	1-3	Resistant
III	4-8	Moderate
IV	9-15	Non-resistant
V	>15	Susceptible

Table 2. Classification of natural durability of wood

Degree of damage	Termite attack on wood	Classified to natural durability
0	No damage	Very durable (VD)
1	Hardly visible damage	Durable (D)
2	Superficial and slightly inner damage	Moderate durable (MD)
3	Moderate inner damage	Non-durable (ND)
4	Heavy inner damage	Perishable (P)

Results and Discussion

The mean values for wood density, coated spreading rate, weight loss, class, level resistant, and classified natural wood durability are displayed in Tabel 3.

As been illustrated by Table 3, the highest spreading rate of coating system was recorded from Pulai (*Alstonia scholaris*), coated with OB₂ and OB₃, where each has 0.014 g/cm², and the lowest was recorded from Binuang (*Octomeles* sp), coated with OB₁ of 0,005 gr/cm². An average

of spreading rates of WB in general (0.01 g/cm²) is equal to an average of OB1-3 of 0.01 g/cm², and this average of the spreading rates recorded from this research is lower than those reported by (Wahyudi and Arifudin 2018) for 0.19 g/cm² for gluing a glulam made from Sago bark combined with two less used species applied for both surfaces. Lower in glue spreading rates recorded from this investigation are probably because human error, where the workers are different to those previous experiment.

Tabel 3. The mean values for wood density, coated spreading rate, weight loss, wood resistant class, level resistant, and classified natural wood durability are displayed in Tabel 3.

Wood species	Density (g/cm ³)	Coating system	SR (g/cm ²)	WL (%)	Class	Level of resistant	DD	classified natural durability
Pulai	0.32	Control		38.654	V	Susceptible	3	ND
		Mowilek	0.011	8.468 ^C	IV	Moderate resistant	2	MD
		Paint	0.014	8.646 ^C	IV	Moderate resistant	2	MD
		Varnish	0.014	1.892 ^d	II	Resistant	2	MD
		Melamine	0.012	25.177 ^e 11.041 ^a	V	Susceptible	2	MD
Binuang	0.42	Control		6.141	III	Moderate resistant	3	ND
		Mowilek	0.009	2.742 ^d	II	Resistant	0	VD
		Paint	0.009	9.242 ^c	IV	Non-resistant	0	VD
		Varnish	0.007	6.952 ^c	III	Moderate resistant	0	VD
		Melamine	0.005	2.387 ^d 5.331 ^b	II	Resistant	2	MD
Jamb	0.63	Control		5.043	III	moderate resistant	2	MD
		Mowilek	0.009	2.940 ^d	II	resistant	0	VD
		Paint	0.012	1.783 ^d	II	resistant	0	VD
		Varnish	0.011	1.563 ^d	II	resistant	0	VD
		Melamine	0.008	3.992 ^d 2.571 ^b	III	moderate resistant	0	VD

Remarks : SR= Spreading rate, WL= weight loss, DD= degree of damage, ND=non-durable, MD= moderate durable, VD= very durable, S= susceptible, MR = moderate resistant, R=resistant, NR= Non-resistant

Percent WL recorded from the control samples for three species are higher than those recorded from the three coated systems used, such as 38.65% recorded from Pulai, followed by 12.12% of Binuang and 6.14% of Jambu. It seems that Pulai coated with OB₂ could prevent WL by 95.1% compared to the control. Similarly, coating applied for other two wood species could prevent WL by 58.2% and 56.0% for Jambu dan Binuang, respectively. These results summarize that coating systems had an impact to enhance the life services of wood material from subterranean termite tested. Coating systems are usually employed to extend the change of color, protect wood surface from biotic and abiotic factors, and mostly for softwood end products (Gobakken and Westin 2008; Gurleyen *et al.* 2019). It is also supported that coating systems could protect weight loss of wood during service, mainly due to termite attack (Amemiya and Marsuoka 1979).

Analysis of variance (ANOVA) for percent WL amongst three wood species are highly significant ($p=0.001$), but four coating regimes had a significant impact to prevent WL ($p=0.027$). Post hoc test using least significance difference (LSD) _{0.05} indicated that the WL recorded from Pulai is different to Binuang and Jambu. Amongst four coating regimes, their means for the WL are not significantly different, however, when the coating regimes were applied to different wood species, the WL resulted in different percentages (Table 3). The WL recorded for Jambu are lesser than the others.

Table 3 indicates that in general wood resistance class and level of resistance for three inferior wood species from Indonesian New Guinea, using percent of wood weight loss (Table 1), could be improved. Pulai without coating treatment or control has wood resistant class V and it could be improved by coating with OB₂ into wood resistant class II. Pulai control has Susceptible (S) for level of resistance and improve to the Resistant (R) after being coated OB₂. Binuang control samples are fallen into wood resistance class IV or Not Resistant (NR) and coated with WB and OB₁ could improve wood class resistance into class II for Resistant (R). Jambu originally (control sample) was classified into moderate wood resistant class III or Moderate (M), after being coated with WB and OB₂ and OB₃ could improve wood resistant class into II or Resistance (R). It could be highlighted that two coating regimes could improve wood resistant class grade and wood resistant level categories. These three inferior wood species had light density and bright color, presumably they had low extractive substances that could be a toxic substance for termite (Amaliyah *et al.* 2020; Nakai and Yoshimura 2000).

With regard to the degree of damage (DD) and classification of natural durability, Pulai without treatment (control) had degree of damage (DD) for scale 3, and after being treated with coating, it is upgraded from into 2 scale or from Non-Durable (ND) into Moderate Durable (MD). Binuang from DD level 3 of control sample into DD 0-2 meaning Very Durable (VD) into MD. Remarkable improvement is achieved for Jambu, four coating regimes could upgrade DD class 2 into DD 0 or from MD into VD. Pulai wood natural durability could be improved from Non-Durable (control) into moderate durable by coating both WB and OB system. Similarly,

Binuang treated with two coating regimes can be upgraded from ND into MD and D. Remarkable achievement could be pointed into Jambu, where its natural durability could be improved from MD (2) into VD (0), meaning from moderate durable (control) into very durable (coating systems).

It highlights that coating systems are not only improve the natural durability of wood against subterranean termite ((Hadi *et al.* 2016; Zulfiana *et al.* 2020) but also stabilize wood from biotic and abiotic factors when the wood is exposed outdoor and having direct contacts water, sunlight and other factors (Knapic *et al.* 2018; Okahisa *et al.* 2019; Pánek *et al.* 2019).

Application of wood coating to improve wood life services by layering wood surface and enhance the natural beauty of wood could be conducted using simple method with low cost and the coating material available in local market (Knapic *et al.* 2018; Ozgenc *et al.* 2012). This coating treatment could be applied into any wooden product with

Conclusions

It is summarized that three inferior wood species coated with two coating regimes had different durability performance tested against subterranean termite. Coating systems, oil dan water bases, could improve natural durability of three inferior wood species collected from Indonesian New Guinea.

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