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Retention of Borax Preservative And Intensity of Blue Stain Fungus Attack on Pulai (Alstonia scholaris R.Br.) Based on Preservation Method

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A B S T R A C T

Pulai (Alstonia scholaris R.Br.) is a commercial wood with many important uses such as in wooden light construction, furniture, and wooden craft materials, with durability class IV-V is not durable and can easily attacked by wood attacking organisms like blue stain fungus. It is necessary to increase its durability properties through a preservation process. This study aims to determine the effect of the preservation method using borax preservative on pulai wood to the retention value and intensity of blue stain fungus attacks. Analysis of variance using a completely randomized design (CRD) with three treatments of simple preservation methods (cold immersion, dipping, and brushing) with concentration of 5% borax at 20 replication samples and continued with the LSD test at confidence level of 99%. The results showed that the preservation method had a significant effect to the retention value and intensity of blue stain fungus attack. The cold immersion method treatment gave the best results, with retention value of 0.687 kg/m3 but still could not meet the AS1604-2004 standard (0.753 kg/m3), while the intensity of blue stain fungus attack value of 11.55% was quite effective in inhibiting blue stains fungus attacks compared to other preservation treatments

INTRODUCTION

Pulai (Alstonia scholaris R.Br.) is an industrial plant that has high economic value. Pulai trees can grow up to 40 meters high with a trunk diameter of 125 cm. Pulai wood is widely used as raw material for plywood, making crates, furniture, craft materials such as wood carvings, and is used in light wood construction with the characteristics of its light but strong wood including strength class IV-V. Pulai wood is easy to dry, easy to work with, moderate shrinkage expansion, low durability including durability class IV-V, but its nature is easy to preserve (Pokhrel, 2024).

The preservation process is needed to prevent Pulai wood from being quickly damaged by attacks by wood-destroying organisms, thereby increasing the service life of the wood, avoiding replacing wood in wood construction and reducing the final cost of wood products (Dumanauw, 2007). One important factor in the wood preservation process is the preservation method. Simple non-pressure preservation methods such as cold immersion, dipping and brushing can be applied because they are easy to do, simple equipment, relatively inexpensive, and have relatively high retention values (Leonardo Pasaribu, Edy Budiarso, 2023).

Borax is one of the wood preservatives that is easily found on the market, the price is also relatively cheap, and relatively safe for humans, low toxicity to mammals. The use of borax is widely used as a herbicide and pesticide, it is toxic to fungi and insects, odorless, does not change the color of wood, has a low evaporation rate, is easily soluble in water solvents, has high penetration into wood even in heartwood, and is non-flammable so it can be used as a fire-resistant preservative. Borax in New Zealand is used to protect wood in house construction and is also used in large quantities as a fire retardant wood preservative formula (Dayadi, 2005).

LITERATURE REVIEW

Wood from the low-durability class is very susceptible to attack by coloring fungi, one of which is blue stain fungus. The intensity of growth and attack of blue stain fungus which is included in the Ascomycetes class is very fast, starting after the log is cut down. This is because the blue stain fungus reproduces with tools in the form of conidia (Martono, 1989). The research results by Sanusi, (2012) regarding the cold immersion treatment for 10 minutes of rattan using 0.5% formalin and 10% boric acid as preservative were not effective in protecting rattan from blue stain fungus attacks, where the blue stain fungus causes the rattan to become dark and brownish black in color, causing a decrease in quality. Research by Abdurrohim & Martawijaya, (1987) that examining diffusion preservation using BFCA preservative (containing of boron, flour, chrome, arsenic) on ten species of Irian Jaya wood (including Pulai wood) with durability classes III-V showed that only 3 species were not attacked by blue stain fungus, Pulai and 6 other species experienced severe blue stain fungus attacks. Based on the above, it is necessary to conduct research on the retention value and intensity of blue stain fungus attacks on Pulai wood based on the preservation method using borax preservative which is useful in early control of wood from blue stain fungus attacks.

METHODOLOGY

1. Tools and Materials

a. Tools

The equipment used in the study included: circular saw, planer, digital scale, digital caliper, oven, desiccator, plastic tub, brush, pipette, measuring cup, stirrer, stopwatch, hygrometer (dry bulb and wet bulb thermometer), millimeter dot grid plastic.

b. Materials

The materials used in the study were Pulai wood (*Alstonia scholaris* R.Br.) cut from Pampang Village, North Samarinda District, East Kalimantan Province; blue stain fungus that had been cultured on PDA (Potato Dextrose Agar) media from the Laboratory of Plant Pests and Diseases, Faculty of Agriculture, Mulawarman University; borax preservative $Na_2.B_4O_7.10H_2O$ (Sodium tetraborate decahydrate) in the form of white coarse powder; and oil paint.

2. Research Procedure

a. Material Preparation and Making of Test Samples

Pulai trees with a diameter of ±30 cm at breast height with a trunk length of ±10 m were cut down and taken at the base of the trunk for 3 m and then cut into three parts of 1 m. Cut and split into sticks measuring 2 x 2 x 30 cm for three types of preservation method treatments and one control treatment where each had 20 repetitions. Test samples measuring 2 x 2 x 2 cm were made for 20 repetitions to measure moisture content and wood density. All test samples were free of defects, conditioned in a constant room at a temperature of 20±1°C and a relative humidity of 65±5% until they reached a normal moisture content equilibrium condition (±12%). The 2 x 2 x 30 cm test sample was painted on the end surface so that during the preservation process the preservative solution did not enter through the transverse cross-section. After the paint had dried and the normal moisture content was reached, the wood preservation process could be carried out by first measuring its dimensions and weighing it to test the retention value of the preservative material.

b. Preparation of Borax Preservative Solution

A 5% concentration borax preservative solution is made by dissolving 5 g of borax solid crystals in 95 ml of clean water (b/v ratio). The volume of borax preservative solution used in the study is adjusted to the size of the Pulai wood test sample immersion tank.

c. Cultivation of Blue Fungus (Blue Stain)

Blue stain fungus is taken from laboratory preparations stored in low temperature storage (5°C) and is first activated by culturing in a petri dish containing 15 ml of PDA media. After the blue stain fungus has grown to fill the dish, the blue stain fungus isolate is inoculated into a petri dish containing new PDA media that has been sterilized in an autoclave. PDA media is made from 20 g of agar, 150 g of potatoes, 20 g of dextrose, and dissolved in 1,000 ml of distilled water.

d. Preservation Process of Pulai Wood

This study used three preservation methods as treatments, namely cold immersion, dipping, and brushing of Pulai wood test samples measuring 2 x 2 x 30 cm in a 5% borax preservative solution. Before the preservation process, the test sample was weighed (b0) and its dimensions were measured (v) then given research treatments, namely cold immersion treatment, the test sample was soaked for 20 minutes (the test sample was completely submerged at a depth of 2 cm from the surface of the preservative solution); dipping treatment (the test sample was dipped for 3 minutes); while in the re-brushing treatment, the test sample was evenly coated with borax preservative solution over its entire surface using a brush once. After the preservation process, the test sample was wiped using a dry cloth and then the weight was weighed after the preservation process (b1) to determine the retention value of the borax preservative.

e. Testing of Pulai Wood Test Samples

The test values of moisture content and density of Pulai wood test samples at equilibrium conditions in constant room storage (normal conditions) of 2 x 2 x 2 cm test samples using DIN 52183-7 and DIN 52182-76 standards, where the test samples before preservation were weighed (bn) and their dimensions measured (vn), then put into an oven at a temperature of 100±3°C for 48 hours, then cooled in a desiccator and then weighed for their oven dry weight (bkt) and oven dry dimensions (vkt). The normal moisture content value is calculated based on equation (1), while the normal density value and oven dry density are calculated based on equations (2) and (3):

$$KAn = \frac{bn-bkt}{bkt} \times 100\% \quad \text{..... (1)}$$

$$\rho n = \frac{bn}{vn} \quad \text{..... (2)}$$

$$\rho kt = \frac{bkt}{vkt} \quad \text{..... (3)}$$

Description:
KAn = Normal moisture content (%)
ρn = Normal density of test sample (g/cm^3)
ρkt = Oven dry density of test sample (g/cm^3)
bn = Normal weight of test sample (g)
bkt = Oven dry weight of test sample (g)
vn = Normal volume of test sample (cm^3)
vkt = Oven dry volume of test sample (cm^3)

The preservative retention test value is the effective amount of preservative that is absorbed and remains in the wood test sample that has undergone the preservation process. The calculation of the preservative retention value uses equation (4) (Muslim et al., 2022):

$$R = (b1-b0)/v \times K \quad \text{..... (4)}$$

Description:
R = Preservative retention (kg/m3)
b1 = weight of test sample after preservation process (g)
b0 = weight of test sample before preservation process (g)
v = volume of test sample before preservation (m3)
K = preservative concentration (%)

The value of the blue stain fungus attack intensity test was observed from the control treatment (without preservation process) and three preservation method treatments, where each side (radial and tangential planes) of the test sample at 3 different locations were dripped with 3 drops of blue stain fungus seeds each. The test sample was stored in a room with a temperature of around 21 - 32°C and relative humidity >80% for 35 days until blue stain fungus infection occurred in the test sample and observations of the attack area were carried out every 2 days. The intensity of the blue stain fungus attack was calculated using equation (5):

$$P = \frac{(P1+P2+\cdots+Pn)}{A}\ x\ 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Description:
P = Intensity of blue mold attack (%)
P1, P2, … Pn = Increase in the area of blue stain fungus attack in each observation (mm^2)
A = Total surface area of test sample (mm^2)

RESULTS AND DISCUSSION

1. Moisture Content and Density of Pulai Wood

The moisture content and density values of the pulai wood test samples can be seen in Table 1.

Table 1. Average Moisture Content and Density Values of Pulai Wood

Physical Properties	**Average**	**KV (%)**
Normal moisture content (%)	11,85	5,65
Normal density (g/cm3)	0,42	10,81
Oven dry density (g/cm3)	0,36	9,01

The normal moisture content of Pulai wood after being conditioned in a constant room reaches 11.85%. The moisture content value is below the mositure content of the fiber saturation point (<30%), which means that the wood cell cavities are relatively empty and not filled with water so that preservatives can more easily enter the wood and increase preservative retention. The moisture content of wood plays an important role in the impregnation of preservatives into wood where the moisture content must be below the fiber saturation point so that the cell cavities are not filled with water (Salmayanti et al., 2013). The normal and oven-dry density values of pulai wood are 0.42 g/cm3 and 0.36 g/cm3, where the density value <0.6 g/cm3 is low-density wood (Dumanauw, 2007), and is included in strength class III-IV based on its density value (Ministry of Environment and Forestry, 2020). Wood with strength class III-V and durability class V is very susceptible to damage due to attacks by wood-destroying organisms, so a preservation process is needed so that the service life of Pulai wood is longer (Ministry of Environment and Forestry, 2020). Pulai wood is included in durability class V, including non-durable wood (Anggraini et al., 2024). Low-density wood is generally composed of larger cells than high-density wood so that it has good

permeability properties and can better accept preservative absorption. Low-density wood, the proportion of the volume of cell cavities (vessels) as fluid transporters will be higher so that the wood is easier to produce higher preservative absorption (Kusumaningsih, 2017). This means that Pulai wood has the property of being easily treated with preservatives even using simple preservation methods such as cold immersion, dipping and brushing. The Coefficient of Variation (CV) value in this study was also quite low at 5.65% for moisture content, 10.81% for normal density, and 9.01% for oven dry density, this indicates that the conditioning of Pulai wood in a constant room is quite good so that it produces fairly uniform test data.

2. **Retention of Borax Preservative**

The retention value is a parameter of the success of wood preservation seen from the amount of retention value produced. The retention value of 5% borax preservative based on the preservation method can be seen in Table 2.

Table 2. Average Retention Value of Borax Preservative Based on Preservation Method

Preservation Method	Average (kg/m^3)	KV (%)
Cold immersion	0,687	6,90
Dipping	0,486	9,98
Brushing	0,479	9,17

The highest retention value in this study was found in the cold immersion method for 20 minutes at 0.687 kg/m3 and the lowest in the brushing method at 0.479 kg/m3. The value of the Coefficient of Variation (CV) for preservative retention was also quite low, ranging from 6.90% - 9.17%, which indicates that The preservation process has been carried out properly, producing fairly uniform test data. To see the effect of the treatment of the preservation method on the retention value, a analysis of variance test was carried out in Table 3.

Table 3. Analysis of Variance of the Effect of Preservation Methods on the Retention of Borax Preservatives in Pulai Wood

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Count	F Table (0,01)
Treatment	2	0,557	0,27849	119,01*	5,00
Error	57	0,134	0,00234	-	-
Total	59	0,690	-	-	-

Note: * = Significant Effect

Analysis of variance shows a significant effect of the treatment of preservation methods on the retention value of the resulting preservative material. To see the significance of the difference in retention values between the treatments of preservation methods, an LSD test was carried out as in Table 4.

Table 4. LSD Test of Borax Preservative Retention on Pulai Wood Based on Preservation Method

Treatment	Average	Average Difference			LSD (0,01)
		Immersion	Dipping	Brushing	
Immersion	0,687	-	0,201*	0,208*	0,041
Dipping	0,486	-	-	0,007ns	
Brushing	0,479	-	-	-	

Ket = * = Significantly Different; Ns = Non Significant

The results of the LSD test showed a significant difference between the cold immersion method treatment against dipping, and between cold immersion against brushing. A non significant difference occurred between the dipping method treatment against brushing. This means that the cold immersion method is the best method to produce high retention, while the dipping method is slightly better than the brushing method but the difference is not significant.

The significant influence and difference, as well as the tendency for higher retention with the better preservation method used is due to the longer contact time of Pulai wood with the borax preservative solution, where in the brushing preservation process only the preservative is applied once using a brush, while in the Pulai wood dipping it is only dipped for 3 minutes, and the cold immersion is longer, namely for 20 minutes, which results in better preservative absorption. In addition, the longer the wood is in the preservative solution, the opportunity for air in the wood cavities to escape and be replaced by the preservative solution. Factors that can affect the retention value include the preservation method, type of preservative, preservative concentration, target retention value, and wood characteristics, including the size of the preserved wood product (Lebow & Conklin, 2011). The retention value also tends to increase with increasing duration of the preservation process used and is increasingly optimal in direct proportion to the preservation method used (Soimin & Nahlunnisa, 2021). All retention values based on the preservation method in this study cannot meet the SNI 03-5010.1-1999 standard (SNI, 1999), namely the preservative retention required for indoor used is 8.2 kg/m3 and outdoor used is 11.3 kg/m3, also cannot meet the requirements of the Department of Public Works, (1987) (DPU, 1987) the minimum retention of good preservatives for wood building materials indoor installed and not in direct contact with the ground is 5 kg/m3. However, the retention value of the cold immersion method for 20 minutes in this study (0.687 kg/m3) almost meets the Australian standard AS1604-2005 (Australian Standard, 2005) at Hazard Level 1 (H1) which is for preservatives containing boron with indoor used, on land that is completely protected from the weather, good ventilation, and protected from termites that required >0.753 kg/m3. This means that the simple method of preserving Pulai wood with cold immersion can be done by adding immersion time or increasing the concentration of borax or its interaction so that the retention value becomes better and meets the required usage standards or hazard levels.

Intensity of Blue Stain Fungus Attack

The intensity value of the blue stain fungus attack on Pulai wood that was not preserved (control) and used a different preservation method can be seen in Table 5.

Table 5. Average Value of Blue Stain Fungus Attack Intensity on Pulai Wood Based on Preservation Method

Preservation Treatment	Average (%)	KV (%)
Control	88,47 (1,22)	6,27
Immersion	11,55 (0,93)	10,15
Dipping	42,20 (0,71)	10,99
Brushing	64,01 (0,35)	16,67

Description: the Value in Brackets is the Transformation of the % Value of the Intensity of Blue Fungus Attack Into the Arc Form √%

The highest average value of the intensity of blue stain fungus attack occurred in unpreserved Pulai wood (control) at 88.47%, while the lowest was in the cold immersion method at 11.55%. The Coefficient of Variation (CV) value of the intensity of the blue stain fungus attack was also quite low, ranging from 6.27% - 16.67%, which indicates that the testing process was carried out quite well and produced uniform values in each treatment of the preservation method. Judging from the CV value, there is a tendency for the test data on the intensity of the ble stain fungus attack to be more uniform with the better the preservation method. This is due to the more even distribution of preservative on the wood surface with the better the preservation method.

To see the effect of the treatment of the preservation method on the intensity value of the blue stain fungus attack, a analysis of variance test was carried out in Table 6.

Table 6. Analysis of Variance of the Effect of Preservation Methods on the Intensity of Blue Stain Fungus Attacks on Pulai Wood

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Count	F Table (0,01)
Treatment	3	8,46	2,820	420,86*	4,05
Error	76	0,51	0,007	-	
Total	79	8,97	-	-	

Description: * = Significant Effect

Analysis of variance shows a significant effect of the treatment of different preservation methods on the intensity value of blue stain fungus attacks. To see the significance of the difference in the intensity value of blue stain fungus attacks between the preservation method treatments, an LSD test was carried out as in Table 7.

Table 7. LSD Test of Blue Stain Fungus Attack Intensity on Pulai Wood Based on Preservation Method

Treatment	Average	Difference Average			LSD (0,01)
		Immersion	Dipping	Brushing	
Control	1,22	0,30*	0,52*	0,88*	0,07
Immersion	0,93	-	0,22*	0,58*	
Dipping	0,71	-	-	0,36*	
Brushing	0,35	-	-	-	

Description: * = Significantly Different

The results of the LSD test showed a significant difference between all preservation method treatments and also against the control.

To see more clearly the intensity of the blue stain fungus attack during the 35-day test period, see Figure 1 below:

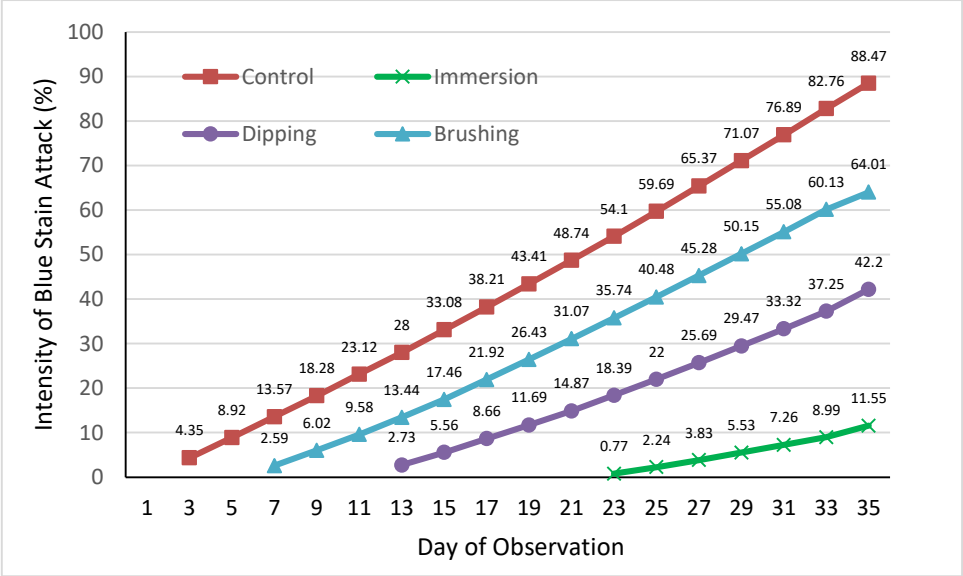

Figure 1. Intensity of Blue Fungus Attack on Pulai Wood Based on Preservation Method

Test data shows that the highest average value of blue stain fungus attack intensity occurred in unpreserved pulai wood (control) at 88.47%, while the intensity of blue stain fungus attack was lower in those given preservative treatment. Control of pPlai wood was also attacked by blue stain fungus more quickly (since day 3) compared to preserved Pulai wood, where the cold immersion method only caused attacks on day 23. There was a tendency for the speed and intensity of blue stain fungus attacks to be lower in the better preservation method (cold immersion method). This is due to the higher retention value of borax preservative in the cold immersion method compared to other methods. The high retention value determines the durability and level of protection of wood against the risk of wood-destroying attacks, especially from biological groups such as fungi and insects (Arifin et al., 2022). Differences in the speed and intensity of attacks are also caused by the uneven distribution of

preservatives such as in the brushing method, which causes the wood to be attacked by blue stain fungus more quickly and spread more widely. Previous researchers on the distribution of preservatives based on differences in preservation methods stated that the distribution of preservatives would be relatively more even with better preservation methods so that it could prevent attacks by wood-destroying organisms (Febrianto et al., 2014).

CONCLUSION AND RECOMMENDATION

The preservation method affects the retention value of borax preservatives, where the better the preservation method, the higher the retention value. The cold immersion method produces the highest retention compared to the dipping and brushing methods.

The retention value of 5% borax preservatives based on the preservation method in this study has not meet the SNI 03-5010.1-1999 standard and the requirements of the Department of Public Works, (1987), but is close to meet the Australian standard AS1604-2004.

The preservation method also affects the intensity of blue stain fungus attacks, where the better the preservation method, the better the retention value and the lower the intensity of blue stain fungus attacks.

The 5% borax preservative using a simple preservation method, especially the cold immersion method is quite capable of inhibiting blue stain fungus attacks on Pulai wood.

It is recommended to use the cold immersion method with borax concentration of >5% and a immersion time more than 20 minutes to produce better preservative retention and intensity of blue stain fungus attacks and meet the preservation quality standards.

FUTHER STUDY

This research still has a delay, so it is necessary to conduct further research related to the topic of Retention of Borax Preservative and Intensity of Blue Stain Fungus Attack on Pulai (Alstonia scholaris R.Br.) Based on Preservation Method to improve this research and add insight for readers

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