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TERMITE RESISTANCE OF SAGO PARTICLE BOARD WITH CITRIC ACID-SUSCROSE ADHESIVE

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ABSTRACT

In general, particle board uses formaldehyde-based synthetic adhesives. One of the ways of minimizing the use of synthetic adhesives is by using natural adhesives such as citric acid and sucrose. Previous studies on particle board particularly regarding the physical and mechanical properties of particle board made of dregs and bark fiber of sago (Metroxylon spp) based on layer composition and citric acid-sucrose ratio, show that in addition to its physical and mechanical properties, the quality of particle board is also determined by its resistance to attacks by wood destroying organisms such as termites (Coptotermes curvignathus). This study used a completely randomized factorial design (CRD) with two factors, namely layer composition (70/30, 60/40, 50/50) and citric acid- sucrose ratio (0/100, 25/75, 75/ 25, 100/0). The research found that the value of weight loss in the sample that was fed to termites at the end of the test was 7.32-13.22%. The highest average weight loss value was found in the particle layer composition of 50/50 and the citric acid to sucrose ratio of 0/100, which was 13.22%. Meanwhile, the lowest average weight loss value was found in particleboard with the particle layer composition of 70/30 and the citric acid to sucrose ratio of 100/0, which was 7,3207%. The highest percentage of termite mortality, which reached 100%, was found in particle board with the particle layer composition of 70/30 with the citric acid to sucrose ratio of 100/0. Meanwhile, the lowest percentage of termite mortality was 89.81% in a 50/50 layer composition with a 0/100 citric acid to sucrose ratio. Particle board made of sago fiber and bark with a layer composition of 70/30 and a ratio of citric acid to sucrose of 100/0, classified under class 2 durability, is the optimum treatment to resist termite attack.

Keywords: *Citric Acid-Sucrose Ratio; Coptotermes curvignathus; Durability of Particle Board, Layer Composition*

INTRODUCTION

Forest productivity in Indonesia is currently declining. Wood, as the main raw material for the timber industry, tends to experience a decline in production, while the demand for wood is increasing both for building materials and for household furniture. One way to overcome the shortage of wood raw materials is to streamline the use of wood and utilise other materials containing lignocellulose, one of which is agricultural waste. Lignocellulose is a complex component of various waste materials from industry, agriculture, and forestry. The lignocellulose component itself consists of complex polymers of cellulose, hemicellulose, and lignin (Anindyawati, 2010). Lignocellulose is derived from agriculture, one of which is the sago palm.

Sago plants can be processed into staple foods, and produce waste in the form of pulp and sago bark fibres that have not been optimised for use, causing environmental problems, namely the smell caused. An alternative to sago waste utilisation is to make it a particleboard product. Particleboard is a sheet of material containing lignocellulose such as chips, flakes, strands that are joined together using organic binders by providing heat treatment, pressure, moisture content, catalysts, and so on (Slamet, 2013).

Particleboard generally uses formaldehyde-based synthetic adhesives, which can lead to formaldehyde emissions that are harmful to health. These emissions come from residual free formaldehyde still present in the adhesive, as well as formaldehyde released during the use process. One way to minimise the use of synthetic adhesives is to use natural adhesives such as citric acid and sucrose. In addition to physical and mechanical properties, the quality of particleboard is also determined by its resistance to attack by wood-destroying organisms such as termites. Termites are wood-destroying insects that have harmed many people. This study aims to determine the durability of particleboard made from sago (*Metroxylon spp*) pulp and bark fibre against subterranean termites (*C.curvignathus*), analyse the citric acid-sucrose ratio and composition of particleboard layers that have the best resistance to subterranean termites (*C.cuvignathus*) and analyse the interaction between the citric acid-sucrose ratio and the composition of particleboard layers against subterranean termites (*C.curvignathus*).

METHODS

Location and Time of Research

This research was conducted at the Wood Work Shop Laboratory of the Faculty of Forestry, Tanjungpura University, as a place to cut particleboard test samples, and the Wood Technology Laboratory of the Faculty of Forestry, Tanjungpura University, as a place to test the durability of particleboard. The research was carried out for ± 2 months, starting from termite conditioning, cutting test samples, testing, and data processing.

Research Materials

The materials used in the study were particle boards obtained from previous research on the physical and mechanical properties of particle boards of pulp and sago bark fibre (*Metroxylon spp*) based on the composition of particle arrangement and the ratio of sucrose citric acid adhesive (Wati *et al.,* 2021), subterranean termite (*C. cuvignathus*) obtained from behind the new campus of the Faculty of Forestry, Tanjungpura University, sand as a medium for termite conditioning and board testing, cotton wool to maintain moisture during board testing, distilled water to moisten the sand, label paper to identify the test samples, and aluminium foil for baking the test samples.

Research Tools

The tools used in this study are a band saw to cut the test sample, an electric oven to dry the test sample, a desiccator for conditioning the test sample, tweezers to separate dead and live termites, a plastic cup as a testing container plastic gauze for the barrier between the test sample and sand, a black tub for termite conditioning, chicken feathers to transfer termites from colonies to test containers, black cloth to cover black tubs and plastic boxes, plastic containers to store test containers, mesh filters to sift sand, autoclaves to sterilise sand, cameras to document activities, analytical scales to weigh test samples and stationery to write the results of the data generated.

Research Procedures

a. Termite Collection and Conditioning

The termites used for testing were obtained from behind the new campus of the Faculty of Forestry, Tanjungpura University. The termites were taken along with the infested wood, then stored in a black tub filled with sand, and underneath the tub was a basin of water so that ants could not enter the tub. ±The termites were then conditioned for one month before testing. Furthermore, the test samples were cut to a size of 2cm x 2cm x 1cm using a band saw and oven dried for 3 days at 60 ºC (Saman *et al.,* 2016) and then weighed to get the initial weight.

b. Testing the Resistance of Particleboard to Termite Infestation

This test method uses the *no-choice test* method. The *no-choice* test method refers to the research of Ohmura *et al*. (2000), which has modified the test container. This test uses a plastic container measuring six cm in diameter and six cm in height. The test container must be sterilised using 70% alcohol, then each plastic cup is filled with 10 grams of sterile sand. Sand sterilisation is carried out by washing it thoroughly and then putting it into an *autoclave* for 30 minutes at a temperature of 120 ºC with a pressure of one atm. Plastic gauze measuring four cm in diameter was placed on the sand to prevent direct contact of the sample with the sand. Next, one sample was put into a plastic cup with a lid that had previously been given small holes for air circulation, along with 55 subterranean termites, with a ratio of 50 worker caste and five soldiers. The plastic cups containing the termites were then placed into plastic tubs. On the inside of the plastic tub, cotton wool was moistened to maintain moisture in the plastic tub. The test units were then covered with black cloth and kept in a dark room for 21 days, during which a check was carried out every three days. Checking was done to remove dead termites. The calculation of termite mortality and weight reduction is based on the percentage of total termite count and dry weight of the test sample.

Data Analysis

The research design used a factorial design in a completely randomised design. The first factor was Coating Composition (70/30, 60/40, and 50/50), and the second factor was citric acid-sucrose ratio (0/100, 25/75, 75/25, and 100/0). Observational data obtained were analysed with the F-test (ANOVA). If the results of the F test were significantly different, it was continued with the Tukey HSD further test.

RESULTS AND DISCUSSION

Weight Loss of Test Sample

The weight loss value of the test samples indicates the activity of subterranean termites (C. curvignathus) on the test samples fed during the test period. The average value of weight loss obtained in the test was 7.32 - 13.22%. The highest weight loss rate was found in the particle layer composition of 50/50 and sucrose citric acid ratio of 0/100, which was 13.22%. Meanwhile, the lowest average weight loss value of the test samples was found on particle boards with a particle layer composition of 70/30 and a sucrose citric acid ratio of 100/0, which was 7.32%. The average value of weight loss is presented in Figure 1.

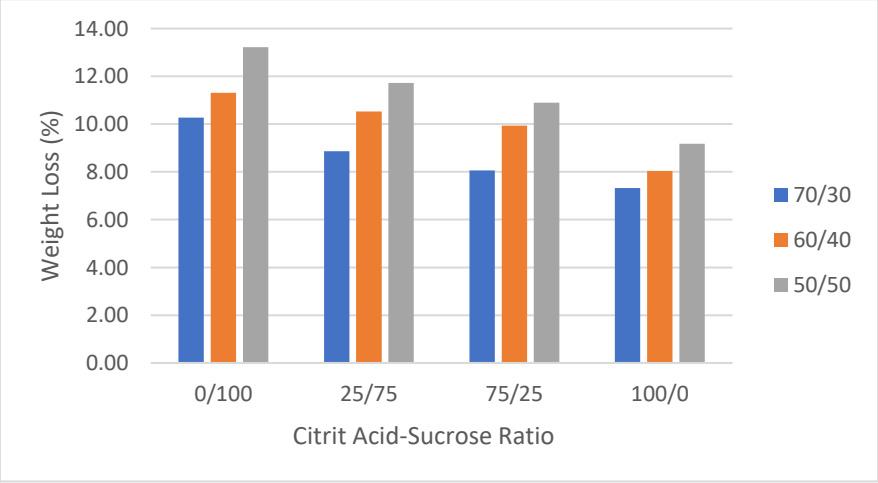

Figure 1. The Average Value of The Weight Loss of Particle Board Made Sago Bark Dregs and Fiber of Sago with Ratio of Citric Acid-sucrose

The value of weight loss was then subjected to an analysis of variance test with the aim of knowing the factors that affect the value of weight loss. The calculation of the analysis of

variance test can be seen in Table 1.

Table 1. Analysis of Variance in Weight Loss of Particleboard Made from Sago Palm Pulp and Fibre.

SK	DB	JK	KT	F-Count	F-Table 5%	F-Table 1%
Treatment	11	165,02				
Layer Composition	2	69,17	34,58	15,56**	3,19	5,07
Ratio (B)	3	92,16	30,72	13,82**	2,79	4,21
AB	6	3,69	0,61	0,27tn	2,29	3,20
Galat	48	106,64	2,22			
Total	**59**	**271,66**				

Notes: **= significant effect at 1% level, tn= no significant effect

The results of the analysis of variance showed that the factors of particle layer composition, sucrose citric acid ratio had a very significant effect, while the interaction between the two had no significant effect on the weight loss value of the particle board test sample. Furthermore, to find out the difference in each treatment that affects the further test, namely the Honest Real Difference test. The results of the calculation of the Honest Real Difference test on the particle layer composition factor can be seen in Table 2.

Table 2. The Results of The Calculation of The Honest Real Difference Test on The Particle Layer Composition Factor

Layer Composition	Avarage	Notation
a1	8,62	a
a2	9,95	b
a3	11,25	c
BNJ 5% = 1,13	BNJ 1% =1,38	

Source: Data processing results (2022)
Description:
- Means followed by the same letter indicate treatments are not significantly different.
- Means followed by unequal letters indicate significantly different treatments

The results of the BNJ test on weight loss in Table.2 show that treatment a1 is significantly different from treatments a2 and a3, treatment a2 is significantly different from a3 and a1, treatment a3 is significantly different from treatments a1 and a2.

Table 3. BNJ Test Results of Weight Loss of Particleboard Test Samples at Sucrose Citric Acid Ratio Factor

Citrit Acid-Sukrose Ratio	Avarage	Notation
b4	8,18	a
b3	9,63	b
b2	10,37	bc
b1	11,60	c
BNJ 5% = 1,31	**BNJ 1% =1,95**	

Source: Data processing results (2022)
Description:
- Means followed by the same letter indicate treatments are not significantly different.
- Means followed by unequal letters indicate significantly different treatments
- Means followed by unequal letters indicate significantly different treatments

The BNJ test results in the sucrose citric acid ratio factor table show that treatment b4 is significantly different from treatment b3, b2 and b1 but treatment b3 is not significantly different

from treatment b2 but significantly different from treatment b1 and b4. Furthermore, treatment b2 was not significantly different from treatment b1 and b3 but significantly different from treatment b4. Treatment b1 was not significantly different from treatment b2.
The cellulose content between sago pulp and bark is different. The cellulose content of sago pulp is 19.55%, while that of sago bark is 56.86% (Kiat 2006). High cellulose content is more likely to be favoured by subterranean termites, but the results showed that the highest weight loss value was in the 50/50 layers composition. It is suspected that in the proportion of face and core layers, sago bark fibre has a harder composition so that termites prefer the composition of materials that contain more sago pulp because termites prefer soft compositions compared to hard compositions. This is in line with Nandika (2015) who stated that termites will choose the most suitable type of food such as containing a lot of cellulose, easy to bite and chew. Mechanical termite bites will prefer soft and available food and leave hard food.

The results showed that particleboard using sucrose citric acid 100/0 had a low weight loss value compared to others, this is because the high content of citric acid can damage the consumption activity of termites so that the weight loss is lower. This is in line with Indrayani et al (2015) which states that the weight loss value of MDF (Medium Density Fiberboard) specimens made from citric acid is lower than that of MDF specimens containing a mixture of citric acid and sucrose, the average weight loss value of MDF specimens containing a mixture of citric acid and sucrose is more than 10%, while the average weight loss of MDF specimens containing citric acid is less than 10%.

Based on the weight loss value, particleboard can be classified for its resistance to subterranean termite attack as shown in Table 4.

Table 4. Classification of Particle Board Resistance to Subterranean Termite Attack

Layer Composition	Citrit Acid-Sucrose Ratio	Average	Durable Class	Endurance
70/30	0/100	10,2768	III	Medium
	25/75	8,8592	III	Medium
	75/25	8,0548	III	Medium
	100/0	7,3207	II	Good
60/40	0/100	11,3068	IV	Hold
	25/75	10,5325	III	Medium
	75/25	9,9373	III	Medium
	100/0	8,0408	III	Medium
50/50	0/100	13,2243	IV	Bad
	25/75	11,7272	IV	Bad
	75/25	10,9010	III	Medium
	100/0	9,1791	III	Medium

Source: Data processing results (2022)

Based on the classification of particleboard durability, in general particleboard has poor to moderate durability, except for the treatment of layer composition 70/30 with sucrose citric acid ratio 100/0 including durability class II with the lowest weight loss value. This is in line with Tenriawaru et al (2018) which states that sago bark is not resistant to subterranean termites and is classified in durability class IV based on SNI 01-7206-2006.

Termity Mortality

The percentage of termite mortality is obtained from the calculation of the number of termites that die during the test period. The feeding behaviour of termites in nature and in the laboratory is different, when in nature termites are free to choose their own food with the most suitable environment for their life, while in the laboratory termites are forced to eat (forced feeding test) with the given material. Subterranean termites will first adjust to the environment (plastic cups) and then they will eat the test samples given. The highest percentage of termite mortality is

found in particleboard with a layer composition of 70/30 with a sucrose citric acid ratio of 100/0, which is 100%. Meanwhile, the lowest termite mortality percentage was found in the 50/50 layers composition with 0/100 sucrose citric acid ratio, which was 89.81%. The average mortality percentage of termite samples in this study is presented in Figure 2.

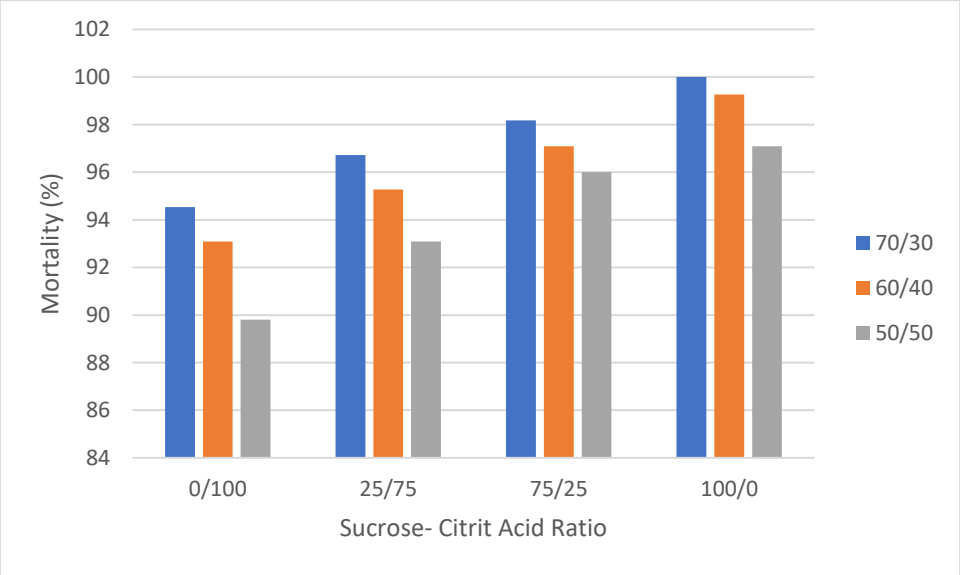

Figure 2. Termite Mortality Value of Particle Board Made Sago Bark Dregs and Fiber of Sago with Ratio of Citric Acid-Sucrose

The termite mortality values obtained were then subjected to an analysis of variance test to determine the factors influencing weight loss. The results of the analysis of variance test calculations can be seen in Table 5.

Table 5. Analysis of Variance of Termite Mortality Values of Particleboard Made from Sago Palm Pulp and Bark Fibre.

SK	DB	JK	KT	F-Count	Table 5%	Table 1%
Treatment	11	459,44				
Layer Composition (A)	2	116,47	58,23	4,88*	3,19	5,07
Ratio (B)	3	332,50	110,83	9,29**	2,79	4,21
AB	6	10,46	1,74	0,14tn	2,29	3,20
Galatt	48	572,56	11,92			
Total	**59**	**1032,01**				

Notes: **= significant effect at 1% level, tn= no significant effect

The results of the analysis of variance showed that the particle layer composition factor had a significant effect on termite mortality percentage, while the sucrose citric acid ratio had a significant effect on termite mortality percentage. However, the interaction between the two had no significant effect on termite mortality percentage.

Furthermore, to find out the differences in each influential treatment, a further test of Real Honest Difference was conducted. The results of the BNJ further test calculation on the layer composition factor are presented in Table 6.

Table 6. Results of The BNJ Termite Mortality Test on Particle Board Tests on The Layer Composition Factor

Layer Composition	Avarage	Notation
a3	94	a
a2	96,18	ab
a1	97,36	bc
BNJ 5% = 3,04	**BNJ 1% = 4,14**	

Source: Data processing results (2022)
Description:
- Means followed by the same letter indicate treatments are not significantly different.
- Means followed by unequal letters indicate significantly different treatments

Based on the BNJ results on the particle layer composition factor, it shows that treatment a3 is not significantly different from treatment a2, but significantly different from treatment a1. Treatment a2 is not significantly different from treatment a1.

Table 7. BNJ Test Results of Termite Mortality on Particleboard Test Samples for Sucrose Citric Acid Ratio Factor.

Citrid Acid-Sucrose Ratio	Avarage	Notation
b1	92,48	a
b2	95,03	ab
b3	97,09	bc
b4	98,79	c
BNJ 5%=1,44	**BNJ 1% =1,82**	

Source: Data processing results (2022)
Description:
- Means followed by the same letter indicate treatments are not significantly different.
- Means followed by unequal letters indicate significantly different treatments

The BNJ test results on the sucrose citric acid ratio factor showed that treatment b1 was not significantly different from treatment b2 but significantly different from the other treatments. Furthermore, the test results showed that treatment b2 was not significantly different from treatment b3, but significantly different from treatment b4. Treatment b3 was not significantly different from treatment b4.

The results showed that the particle layer composition factor, which is due to the presence of chemicals derived from citric acid, can inhibit termite activity. The compound has toxic power that can affect the movement and breathing of subterranean termites Coptotermes curvignathus. This is in line with the research of Nabu et al 2015 which examined the anti-termite activity of orange peel, that essential oil from orange peel has toxic power and can kill subterranean termites.

Based on the termite mortality value in the particle layer composition treatment factor, the higher the particle layer composition of pulp and sago bark fibre, the higher the termite mortality value. Generally, termites dislike hard food materials, making it difficult for them to bite and destroy the food material. Sago pulp is softer than sago bark fibre, so termites prefer food that is easy to bite and easy to destroy compared to hard materials. This test also forces termites to choose only one food so that termites that do not like their food choose not to eat and eventually the termites become weak and die. This is supported by Daviyana *et al* (2013).

CONCLUSIONS AND RECOMMENDATIONS

The average value of weight loss obtained in the test was 7.3207-13.2243%. The highest weight loss rate was found in particle board with 50/50 layer composition and 0/100 sucrose citric acid ratio (13.2243%). The highest average termite mortality rate was found in particleboard with 70/30 layer composition (97.3636%). Particleboard made from sago fibre and bark with a layer composition of 70/30 and a sucrose citric acid ratio of 100/0 belonging to durability class II is the optimum treatment to resist subterranean termite infestation.

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