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Feeding rate of subterranean termites in wood treated with smoke wood and borax

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Abstract. This study aimed to analyze the feeding preference of subterranean termites (*Coptotermes curvignathus*) against 3 Indonesian native woods such as Jabon (*Anthocephalus cadamba*), Jati (*Tectona grandis*) and Ulin (*Eusideroxylon zwageri*) treated with borax and bamboo smoke wood. The method was conducted and evaluated according to *Japanese Industrial Standards* (JIS 2004) and Indonesian National Standard (SNI 2014) with *Pinus mercusii* as the control. The results showed that Jabon (*A. cadamba*), Jati (*T. grandis*) and Ulin (*E. zwageri*) woods treated using smoke and borax were not significantly different. All treatments have effectively increased the resistance to subterranean termite attacks. The treated wood samples have less weight loss, higher termite mortality, and lower termite feeding rate compared to the untreated wood. Daily termite feeding rate of untreated *P. mercusii* was 1.63 mg/termite/day, smoke wood treated was 1.5 mg/termite/day and borax treated wood was 1.4 mg/termite/day. In conclusion, the smoke wood treatments effectively decreased the daily feeding rate of the termites.

1. Introduction

Indonesia is one of the wood supplier with 37.5 million m³ wood production and 85% of log plantations come from forest [1]. Existing house in Indonesia was built with mature wood, but in 2018 disadvantages of economic cost due to termite attack of this existing house was US\$ 500 million [2,3]. Wood preservation can extend the service life of wood, and it can be done by adding toxic chemicals or doing preservatives treatment to the wood. Termiticides, one of termite repellent, use chemical ingredient identified as Persistent Organic Pollutants [4]. This makes the interest of new environmentally safe biopesticides increase toward plant species and natural resources, which can provide effective insecticidal activities. Smoke woods of bamboo wulung is one of promising plant species which can provide sufficient quantities of active compounds, and has been used for large scale pest management for relatively favourable production costs [5]. Research about wood preservation for control termites attack using liquid smoke from bamboo wulung has not be done yet. The purpose of this study was to analyze the feeding preference of subterranean termites (*Coptotermes curvignathus*) against 3 Indonesian native woods such as Jabon (*Anthocephalus cadamba*), Jati (*Tectona grandis*) and Ulin (*Eusideroxylon zwageri*) treated with borax and bamboo smoke wood preservation.

2. Materials and methods

2.1. Wood preparation

The wood species used in this research were Indonesian Pine wood (*P. merkusii*), Jabon (*A. cadamba*) and Jati (*T. grandis*) taken from Semarang, whereas Ulin (*E. zwageri*) wood was taken from North Kalimantan, Indonesia. Small clear specimens of 4 woods sized 2 x 2 x 2 cm (W:T:L) were used for the test. The wood samples were dried at 60 °C for 48 hours. Untreated Pine woods (*P. merkusii*) preserved were prepared for comparison (control).

2.2. Liquid smoke processes

Bamboo wulung was pyrolyzed at 400 °C for 5 hours using pyrolyzer [6,7]. Three kilograms of bamboo wulung were weight and inserted into pyrolyzer to form liquid smoke solution. Then, the solution was cooled at room temperature to separate the liquid smoke (pyroligneous liquor) and the sludge [8]. The liquid smokes were purified by distilling 1 liter of them into the distillation flask at 107° C, and heated using a hot plate. The liquid smoke charcoal were obtained for 7 hours [9,10]. Finally, the liquid smoke charcoal was analyzed using Gas Chromatography Mass Spectroscopy (GC-MS Pyrolysis).

2.3. Feeding-preference test

Two treatments were applied to wood samples of each species (soaked in 5% of liquid smoke charcoal 24 h and 5 % of borax for 24 h). Then, each wood sample was subjected to subterranean termites *C. curvignathus* according to JIS [11] and each of the experiment repeated three times. At the end of this step, the sample weight loss (WL), termite mortality, resistance class, and termite feeding rate were determined [11,12,13]. To evaluate the effectiveness of preservation methods, Indonesian standard [14] was used for indicating the higher resistance to termite attack.

2.4. Data analysis

The investigated factors were (1) wood species consisting of Jabon (*A. cadamba*), Jati (*T. grandis*) and Ulin (*E. zwageri*) woods and (2) treatment consisting of untreated wood and treated wood (smoked woods). There were three replications of randomized factorial designed for statistical purposes. Duncan's test was used for further analysis significant differences determined at $p < 0.05$.

3. Result and discussion

Untreated *P. merkusii* had poorly resistance than treated Jabon (*A. cadamba*), Jati (*T. grandis*) and Ulin (*E. zwageri*) woods due to WL and termite mortality. Table 1 showed that the effect of smoked wood and boraks treatment was highly significant for termite mortality, WL and feeding rate. Table 1 showed that the treated wood by 5% smoke on Ulin wood and Jati in day 20 caused 100% mortality, while on Jabon wood the 100% mortality in day 30.

Table 1. Termite mortality of the smoked wood 5% and Borax 5% for Jabon (*A.cadamba*), Jati (*T. grandis*) and Ulin (*E. zwageri*) woods.

Treatment	Sample	Mortality (%)					
		5	10	15	20	25	30
Control	<i>P. merkusii</i>	21.81±1.37	11.51±0.90	6.29±2.24	4.08±1.16	2.33±0.84	1.91±0.70
	<i>E. zwageri</i>	17.56±3.74	2.08±3.60	0.67±1.15	0.00 ±0.00	0.00 ± 0.00	0.00 ± 0.00
Smoke 5%	<i>T. grandis</i>	20.78±1.26	4.17±2.03	2.42±2.98	0.00 ±0.00	0.00 ± 0.00	0.00 ± 0.00
	<i>A. cadamba</i>	20.33±3.78	3.67±4.72	1.17±2.02	1.33±2.30	1.33± 2.30	0.00 ± 0.00
	<i>E. zwageri</i>	20.89±0.19	9.5±1.75	4.67±1.75	2.45±1.57	0.00 ± 0.00	0.00 ± 0.00
Borax 5%	<i>T. grandis</i>	22.89±3.74	4.92±2.15	2.42±3.16	1.55±2.41	0.00 ± 0.00	0.00 ± 0.00
	<i>A.cadamba</i>	20.45±1.07	5±3.69	2.58±4.47	1.89±3.27	1.67± 2.88	0.00 ± 0.00

However, the termite was still survived on the controlled wood, Pine wood, till day 30 of treatments. Test by 5% borax on Ulin and Jati wood showed 100% mortality on day 25, while on Jabon wood 100% mortality happened on day 30. Table 2 showed that termites' daily consumption of untreated *P. mercusii* was 1.63 mg/day, smoke treated wood was 1.5 mg/termite/day and borax treated wood was 1.4 mg/termite/day. This meant that feeding rate of *P. mercusii* was higher than Ulin, Jati and Jabon. Based on WL and Indonesian Standard, untreated *P. mercusii* is poorly resistance but the smoke and borax treated woods are resistance. WL of wood treated with borax or with smoke was significantly lower than untreated wood.

The most durable samples are Jabon, Jati, and then Ulin woods. Wood treatments by using borax and smoke could decrease termite's daily consumption through various mechanisms. Borax treatment is poisonous as it results in chemical modification of the wood, the acetyl compound; polystyrene creates a higher density and fills the lumen [15], while smoked wood has acetic acid compounds. Gas chromatogram of bamboo wulung showed that the main content of liquid smoke that produced by pyrolysis dominated by 25.05% of acetic acid. This result correlate with the prior study identified the chemical composition of smoked bamboo which was dominated by acetic acid [16,17].

Table 2. Feeding preference of termites to wood samples with smoked woods and borax treatment.

Control	Daily consumption (mg)					
	Smoke 5%			Borax 5%		
Pine wood	Ulin	Jati	Jabon	Ulin	Jati	Jabon
1.64	1.46	1.49	1.50	1.45	1.46	1.52

Borax and smoked wood treatment led to the lowest feeding rates, as indicated by the wood reaching resistance (very resistant) for three wood species. Acetylation and smoke were associated with higher feeding rates compared to other treatments. Lower wood consumption might be achieved by increasing the weight percent gain from the acetylation process and extending the smoke process [18].

During a month-test period, Jabon wood had the highest attack intensity because Jabon had very low density and seemed easier attacked for feeding. The three-wood species were susceptible to biodeterioration organisms because they were cut at a young age and dominantly consisting of sapwood and juvenile wood resulting less extractive content. The results of this study indicate that smoked wood has same better resistance to subterranean termite attacks with borax treatment. Smoked wood and borax treatment significantly increased the resistance of wood to subterranean termite attack. Smoke wood 5% should be examined regarding its arresting ability under the field conditions to establish environmentally benign termite management as a result of the commercialization of termite treatment technology.

4. Conclusion

Jabon, Jati, and Ulin woods that treated using smoke and borax were not significantly different. All treatments have effectively increased the resistance to subterranean termite attacks. Daily termite feeding rate of untreated *P. mercusii* was higher than Ulin, Jati and Jabon. The smoke wood treatments effectively decreased the daily feeding rate of the termites.

Acknowledgments

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