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The evaluation of *Agathis* wood from densification process to the resistance of *Trametes versicolor* fungi

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The evaluation of *Agathis* wood from densification process to the resistance of *Trametes versicolor* fungi

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Abstract. Most species of wood from community forests have low quality compared to wood from natural forests because it is generally cut down in young years so that it has a high portion of juvenile wood and low durability. One process of improving wood quality is the densification process. The purpose of this research is to determine the resistance to *Trametes versicolor* fungi from densified wood with initial treatment of soaking on CH₃COOH and H₂O₂ 20% solution, borax 3%, and distilled water. *Agathis* wood boards made of 23 cm x 20 cm x 2.5 cm were densified with a target of 30% thickness reduction, at a temperature of 150 °C for 15 minutes. After the densification process, the test samples were measured and calculated for density and recovery of a set and tested for MOE and MOR and resistance to *T.versicolor* fungi. The results showed that the three types of treatment, soaking with CH₃COOH and H₂O₂, had a very high weight loss. This situation did not only attack from *T.versicolor* but also degradation of wood by CH₃COOH and H₂O₂. Th immersion with borax and distilled water only experienced very little weight loss. It shows that *T.versicolor* fungi less favors the densified *Agathis* wood.

1. Introduction

Currently, Indonesia's forests have been degraded so high that the supply of logs from natural forests dwindling, while demand for raw materials, especially high-quality wood is increasing. To overcome the problem of scarcity of logs, community forests and plantations have been developed.

One type of fast-growing wood originating from plantations and favored by the community is *Agathis* because of its rapid growth. Besides, it can increase people's income. However, these fast-growing types of wood have low quality, low strength and durability [1].

The wood processing technology is currently developing in accordance with the advancement of science and technology. One wood processing technology that can increase wood density is the wood densification process. This process is an alternative wood modification technology that is deemed necessary to overcome the scarcity of high-quality wood [2].

Wood densification is a wood compaction process that aims to increase wood density and strength. The working principle of this method is to modify the condition of wood compaction so that deformation occurs due to compaction using a hot press that will produce a fixed dimension of wood (fixation) and increase the properties of the wood, especially physical and mechanical properties [3]. Based on the results of the study by Wahyuni et al. [4], they stated that the success of the densification process is influenced by the modification of the method, initial treatment, and type of wood. Research conducted by Tirtayasa [5] showed that the densification process with initial treatment soaking with CH₃COOH and H₂O₂ can increase the strength and stiffness of *gmelina* wood at a concentration of 20%.

In addition to strength, the durability of the wood from fast-growing wood species needs to be increased. Wood that has a strong high class is meaningless if the durable class is low because its useful life will be short [6]. The initial treatment is expected to be able to increase the strength and wood durability. Hunt and Garratt [7] defined that wood preservatives are chemicals given to wood so that the wood is resistant to fungus (insect), insect, or marine attacks. To assess the success of preservation, it is necessary to test wood resistance to microorganisms and insects such as wood resistance to fungi. This observation can affect the physical and mechanical properties of wood.

This research was directed through the densification process by modifying the initial treatment of soaking the wood with CH_3COOH , H_2O_2 20% solution, and borax 3%, which is expected to increase the wood durability, especially wood resistance to destructive organisms, namely fungi.

2. Data and methods

2.1. Sample test preparation

Board as research material was a size of 100 x 20 x 2 cm. Each board was divided into four parts with a size of 25 (P) x 20 (L) x 2 (T) as the test sample. Each test sample was divided into two parts, one for control and the other for densification. The sketch of the test sample can be seen in figure 1.

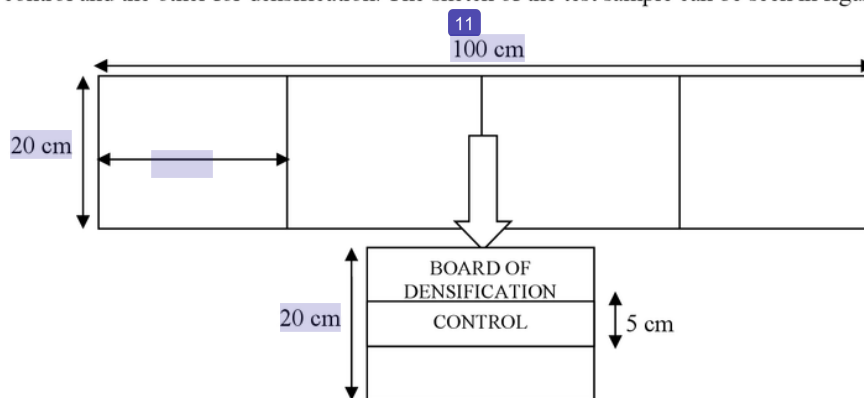


Figure 1. Sketch of the sample test.

2.2. Densification process

The densification process was carried out by pretreatment, treatment at CH_3COOH and H_2O_2 20% solution, borax 3%, and distilled water. After soaking for 24 hours with an 80 °C immersion temperature, the sample was then cooled into the desiccator for 15 minutes before being put under pressure. Before the sample was pressed, a stick that has a thickness of 1.4 cm was placed on both sides so that when the pressing was done, the thickness of the sample could adjust to the thickness of the stick, in which the target thickness is 30% from the initial thickness of 2 cm. Then, the sample was pressed hot and allowed to stand for 15 minutes with a temperature of 1500 °C. The sample results of the densification process and the control sample were then made a test sample for observing wood resistance to mushrooms with a size of 5 cm (P) x 2.5 cm (L) x 1.5 cm (T).

2.3. Wood durability tests against fungus

The testing of wood against fungi resistance was conducted before making a mushroom culture medium using Standard (SNI 01-7207-2014). Testing of wood against weathering mushrooms was obtained by calculating the weight loss and the classification table of wood resistance to weathering fungi.

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3. Results and discussion

The densification process was carried out with several initial treatments, namely CH₃COOH and H₂O₂ 20% solution, borax 3%, and distilled water which showed different results between treatments. Decreasing weight is an indicator that can be used to see wood resistance to weathering fungi. The smaller the decrease in weight, the higher the wood resistance to weathering fungi. The results of the decrease in wood weight from several initial treatments before the densification process can be seen in figure 2.

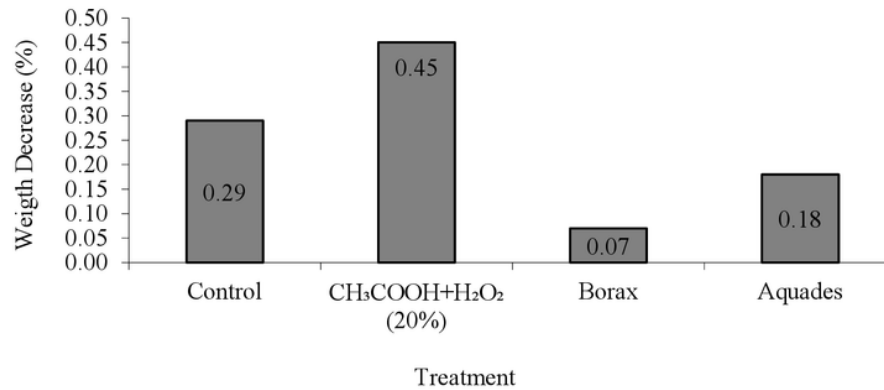


Figure 2. Weight decrease of *Agathis sp.* wood densification results after testing a fungus attack *T. versicolor* feed for three months.

The highest decrease in weight in the immersion treatment was before the densification process with 20% CH₃COOH and H₂O₂ solutions. Beside being attacked by fungus, wood was also degraded by CH₃COOH and H₂O₂ solution. CH₃COOH and H₂O₂ solutions can soften the wood constituent cells by removing lignin in wood. Jasni et al. [8] proved that borax with a minimum concentration of 3% could increase wood resistance to termites. Observations of fungal growth showed that the presence of borax in the wood resulted in the fungus in the media gradually dying, as evidenced by the change of the fungus color that was supposed to be white to yellowish.

Based on the classification of SNI 7207 [9], wood resistance to *T.versicolor* weathering fungi can be seen in table 1.

Table 1. Classification of *Agathis sp.* wood durability against rot fungi especially fungi *T.versicolor* with some pretreatments.

Treatment	Weight decrease (%)	Durability	Resistance
Control	0.29	I	Highly resistant
CH ₃ COOH+H ₂ O ₂ (20%)	0.45	I	Highly resistant
Borax (3%)	0.07	I	Highly resistant
Distilled water	0.18	I	Highly resistant

Table 1 shows that the results of the densification process with initial treatment of CH₃COOH and H₂O₂ soaking 20%, borax 3%, and distilled water can be classified into durable class I with a very resistant level, which is resistance from *T.versicolor* fungus attack.

Agathis sp. wood belongs to the durable grade IV based on the Indonesian Atlas of Wood Volume I. The study on wood durability used termites as wood-destroying organisms to test the durability of *Agathis sp.* wood [10]. Suprpti [11] conducted a study on the resilience of 84 Indonesian wood species against fungi. One type of wood used was *Agathis sp.*. *Agathis sp.* wood was tested with the *Pycnoporus*

sanguineus fungi, which belong to the class III durable (somewhat resistant), and with the *Dacryopinax* mushroom. *Spathularia* is a long lasting class II (resistant), with the *Schizophyllum* commune fungi, which belong to the class III (somewhat resistant).

In this study, *Agathis sp.* was tested by using the *T.versicolor* fungus. All treatments showed a decrease in weight to the class of durable I (highly resistant). It means that the treatment given before densification could make the fungus *T.versicolor* unable to attack the wood densification results. The densification of wood with temperature and time felts caused the lumen narrowing and the cell wall more tightly to each other. Besides, with the presence of heat and press for a certain time, the cell wall containing cellulose undergone plasticization which caused permanent shape changes. When the lumen and cell wall became narrow and increasingly tight, the penetration of the fungal mycelium decreased due to the narrow space to penetrate the wood deeper. It increased the durability of the wood from densification.

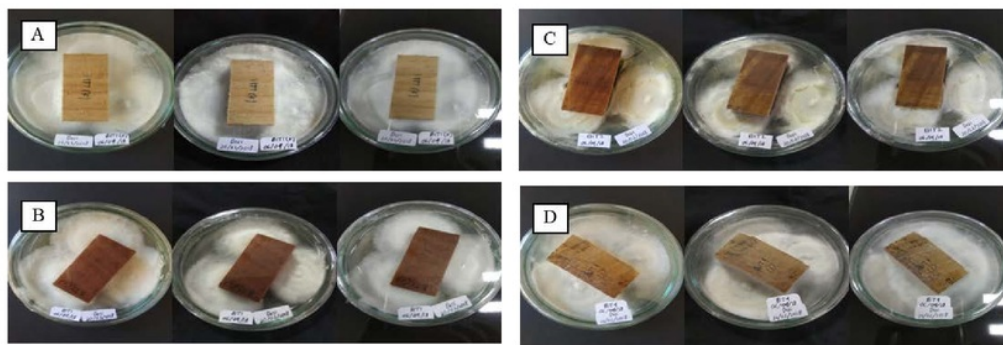


Figure 3. The growth of fungi in the test sample (a) control, (b) CH₃COOH and H₂O₂, (c) borax, (d) distilled water for three months testing using *T. versicolor* mushroom.

4. Conclusion

Agathis sp. wood which was densified using 20% soaking treatment CH₃COOH and H₂O₂, 3% borax, and distilled water could increase wood durability against *T. versicolor*.

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Acknowledgements

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