Influence of jeringau (Acorus calamus Linn.) rhizome extract against dry-wood termites (Cryptotermes cynocephalus Light.)

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Abstract. Rubberwood (Hevea brasiliensis Muell Arg.) is classified as a hardwood, yet it is vulnerable to dry-wood termites attack, namely Cryptotermes cynocephalus Light. Hence, a preservative is necessary for prevention. The purpose of this research was to examine the effect of jeringau rhizome extract on dry-wood termites C. cynocephalus attack. The experimental design was a completely randomized factorial design with two factors include 2 levels of solvent (water and ethanol) and 4 levels of extract ratio (1:4, 1:6, 1:8, and 1:10). Parameters observed were actual retention, termites mortality, sample weight loss, and attack degree. Rubberwood was sized in 5 cm x 3 cm x 3 cm. The method used was immersing the samples in a container that contains jeringau rhizome extract in various treatments for 72 hours. The immersed samples were then fed to healthy and active C. cynocephalus for 12 weeks. The results showed that the type of solvents and extract ratio had a significant effect on termites mortality and samples weight loss, while actual retention was influenced by the extract ratio. In conclusion, the most effective formula to prevent dry-wood termites attack was jeringau rhizome extract with a weight ratio of jeringau powder and ethanol 1:6.

1. Introduction

Wood is a material utilized for construction and carpentry. Compared to other construction materials such as iron or concrete, wood has several advantages, namely being lighter in the same volume, easy workmanship, aesthetic outer appearance, and so on. On the other hand, wood has several weaknesses such as anisotropic properties, hygroscopic properties, and less resistance to wood-destroying organisms attacks.

Wood is widely used for human needs such as making equipment, construction structures for housing, raw materials in the furniture industry, and vice versa [1]. As wood becomes increasingly expensive and the potential for high-quality wood species decreases, more and more low-quality wood will be used, one of which is rubberwood (Hevea brasiliensis (Muell.) Arg.). Rubberwood is usually used as raw material for the production of furniture and indoor building components. It can be used as parquet, particleboard, blockboard, wood cement board, and medium-density fibreboard [2-5]. The wood of the rubber tree is light, has a uniform color that varies from white to cream, and has a homogeneous texture, and the sapwood is not easily distinguishable from the heartwood [4,5].

Rubberwood has low natural durability, namely durable class V, but has strong class II-III [6]. Although wood is versatile, it is an organic material that can damage due to degradation by biological agents such as termites [7]. Rubberwood is easily attacked by wood-destroying organisms, especially...
insects such as subterranean termites, dry-wood powder beetles, and dry-wood termites Cryptotermes cynocephalus Light. According to former research [8], dry-wood termites are specific insects that can enter exposed wood directly from the air, in a wood moisture content of 5-6%.

To increase the wood’s resistance to C. cynocephalus attacks, wood preservation is carried out. Wood preservatives that are commonly used are synthetic chemical preservatives. These materials are generally expensive and can cause environmental pollution. Therefore, it is necessary to develop plant-based wood preservatives that are cheaper and friendly to the environment. One of the potential ingredients of vegetable elements is jeringau rhizomes extract (Acorus calamus Linn.). It is considered information that jeringau rhizome has active oil content that can be used as a repellent, antifeedant (lowering appetite), and antifertility (sterile) for insects [9]. Although the rhizome of jeringau is easy to obtain and relatively cheap in price, the only part that can be used as a wood preservative is its rhizome, and the amount is not too large compared to the whole plant material. Based on this, it is necessary to take action to optimize the use of jeringau rhizome extract as a wood preservative by choosing ethanol and water as the solvents, with the consideration that ethanol is one of the excellent organic solvents and water that is commonly used and cheap in price. In addition, it is also necessary to look for the optimal ratio between jeringau and extracting material.

According to these considerations, it is necessary to study the use of jeringau rhizome extract as a preservative for rubberwood. This study aimed to determine the types of solvents and the most effective ratio of jeringau extract and solvents which prevent C. cynocephalus attacks.

2. Materials and Methods

2.1. Material and equipment

The research material used for the test samples was rubberwood measuring 5 cm x 3 cm x 3 cm. Rubberwood was collected from a community forest in Samigaluh Sub-district, Kulonprogo Regency, Yogyakarta Special Region, aged 25 years, with diameter of 31 cm at chest height and high free branches 7 m. The preservative used was jeringau rhizome extract (Acorus calamus Linn.) which was made from jeringau rhizomes from jeringau plant aged 9-12 months, collected from Borobudur District, Magelang Regency, Central Java Province. The solvents used were 96% technical ethanol (C₂H₅OH) and water (H₂O).

The test insect was dry-wood termite namely C. cynocephalus Light., in a healthy and active nymph stage, collected from the Entomology Laboratory of the Center for Research and Development of Forest Products. The number of dry-wood termites used was 50 for each samples.

The equipments used in this research were circular saws, sandpaper, oven, analytical scales, calipers, glass tubes with diameter of 2.5 cm and a height of 4 cm, a blender, a 60 mesh and 100 mesh sieve, gauze, glass bottles, glass stirrers, and ballast.

2.2. Methods

2.2.1. Samples Preparation. After being logged, the wood was bucked into pieces, then sawed into boards, then cut to size of 5 cm x 3 cm x 3 cm. 50 defectless test samples were selected and coded.

2.2.2. Preservative preparation. Jeringau extraction, the first step was trimming the leaves and cleaning the dirt on the rhizomes, then dried the rhizomes under the sunlight until it was stiff or easily broken. After the samples were completely dry, the root fibers of the rhizomes were trimmed to prevent the oil to evaporate during the drying process [10].

The dried jeringau rhizomes were blended to reduce the size until smooth. Then sieved to collect the powder (between 60-100 mesh). Water content of powder was measured to examine the actual weight of the rhizomes as the basis to determine the extraction ratio. The next step was jeringau extract preparation by dissolving the jeringau powder with solvent (96% ethanol and water) in a plastic container which was covered using a plastic sheet for 72 hours with occasional stirring. The weight ratio of rhizomes powder and the solvent include 4 levels, namely 1:4, 1:6, 1:8, and 1:10.
2.2.3. Cold soaking preservative. Before the curing process, the two sides of the test samples surface (radial and transversal side) were coated with Duco paint to prevent double penetration, so that only the tangential side was inserted into the curing agent. Then the test samples were air-dried at room temperature until the weight was constant. Furthermore, the dimensions of the test samples were measured to determine the volume of wood as the basis for calculating the actual retention. The test samples were immersed in the preservative solution in a plastic container for 72 hours, then aerated and weighed.

2.2.4. Feeding the samples to dry-wood termites. The test samples were fed to the dry-wood termite *C. cynocephalus*. On the tangential sides of the samples, a glass tube with diameter of 1.8 cm and 3 cm height was attached. Then 50 healthy and active termites were put into the glass tube and covered with cotton to prevent other animal entry. The feeding of the test samples to dry-wood termites was placed in a dark room and at room temperature for 12 weeks [11] for later observation. The observation was conducted by weighing the samples and calculate termites mortality.

2.2.5. Data Analysis. The observed parameters include actual retention, termites mortality, samples weight reduction, and degree of damage are presented in tabular form. Based on the average value obtained, the efficacy value can be determined.

Table 1. Damage degree.

| Relative weight reduction | Samples condition                      |
|---------------------------|----------------------------------------|
| ≤ 10 %                    | Light attack, leaves bite mark          |
| 11 – 40%                  | Moderate attack in the form of narrow tubes |
| 41 – 70%                  | Heavy attack in the form of deep and wide tubes |
| >70 %                     | Heavy attack                           |

Source: ASTM D 2.278-66 (1980) revised 1985 [12]

3. Results and Discussion

3.1. Actual retention

According to the calculation, the actual retention of the preservative in various types of treatment was obtained with various factors, including the type of solvent and powder-solvent weight ratio, as shown in Table 2.

Table 2. The average of preservatives actual retention (kg m⁻³).

| Solvent     | Powder-solvent ratio (B) | B4 (1:10) | B3 (1:8) | B2 (1:6) | B1 (1:4) |
|-------------|--------------------------|-----------|----------|----------|----------|
| Water (A1)  |                          | 5.06      | 5.97     | 6.82     | 10.42    |
| Ethanol (A2)|                          | 4.90      | 5.08     | 8.77     | 13.57    |

Preservative solution using ethanol as solvent and jeringau extract with ratio of 1:4 showed the highest actual retention. Furthermore, from these data, analysis of variance and F test was carried out with the results as shown in Table 3.

The results of the ANOVA in Table 3 shows that powder-solvent ratio has a very significant effect, but for solvent and interactions between two factors did not show a significant difference. To find out at what level the ratio which shows the difference was further tested by the LSD test [13] with α = 0.01. The LSD test results showed that there were significant differences between B1, B2, and B4. It means that the lower the powder-solvent ratio, the actual retention of preservative is higher.
**Table 3.** Analysis of variance of actual retention.

| SD    | DF | F value |
|-------|----|---------|
| Solvent (A) | 1  | $2.978^{ns}$ |
| Powder-solvent Ratio (B) | 3  | $18.565^{**}$ |
| Interaction A*B | 3  | $1.230^{ns}$ |
| Error | 32 |         |
| Total | 39 |         |

Notes: $ns = $ not significantly different; ** = significantly different, $\alpha = 0.01$

3.2. **Dry-wood termite mortality**

The average termite mortality value in various treatments is shown in Table 4.

**Table 4.** The average of dry-wood termite mortality (%).

| Solvent   | Powder-solvent ratio |
|-----------|----------------------|
|           | Control | B4 (1:10) | B3 (1:8) | B2 (1:6) | B1 (1:4) |
| Water     | 30.4    | 43.2      | 58.8     | 77.6     | 86.4      |
| Ethanol   | 24.4    | 61.2      | 84.0     | 100.0    | 100.0     |

Furthermore, from these data, analysis of variance and F test was carried out with the results as shown in Table 5.

**Table 5.** Analysis of variance of termite mortality.

| SD    | DF | F value |
|-------|----|---------|
| Solvent (A) | 1  | $101.433^{**}$ |
| Powder-solvent Ratio (B) | 3  | $90.26^{**}$ |
| Interaction A*B | 3  | $1.673^{ns}$ |
| Error | 32 |         |
| Total | 39 |         |

Notes: $ns = $ not significantly different; ** = significantly different, $\alpha = 0.01$

The results of the analysis of variance and the F test in Table 4 show that solvent and powder-solvent ratio have a very significant effect, yet the interaction between the two factors had no significant effect. The results of the LSD test showed very significant differences between B4, B3, and B2. The effect of jeringau extracts on termite mortality was caused by the aroma of jeringau extract. Meanwhile, it does not rule out that the active substances euginol and methyl euginol from jeringau rhizomes also increase termite mortality, where the two compounds are phenol group compounds which are very toxic to insects [9]. According to former research [14], jeringau rhizome contain fitochemical component such as steroid, fenol, tannin, flavonoid, glicoside, diterpen, triterpen and alkaloid. Study about ethanolic extract efficacy of jeringau rhizome as insectiside has been conducted and reported that the effectiveness of insecticidal potential was higher in adults than larvae stages [15].

3.3. **Weight reduction of the test samples**

The average weight reduction values for the samples in various treatments are shown in Table 6. It is shown at ANOVA result, which explain that with the lower ratio of jeringau extract, the samples weight reduction also lower.

**Table 6.** The average of test samples weight reduction (g).

| Solvent | Powder-solvent ratio |
|---------|----------------------|
|         | Control | B4 (1:10) | B3 (1:8) | B2 (1:6) | B1 (1:4) |
| Water   | 0.490   | 0.334     | 0.298    | 0.224    | 0.184    |
| Ethanol | 0.740   | 0.144     | 0.108    | 0.040    | 0.030    |
The use of ethanol as solvent provides lower sample weight reduction. It means that ethanol is more effective than water as solvent. Furthermore, from these data, analysis of variance and F test was carried out with the results as shown in Table 7.

### Table 7. Analysis of variance of the test samples weight reduction.

|                          | SD | DF  | F value |
|--------------------------|----|-----|---------|
| Solvent (A)              | 1  | 127.227** |
| Powder-solvent Ratio (B) | 3  | 14.824**  |
| Interaksi A*B            | 3  | 0.293m   |
| Galat                    | 32 |      |         |
| Total                    | 39 |      |         |

Notes: ns = not significantly different; ** = significantly different, α = 0.01

ANOVA and F test resulted in Table 7 showed that the type of solvent has significant effects to sample weight reduction as well as the ratio of jeringau extract, yet there was no interaction between the two factors. The results of the LSD test showed very significantly different between B4, B3 and very significantly different from B2 and B1. It means that with the lower ratio of powder-solvent, the samples weight reduction also lower.

### 3.4. Damage degree

The average weight reduction values for the sample in various treatments are shown in Table 8.

### Table 8. The average of relative weight reduction or damage degree (%).

| Solvent | Powder-solvent ratio | Control | B4 (1:10) | B3 (1:8) | B2 (1:6) | B1 (1:4) |
|---------|----------------------|---------|-----------|----------|----------|----------|
| Water   |                      | 100     | 68.16     | 60.82    | 45.71    | 37.55    |
| Ethanol |                      | 100     | 29.39     | 22.04    | 8.16     | 6.12     |

In general, jeringau extract both with ethanol and water extracts, were able to withstand dry-wood termites attacks compared to controls with an average degree of damage of 16.43% and 53.06%, while the degree of damage to the control reached 100%, meaning that the control wood samples was all destroyed. Further examination was conducted, the jeringau extract with ethanol solvent resisted the attack of dry-wood termites *C. cynocephalus* better than jeringau extract with water solvent, with an average degree of damage of 16.43%.

Furthermore, between jeringau rhizomes powder and solvents (ethanol or water), it can be seen that the lower powder-solvent ratio, the lower the degree of damage. However, damage degree between B1 and B2 has no significant different. It means that jeringau extract ratio of 1:4 and 1:6 has almost the same effectiveness to withstand dry-wood termite attacks. According to the result, jeringau extract with powder-solvent ratio of 1:6 was chosen due to the efficiency of application.

### 4. Conclusion

Through this study, we can conclude that the solvent had a very significant effect on the mortality of dry-wood termites and weight reduction of the test samples, but had no significant effect on the actual retention. The ethanol solvent provides the actual retention yield and higher termite mortality as well as a lower samples weight reduction than water. The factor of powder-solvent weight ratio has a very significant effect on the actual retention, mortality of termites, and weight reduction of the samples. Meanwhile, the interaction had no significant effect. The extract of jeringau rhizomes with ethanol solvent and powder-solvent ratio of 1:6 was effective to withstand the attack of dry-wood termites.

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