Natural Resistance of Rattan Species from Sumatra Against Subterranean Termite and Its Relation to Chemical Properties (Ketahanan Alami Rotan Asal Sumatra terhadap Rayap Tanah dan Hubungannya dengan Sifat Kimia)

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Abstract

The main problem of rattan utilization was the ravages of destructive organisms attack. The objective of this study was to determine the natural resistance of rattan species from Sumatra against subterranean termites and its relation with the chemical characteristics of rattan. All samples were tested for resistance to subterranean termite and its chemical characteristics according to the Indonesian National Standard. Observations, percentage weight loss, termite survival and degree of attack were determined. Results showed that *Calamus insignis, C. holttumii, Daemonorps verticillaris, and D. longipes* included in very resistant (Class I). *Korthalsia flagellaris, C. zonatus, C. laevigatus, D. sepals, C. spectatissimus, C. rugosus,* and *C. oleyanus* included in resistance class II. Furthermore, *D. micracantha* included in the class of moderate resistance (class III). The cellulose content has no significant correlation (P>0.01), and lignin has a significant negative correlation (P<0.01) to the weight loss, termite survival and the degree of attack. Rattan that has resistance class I and II can be utilized as raw material of furniture and crafts, while rattan which have resistance class III require preservation treatment to extend its service life.

Keywords: chemical properties, rattan, resistance class, subterranean termite

Abstrak

Masalah utama pemanfaatan rotan adalah kerusakan akibat serangan organisme perusak. Penelitian ini bertujuan untuk mengetahui ketahanan alami rotan Sumatra terhadap rayap tanah dan hubungannya dengan karakteristik kimia rotan. Sampel rotan diuji ketahanannya terhadap rayap tanah dan karakteristik kimianya dengan Standar Nasional Indonesia. Persentase pengurangan berat, jumlah rayap yang hidup dan derajat serangan ditentukan. Hasil penelitian menunjukkan bahwa *Calamus insignis*, *C. holttumii*, *Daemonorps verticillaris* dan *D. longipes* termasuk ke dalam kelas awet I. *Korthalsia flagellaris, C. zonatus, C. laevigatus, D. sepal, C. spectatissimus, C. rugosus,* dan *C. oleyanus* termasuk ke dalam kelas awet II. *D. micracantha* termasuk ke dalam kelas awet III. Kandungan selulosa rotan tidak mempunyai korelasi yang nyata (P>0,01), dan kandungan lignin mempunyai korelasi negatif yang nyata (P<0,01) terhadap penurunan berat, jumlah rayap hidup dan derajat serangan. Rotan yang mempunyai kelas awet I dan II dapat langsung dimanfaatkan sebagai bahan baku furnitur dan kerajinan tangan, sedangkan rotan yang mempunyai kelas ketahanan III memerlukan perlakuan pengawetan untuk memperpanjang masa pakainya.

Kata kunci: karakteristik kimia, kelas ketahanan, rayap tanah, rotan

Introduction

Rattan is a non-timber product that grows in the tropics and it is used for furniture and crafts (Myers 2015), both indoor and outdoor furniture (Joshi *et al.* 2017). Indonesia is the largest rattan producing country in the world and almost 43% of Indonesian rattan meet the needs of world imports, and it contributes about 0.067% (from GDP) in 2012 (BPS 2013). Nowadays rattan seen as a prospective commodity for state revenue. It is also seen as an important commodity for non-timber forest products which makes rattan one of the most exploited and high-value non-timber materials (Joshi *et al.* 2017). Rattan products also have extended featured export revenues other than oil and gas and can be aligned with the leading agricultural export income such as coffee, rubber, and palm oil. Existing designs have evolved considerably from furniture, accessories, sports equipment and some other forms of products and the processing have also shown high competitiveness (Hartanti 2012).

The majority of rattan used to meet the needs of rattan comes from the island of Borneo, Sulawesi, and Sumatra. At least 314 species of rattan originating from 8 genera and one genus of which are endemic to Indonesia, namely *Cornera*, grow and spread in Indonesia forest. Of the species available in Indonesia, 51 species are reported by Sumarna (1996) in Rachman and Jasni (2013) as commercial rattan species, while 13 lesser species of rattan can be used as an alternative to commercial rattan. The largest number species of rattan found in Kalimantan (133 species), followed by Sumatra (82 species), Papua (47 species), Sulawesi (35 species), Java (30 species), Maluku (11 species), West Nusa Tenggara (NTB), and East Nusa Tenggara (NTT) (only 2 species) (Rachman & Jasni 2013). There are ±50 species of rattan that have been used and traded in Indonesia, apparently only a small portion of which is exported; such as tohiti rattan, manau rattan, sega rattan, irit rattan, pulut putih rattan, semambu rattan, pulut merah rattan, which all belong to the *Calamus* group (Tellu 2008).

Emerging issues in the field of rattan research are the potential of rattan species, physical and chemical characteristics, and their quality level.Those issues should be addressed for furniture, filler glass fiber substitute in composite manufacture (Nikmatin *et al.* 2017), and rattan tea which is containing high flavanoid (Kou & Chen 2012). The quality of rattan is determined by the extent of rattan resistance to biological destructive factors (bio-deterioration), such as fungus and insects (termite), that naturally destroy rattan substrate (Rachman & Jasni 2013). Jasni (2013) reported that many of rattan collected in the storage room were attacked by dry-wood termite and subterranean termites thus it could not be processed for furniture component materials, and also cause serious damage costs reach to 100-300 billion rupiahs every year (Diba *et al.* 2013). Termites are pest insects that live in the tropics and damaging buildings, construction materials and furniture in Indonesia (Subekti *et al.* 2015). *Coptotermes curvignathus* Holmgren is generating the most vicious levels of attack compared to other types of termites (Rust & Su 2012). Termites are entering wood through small hole on wood surface to the heart wood that is parallel with wood fiber. Therefore, it is necessary to know the natural resistance of rattan to termite attack. The resistance of rattan is also influenced by chemical characteristics such as cellulose, lignin, starch, silica, and the presence of phenolic extractives in the rattan (Kirker *et al*. 2013, Romano & Acda 2017). The chemical properties could be expected to be a comparative characteristic for the identification of the type and quality of rattan because the chemical content of each type of rattan varies (Tellu 2008). Chemical properties are related to the structure and size of cells and tissues affecting the physical and mechanical properties of rattan (Tellu 2008).

The importance of knowledge about the resistance classes of rattan is essential in the process of classification of rattan utilization also there is still limitated information about resistance to decay and termite damage. Rattan with resistance class I and II can be utilized to supply the needs of commercial rattan for furniture, webbing or other handicraft items that require long service life. Rattan with resistance class III to V before being used for production materials should be preserved in advance to extend its lifetime period. The purpose of this study was to determine the natural resistance of rattan species from Sumatra against subterranean termites (*Coptotermes curvignathus* Holmgren) and its relation with the characteristics of the chemical components in each specimens of rattan. The results of this study are expected to provide an overview of classification resistance and chemical characteristics of rattan species from Sumatra.

Materials and Methods

Sample preparation

The rattan species were collected from the natural forest in Riau Province. The rattan were processed and researched at the Biology and Preservation Forest Product Laboratoy of Forest Product Research and Development Center in Bogor, West Java. The main material in this research was twelve species of Sumatran rattan (Table 1).

Natural resistance test

Each type of rattan was tested as many as 5 pieces (replicates). The test sample did not distinguish rattan segment and harvesting time. Samples of rattan with a length of 2 cm were inserted into 60 cylindrical containers. The sample was placed in a vertical position and arranged so as to touch the base and wall of the

Table 1 Sumatra rattan species that were used in the research

No.	Local name	Botanical name*
1	Udang	*Korthalsia flagellaris* Miq.
2	Buruk hati	*Calamus insignis* Griff. Var. *Longispinosus* Dransfield
3	Getah	*Daemonorops micracantha* Becc.
4	Batu	*Calamus zonatus* Becc.
5	Tunggal	*Calamus laevigatus* Mart.
6	Perut ayam	*Calamus holttumii* Furtado
7	Getah gunung	*Daemonorps sepal* Becc.
8	Tiban	*Daemonorps verticillaris* Griff. Mart.
9	Manau riang	*Calamus oleyanus* Becc.
10	Tiban lama	*Calamus rugosus* Becc.
11	Sekupang	*Calamus spectatissimus* Furtado
12	Bukit tiban	*Daemonorops longipes* Griff. Mart.

Remarks: *Based on rattan herbarium 1913, Conservation Research and Development Centre; William and Dransfield (2006); Jasni *et al*. (2007)

container. About 200 g of moist sand (moisture content ±7% below water holding capacity) were inserted into the container. Afterwards, 200 subterranean termites were put in the container and stored in a dark room for 1 month. Termite activity in the container was observed every week, and the container was weighed. If the moisture content of the sand down ±2%, then water was added to normalize the water level. This method refers to SNI 7207-2014 (BSN 2014).

After 1 month of testing and observation, the percentage of rattan weight loss, the number of termite survival and the degree of attack was determined by scoring. Standard determination of the resistance of the rattan against subterranean termites (*Coptotermes curvignathus* Holmgren) refers to resistance classifications of rattan based on its weight loss to subterranean termite attack (Table 2) (Jasni & Roliadi 2010) whereas degrees termite attack (Table 3) refers to SNI 7207-2014 (BSN 2014).

Determination of chemical component of rattan

The level of lignin in rattan was determined by SNI 14-0492-1989 (BSN 1989) and cellulose content in rattan was determined by Norman and Jenkins method (Wise 1944).

Data analysis

The study was designed using Completely Randomized Design (CRD) of one factor, *i.e.* twelve species of rattan. Each experiment (species of rattan) was repeated five times in order to obtain 60 data samples. The data were processed using SPSS software ver. 23. The effect of treatment on the percentage of rattan weight loss and termite survival was analyzed using analysis of variance (ANOVA). If the results are significantly different, Duncan test should be performed (Steel & Torrie 1993). Pearson correlation test was conducted to see the correlation of chemical properties with weight loss, termite survival and degree of attack.

Table 2 Classification on the resistance of rattan based on its weight loss to subterranean termite attack

Class	Interval of weight loss, %	Characteristic of resistance
I	< 17.00	very resistant
II	17.00 – 24.00	resistant
III	24.00 – 31.72	moderately resistant
IV	31.72 – 39.76	non resistant
V	> 39.76	susceptible

Source : Jasni & Roliadi (2010)

Table 3 Degree of subterranean termite attack

Percent of attack, %	Condition of test sample	Value of degree attack
0-5	no damage	0
6-15	slightly attack	40
16-35	moderate attack	70
36-50	heavy attack	90
> 50	very heavy attack	100

Source : National Standardization Agency (2014)

Results and Discussion

Natural resistance of rattan

Results of analysis of variance showed that species of rattan have a significant effect on the percentage of weight loss and termite survival. The average resistance of twelve species of rattan against subterranean termites by Duncan test ($P<0.05$) is presented in Table 4.

Based on Duncan test results on weight loss, the rattan species are classified in I, II and III class resistances group with regard to the Roliadi and Jasni (2010), *C. insignis*, *C. holttumii*, *D. verticillaris*, and *D. longipes* have a low average weight loss value that is below 17%, so that the resistance class is high or very resistant (Class I). *K. flagellaris, C. zonatus, C. laevigatus, D. sepals, C. spectatissimus, C. rugosus* and *C. oleyanus* have the average value of medium weight loss, ranging between 17.51 to 23.75%, thus it is included in resistance class II (resistant). Furthermore, *D. micracantha* has a high average weight loss value of 25.16%, so it is included in the resistance class III (moderate). Weight loss value maybe also affected by extractives substances others such as cellubiose, glucose, arabinose, stearic acid, oleic acid in rattan specimens (Hadi, *et al*. 2012). As in research Cornelius and Osbrink (2015) showing that when termite survival on wood was significantly lower, indicating that at least some of the mortality may have been due to toxic compounds in wood.

Rattan resistance can also be assessed through observation of the degree of termite attack. According to the observation of twelve species rattan, rattan in the class I had a degree of attack between 9.2 to 15.5% (slightly attack), while rattan in the class II and III were moderately attacked, with the degree of attack between 16.2 to 24.9% (Table 4).

Different feeding of termite on different rattan species may be due to some differences in chemical characteristics (Hapukotuwa & Grace 2011). Cellulose, lignin, nitrogen, ash, and silica content may have an effect on rattan resistance (Dhawan & Mishr 2007).

Table 4 Natural resistance average of rattan against subterranean termite attack

No.	Rattan species	Weight loss, %	Resistance class	Survival, %	Degree of attack	
		X ± Sd*		X ± Sd*	Damage, %	Condition
1	*Korthalsia flagellaris* Miq.	23.75 ± 115de	II	17.10 ± 1.60de	23.6	moderately
2	*Calamus insignis* Griff. Var. *Longispinosus*	14.54 ± 0.87a	I	7.20 ± 1.90a	14.8	slightly
3	*Daemonorops micracantha* Becc.	25.16 ± 1.16e	III	23.30 ± 1.68f	24.9	moderately
4	*Calamus zonatus* Becc.	23.68 ± 1.03de	II	19.20 ± 2.97de	21.4	moderately
5	*Calamus laevigatus* Mart.	21.35 ± 2.17cd	II	15.20 ± 1.82cd	19.8	moderately
6	*Calamus holttumii* Furtado	13.12 ± 4.41a	I	8.20 ± 1.48a	9.2	slightly
7	*Daemonorps sepal* Becc.	18.60 ± 1.54b	II	12.90 ± 2.16bc	18.0	moderately
8	*Daemonorps verticillaris* Griff. Mart.	14.63 ± 0.61a	I	9.10 ± 1.29a	11.8	slightly moderately
9	*Calamus oleyanus* Becc.	18.53 ± 0.94b	II	19.30 ± 5.54de	18.2	moderately
10	*Calamus rugosus* Becc.	17.51 ± 0.87b	II	13.80 ± 3.05cd	16.2	moderately
11	*Calamus spectatissimus* Furtado	19.60 ± 133bc	II	14.10 ± 1.85cd	20.7	slightly
12	*Daemonorops longipes*	14.81 ± 2.32a	I	9.80 ± 0.91a	15.5	

Griff. Mart.

Remarks: * Means followed by the same letters in the same column are not significantly different at the 5% probability level according to Duncan test. Sd = Standard deviation

Chemical characteristics of rattan

Rattan is easily attacked by subterranean termites mainly because of the high content of starch, sugar and protein. These substances are the main food of termites. In addition, the organisms may also take some main chemical components of rattan, such as cellulose and lignin, and break them down into sugar and starch (Rachman & Jasni 2013). The average results of measurements of chemical properties of twelve species of rattan are presented in Table 5.

As can be seen in Table 5, the cellulose content of twelve species of rattan ranged between 46.51-59.97%, while for lignin ranged between 20.43-27.44%. Differences in chemical composition of material may be influenced by environmental factors, such as biotic, abiotic and climate change (Negassa & Sileshi 2018).

Chemical contents of rattan affect the quality of rattan, including the nature of resilience and durability against termite attack (Winarni & Jasni 2011). From the twelve species of rattan, the highest cellulose content is in *D. sepals*. with 59.97% and the lowest content is in *C. rugosus*. The strong covalent bonds in pyranose ring provide tensile strength on the stem (Jasni *et al.* 2012). The level of cellulose contained in rattan influences rattan bending strength. *C. ornatus* has a cellulose content of 53.73% with a bending radius of 2 cm while *C. zollingeri*. has cellulose content about 41.72% with a bending radius of 1 cm (Rachman & Jasni 2013).

In line with this, it is pointed out that when biomass contains high cellulose will be more easily degraded. Cellulose is one of the main components in rattan biomass which is a food for insects including termites (Little *et al.* 2012). Termites prefer to feed on cellulose (Negassa & Sileshi 2018), because the termitte have an abiity to digest it (Xu *et al.* 2015).

If rattan has cellulose content, it has high elasticity and will be easily damaged by termites vice versa. Jasni *et al.* (2012) reported that *Plectocomia elongata* Martius ex Blume has 23.60% cellulose content that is classified in resistance

Table 5 Chemical component of rattan

No.	Rattan species	Cellulose, %	Lignin, %
1	*Korthalsia flagellaris* Miq.	54.68	25.07
2	*Calamus insignis* Griff. Var. *Longispinosus*	54.61	26.95
3	*Daemonorops micracantha* Becc.	55.20	20.43
4	*Calamus zonatus* Becc.	58.64	21.91
5	*Calamus laevigatus* Mart.	50.80	26.32
6	*Calamus holttumii* Furtado	59.92	27.44
7	*Daemonorps sepal* Becc.	59.97	22.99
8	*Daemonorps verticillaris* Griff. Mart.	50.59	25.31
9	*Calamus oleyanus* Becc.	59.08	26.71
10	*Calamus rugosus* Becc.	46.51	27.15
11	*Calamus spectatissimus* Furtado	49.54	23.78

12	*Daemonorops longipes* Griff. Mart.	54.66	25.81

class V (more susceptible to attack by termites) while *C. ornatus* with a cellulose content of 20.6% was classified in resistance class II with a degree of attack better than *P. elongate.*

However from Table 6 it can be seen that the cellulose content of weight loss, termite survival and the degree of attack has no significant effect (P>0.01). *D. sepal* has a high cellulose content, however the degree of termite damage was not the worst, i.e. 18% of damage with resistance class II and weight loss of about 18.6%. This is possible because the cellulose does not stand alone in rattan but there are other contents such as lignin, solubility, holocellulose, ash, nitrogen, silica and other chemical compositions. Other component such as 5-hydroxymethylfurfural and 1,6 anhydro-β-d-glucopyranose are importand component which is organic compound derived from glucose and fructopyranose and it can be nutrient source for termittes (Xu *et al*. 2015).

The level of lignin in *D. sepal* is 22.99%. These components can also affect the level of termite attack because it contains minerals rich in nutrients for termites. As the ash content which contains many Ca, K, Mg, Mn, Si, S, and ash contained in rattan between 0.22-6% (Sethi *et al.* 2013). Holocellulose can also serve as food for termites because it contains starch. Termites not only consume starch or cellulose, but also lignin and other components which are rich in minerals although termites prefer cellulose as a feed because lignin is difficult to degrade and other minerals such as ash are difficult to be digested (Hapukotuwa & Grace 2011). This result also occurs in Subekti *et al.* (2015) study which found that biomass with higher soluble extractives content would be more resistant to termite attack although cellulose and lignin content were lower than other biomass. Differences in volatile components present in plants are also alleged to affect the survival of the organism, for example 2,3-dyhydro-2,2-dimethyl-3,7-benzofuandiol and stigmast-4-en-3-one can enrich the ability of plants against termitte attack with high level of toxicity (Xu *et al.* 2015).

Lignin is able to protect other components around it because lignin is the most powerful material consisting of an aryl-alkyl structure and ether bonding (Usmana *et al.* 2012, Maciulaitis *et al.* 2012). This is in line with the results of the study that lignin strength and lignin composition have an effect on biomass resistance, including rattan.

Table 6 Correlation of chemical properties with weight loss, termite survival, and degree of attack

		Weight loss	Survival	Degree of attack
Cellulose	Pearson	.026	.253	-.026
	Correlation	.842	.051	.846
	Sig. (2-tailed)	60	60	60
	N			
Lignin	Pearson	-.597**	-.335**	-.546**
	Correlation	.000	.000	.000
	Sig. (2-tailed)	60	60	60

	N

Remarks: ** Correlation is significant at the 0.01 level

As in Table 6 it can be seen that there is a significant correlation between lignin with weight loss, termite survival and degree of attack. As in Table 5 it can be seen that the largest lignin content is in *C. holttumii* of 27.44%, while the lowest lignin content is in *D. micracantha* of 20.43%. Then if it is related to Table 4 it can be seen that on *C. holttumii*, the damage caused by termite attack is only about 9.2%, this is the smallest value compared to other rattan species but otherwise the damage to *D. micracantha* is about 24.9%. High lignin content leads to low termite damage, and lignin interferes with digestion by binding both carbohydrate substrate and digestive enzymes in the insect gut (Dhawan & Mishra 2007).

Conclusion

The natural resistance of rattan is affected by many factors. However the chemical components in the rattan are the major contributing factor determines natural durability and feeding preference of subterranean termites. In general, the rattan from Sumatra is sufficiently resistant to subterranean termites and this level of attack is not always directly proportional to cellulose levels and inversely proportional to levels lignin of the rattan. The level of damage caused by termites in these twelve species of rattan varies. Rattan that have a resistance class I, the level of damage caused by subterranean termites is about 9-14% with cellulose levels between 50-59%, lignin 25-27% while class II about 15-23% with cellulose content about 46-59% and lignin 22-27% and class III about 24.9% with cellulose ±55% and lignin ±20%.

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