

Pleurotus Ostreatus for Durability Test of Rubber and Sengon Woods using Indonesian National Standard and Japanese Standard Methods

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Abstract—This study aims to determine the level of resistance of *Hevea brasiliensis* and *Paraserianthes falcata* (synonym: *Falcataria molucana*) against wood rot fungi *Pleurotus ostreatus* based on Indonesian standard SNI 01.7207-2006 and Japanese standard JIS K 1571-2004. The variables measured were visual appearance and weight loss percentage of wood based on longitudinal and cross section fiber directions of rubber wood and sengon wood. Measurement of oven dry weight loss of wood samples performed after 12 weeks incubation. Replication performed was 10 times at each treatment combination.

The results based on SNI 01.7207-2006, weight loss value of *H. brasiliensis* and *P. falcata* wood with fiber direction longitudinal were 23,12 and 22,25% respectively and cross section were 20,77 and 18,76% respectively, and all were classified to resistance class IV (no resistance). The results based on JIS K 1571-2004, weight loss value of both woods with fiber direction cross section were 10,95 and 14,20% respectively.

Keywords—*H. brasiliensis* wood, Natural durability, *P. falcata* wood, *P. ostreatus*.

I. INTRODUCTION

MORE than 80% of Indonesian wood have low natural durability, for example, rubber wood (*Hevea brasiliensis*) and sengon wood (*Paraserianthes falcata*, synonym: *Falcataria molucana*). In other hand, the need to be evaluated against the wood durability based on Indonesian standard SNI 01.7207-2006 compared with Japanese standard JIS K 1571-2004 by way of conducting research using the standards in a similar condition so that will be generated recommendations for improving standard of SNI 01.7207-2006 [1].

Wood rot fungi are the class of fungi that can break down cellulose and lignin so that the wood becomes rotten, strength and elasticity decreased rapidly. These fungi destroy wood cell wall, which changed its physical and chemical properties of

wood. Natural durability of wood is strongly influenced by the content of extractive substances, although not all extractive substances are toxic to wood destroying organisms. One type of potential wood rot fungi is *Pleurotus ostreatus* or oyster mushroom.

As saprotrophs, wood rotting fungi from basidiomycetes play a vital role in recycling nutrients but they also cause severe damage as agents of timber decay, e.g. dry rot of house timbers by *Serpula lacrymans*. The fruit bodies (basidiocarps) of many mushrooms are edible, and some are grown commercially for food, notably *Agaricus bisporus* (*A. brunnescens*, the white button mushroom), *Pleurotus* spp. (oyster mushrooms) and *Lentinula edodes* (shiitake). There are three types of fungi that attack wood are many buildings in Indonesia, namely: 1). *Schizophyllum commune* Fr; 2). *Pycnoporus sanguineus* (Fr.) Korst, 3). *Dacryopinax spthularia* (Sch) [2].

SNI 01.7207-2006 test is a standard testing new wood preservation in Indonesia [3]. As a comparison standard durability test of wood is JIS K 1571 [4]. This study aims to determine the level of durability *P. falcata* and *H. brasiliensis* against wood rot fungi *P. ostreatus* based on SNI 01.7207-2006 and JIS K 1571-2004.

II. METHODOLOGY

A. Sampling Test

SNI 01.7207-2006. Sample of wood size of 5 x 2.5 x 1.5 cm. Fiber directions of wood sample are cross and longitudinal. Sample weight initially weighed (wet weight), then dried in the oven for 24 hours to reach oven dry weight and moisture content will be calculated.

JIS K 1571-2004. Wood samples measuring of 2 x 2 x 1 cm. Fiber directions are cross and longitudinal. Furthermore, the weight of the specimen was initially weighed (wet weight), then the specimen was dried in an oven until it reaches a dry oven.

B. Culture Propagation Fungi *P. ostreatus*

SNI 01.7207-2006. Cultures of *P. ostreatus* were propagated in Petri dishes containing MEA (Malt Extract Agar) sterile. Fungal culture media containing 50 grams of malt extract, and 20 grams for 1 liter of distilled water. Some 40 cc of the mixture was inserted into the jar testing. Jars with fungal culture media were sterilized in an autoclave for 30 minutes at a pressure of 15 psi. After sterile, jars were placed horizontally so that the culture is at the bottom of the jar neck.

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Fungi were inoculated a few days later. Cultures were incubated for approximately 12 days or until all surfaces are filled with the mycelium (white).

JIS K 1571-2004. Testing the durability of wood against fungi must be made moist by providing fungal cultures in a sterile vessel. Fungal culture media were using quartz sand mixed with extra malt, peptone and glucose. Fungal culture media was prepared by mixing 250 grams of quartz sand, 16 grams of glucose, peptone 1.2 grams and 6 grams of extract malt in 400 cc of distilled water. Then the number of 80 cc of the mixture was inserted into the jar testing. Jars with fungal culture media were sterilized in an autoclave for 30 minutes at a pressure of 15 psi. After sterile, jars were placed horizontally so that the culture is at the bottom of the jar neck. Fungi were inoculated a few days later.

C. Phase Testing Procedures

SNI 01.7207-2006. Feeding test sample of wood for each type isolates *P. ostreatus* done after the entire surface of the media in a jar filled with mycelia. Sterile test sample and the known weight is inserted into the jar containing the test fungus cultures. Fungal cultures contaminated should be replaced and not used in testing. Observations made after 12 weeks. Sample cleaned of mycelium and observed visually by the damage. Damage assessment can be performed according to the condition of test sample from intact until destroyed altogether. Test sample is inserted into the oven for 24 hours. Percentage weight loss was calculated on the basis of the difference in sample weight before and after fungal attack.

JIS K 1571-2004. Sterile test sample which has been calculated weight is inserted into the jar that already contains fungal cultures testers. Observations made after 12 weeks of incubation. Sample cleaned of mycelium and observed visually by the damage. Damage assessment can be performed according to the condition of test sample from the "whole" to "completely destroyed". Classification of damage can be made according to needs. Test sample is then put in oven for 24 hours. Percentage weight loss was calculated on the basis of the difference in sample weight before and after fungal attack.

D. Calculation of Weight Loss

Once feeding is complete, test samples are removed from the glass jar and cleared from the mushrooms that stuck around the sample timber, then weighed with the weight of wet and oven dried to determine dry weight of the furnace. The amount of fungal attack may be calculated by percentage of weight loss, namely:

$$P = \frac{W_1 - W_2}{W_1} \times 100\%$$

with:

P = Percentage weight loss (%)

W₁ = Weight of dry kiln samples before testing (g)

W₂ = dry weight of kiln sample after testing (g)

E. Data Processing

In this research used Completely Randomized Design (CRD) with factorial pattern with three factors: A).

Methodology (ISO and JIS), 2). Fiber direction (longitudinal and cross); 3). Types of wood (sengon and rubber). Replications performed 10 times on each type of combination treatment. Data processing is done using Microsoft Excel 2007 and R to determine the relationship between specific gravity and weight loss (weight loss) of each test method (ISO and JIS) or not significantly different, then use different testing center value (average difference).

III. RESULTS AND DISCUSSION

A. Comparison of Indonesian and Japanese Standardised Tests for Decay Test with Fungi

Comparison of Indonesian and Japanese standardised tests using some types of fungi and tried to develop a new type of fungus as a potential test organism that is *P. ostreatus*. Differences of the two methods are summarized in Table I.

B. Oyster Mushrooms *P. ostreatus* for Durability Test of Rubber and Sengon Woods Using Indonesian National Standard and Japanese Standard Methods

Results Analysis of variance with a confidence interval used was 95%, can be seen that there are real differences between treatment type, method x Direction Fibers, and type of wood x Methods x Direction Fibers on reducing the weight of wood samples. Parameters durability of wood against fungi *P. ostreatus* seen from the specimen weight loss (weight loss) obtained from laboratory test results [Table II].

The results based on SNI 01.7207-2006, weight loss value of *H. brasiliensis* and *P. falcata* wood with fiber direction longitudinal were 23,12 and 22,25% respectively and cross section were 20,77 and 18,76% respectively, classified to durability class IV (no resistance). The results based on JIS K 1571-2004, weight loss value of *H. brasiliensis* and *P. falcata* wood with fiber direction cross section were 10,95 and 14,20% respectively (Table III).

Fungus *P. ostreatus* can damage wood cellulose and lignin. This causes the weight of wood fell from the weight initially. The amount of weight reduction due to fungal attack in a given time indicates the level of fungal attack on wood. Based on the value of SNI 01.7207-2006 weight loss sengon and rubber wood with longitudinal and cross direction of fibers belong to a resistant class IV (not resistant) by the percentage weight loss of 10-30%. This is consistent with the statement [5] which said that rubber and sengon woods belonged to class IV-V which means it has very low durability.

TABLE I
COMPARISON OF TEST METHODS BETWEEN SNI 01.7207-2006 AND JIS K 1571-2004 FOR DECAY TEST WITH FUNGI

No.	Parameter	SNI 01.7207-2006	JIS K 1571-2004
1.	Fungi species	<i>Schizophyllum commune</i> , <i>Picnoporus sanguinus</i> and <i>Dacryopinax spathularia</i> , <i>Pleurotus ostreatus</i> (new type)	<i>Japanese brown-rot fungus</i> , <i>Fomitopsis palustris</i> (Berk. et Curt.) Gilbn. & Ryv. dan <i>white-rot fungus</i> <i>Trametes versicolor</i> (L.: Fr.) Pilat (di RISH Kyoto University),
2.	Wood sample size	50 mm (longitudinal)x 25 mm(tangential) x 15 mm (radial) are made long the axis and parallel to the direction of wood fiber	20 mm x 20 mm x 10 mm are made cross the axis
3.	Control Test	None	Untreated sapwood of <i>Cryptomeria japonica</i> D. Don of <i>Pinus densiflora</i> Sieb. et Zucc.
4.	Test Container	Glass jar (size not specified) with cover or no, cover with cotton	Cylindrical glass jar with a wide opening and a lid, having 50-100 cm ² bottom area and 500-900 ml capacity
5.	Media	PDA (Kolle-Plask method), MEA (50 grams of malt extract with 20 grams agar to 1 liter in distilled water)	350 g quartz sand + 100 ml nutrient solution [D(+)-glucose 4% (m/m), peptone 0.3% (m/m) and malt ekstrak 1.5% (m/m) with pH 5.5-6.0.
6.	Incubation of fungi culture	Static condition	Inoculum 5-6 days incubated. Or reciprocal shaking. A fragment of mycelium is introduced into a 250-300 ml nutrient solution in 1 l shaking flask for 7-10 days.
7.	Dry method of wood sample	Oven 100 °C for 24 hours	60 °C± 2 °C in oven for 48 hours, cooling down in desicator for 30 minuts. Ovendried masses are 0.01 g
8.	Sterilize of wood sample	No specific sterilize method (autoclave?)	With gas sterilize (etilen oxide)
9.	Percent mass loss	[(Weight difference between before and after test)/weight before test] x 100%	[(Weight difference between before and after test)/weight before test] x 100%
10.	Duration of testing	3 months	3 months
11.	Validity of test	No specification	Mean pecrcent mass loss of untreated controls with <i>F. palustris</i> (brown rot fungi) should be >30%; with <i>T versicolor</i> (white rot fungi) should be >15%. Otherwise, retest is needed

TABLE II
ANOVA RESULTS OF THE METHOD OF LOSING WEIGHT, DIRECTION AND TYPE OF WOOD FIBER

source of Variability	DB	JK	KT	F	Pr>F
repeat	9	162.83	18.09	0.89	0.540
Method	1	1943.21	1943.21	95.54	3.03e-14**
Fiber direction	1	7.43	7.43	0.37	0.548
Type	1	82.74	82.74	4.07	0.048*
Method x Direction Fiber	1	249.64	249.64	12.27	0.001**
Methods x Type	1	7.16	7.16	0.35	0.555
Fiber direction x type	1	63.80	63.80	3.14	0.082

Methods x Fiber	1	111.06	111.06	5.46	0.023*
Direction x Type					
Galat /error	63	1281.42	20.34		

Description: ** significantly different at level F test 0.05, * significantly different at test level F 0:05

The weight loss value by the method of SNI was higher than JIS method. This is presumably due to the fungal mycelium into the test sample. Fungal mycelium are still left in the test sample will affect the final weight of test sample after being fed. In addition, the sample size differences SNI and JIS are also thought to cause the difference in the value of losing weight far enough [Table IV].

The ability of fungi *P. ostretus* in causing wood decay vary depending on the characteristics of wood species and types of fungi that attack. Wood fungi have the ability to break down wood components such as cellulose and lignin of complex compounds into simpler compounds that can be absorbed and metabolized by the fungus as food. This can reduce the weight

of timber from the weight initially. The value of the weight loss test sample indicates the level of species of fungi attack the wood of the type of wood used.

TABLE III
THE TEST RESULTS OF *H. BRASILIENSIS* AND *P. FALCATA*

Types of wood	Direction of fiber	Weight loss (%)	
		SNI	JIS
<i>H. brasiliensis</i>	Longitudinal	23.12	9.21
	Cross section	20.77	10.95
<i>P. falcata</i>	Longitudinal	22.25	5.91
	Cross section	18.76	14.20

Fisher's LSD test results between the methods of weight loss (Table IV) shows that the method of SNI (21.23) experienced a greater weight loss compared with the JIS method (11.37). Fisher's LSD test results between the type of test sample (Table V) showed that rubber wood (17.32) experienced greater weight loss than sengon wood (15.28).

TABLE IV
FISHER'S LSD TEST RESULTS OF THE TESTING METHODS OF WEIGHT LOSS

Method	Average (%)
SNI	21.23 ^a
JIS	11.37 ^b

Note: Numbers followed by same letters in the same column are not significantly different at the level of testing 0.05.

TABLE V
FISHER'S LSD TEST RESULTS ON THE TYPE SPECIMEN OF WEIGHT LOSS

Type	Average (%)
Karet	17.32 ^a
Sengon	15.28 ^b

Note: Numbers followed by same letters in the same column are not significantly different at the level of testing 0.05.

Weight loss value of the specimen of sengon and rubber wood based fiber direction and the methods used showed the percentage value of the fiber longitudinal direction is greater than the cross fiber direction on the method of SNI. Longitudinal direction of fiber of JIS method showed a smaller percentage value than the cross fiber direction. The percentage weight loss samples on the SNI method were greater than the JIS method. Based on these results we can conclude that the use of fiber longitudinal direction on the method of SNI and cross fiber direction on the method of JIS increasingly convincing.

Wood observed visually to see the impact caused by the fungus *P. ostreatus* on the specimen timber is fed for 3 months. It is generally seen that the colonization of the mycelium spreads ranging from the wooden sides toward the

middle surface of the wood. Mycelium growing thickened and evenly distributed across the surface of the wood along with increasing incubation time. Seen that the test sample timber that has been attacked by the fungus *P. ostreatus* discoloration became lighter (light brown or reddish) and fragile, both the rubber and the wood sengon.

Microscopic analysis showed that in the early stage of fungi *Pleurotus* spp. invasion on pine, mycelium lived in resin tunnel and xylary rays, while on acacia they lived in vessels and xylary rays. In general, mycelium was penetrated through nocti as a means to spread further in another of wood cells. On the advanced decay process, there were changes in form and cells damage of middle lamella and secondary cell wall [6].

Fungus *P. ostreatus* has been studied and are known to have an average of the highest degradation rate with one another isolate of *P. djamor* on sengon wood, followed by acacia (*Acacia mangium*) wood and pine (*Pinus merkusii*) wood [6]. *P. ostreatus* has an oxidation reaction in the media that AAG and AAT showed positive including white mushrooms [7]. Activity of fungal isolates ligninolitik *P. ostreatus* grown on the medium was measured after sawn wood powder sengon (*P. falcata*) in a bag and weighs about 400 grams, *P. ostreatus* has the ability to reduce levels of lignin substrate (54.6%) and cellulose content (57.7%) [8]. Wood decomposition rate of *P. ostreatus* on sengon wood was highest (92.3 mg/week) on the 2nd weeks.

Rate of degradation level of *P. ostreatus* HO on sengon wood was the highest, followed by on acacia and pine wood [6]. Natural durability of wood is the resistance of a type of wood against wood destroying organisms, in the form of insects, fungi and animals marine borers. In addition, the durability of wood is influenced also by the extractive content, old trees, the wood in the trunk, speed of growth and a place where of wood is used. Generally, the higher content of extractives in the wood, the natural durability of wood tends to increase [9], [10].

Natural durability of wood determined by the type and amount of extractive substances that are toxic to wood destroying organisms present in the wood such as tannins, alkaloids, saponins, phenols, quinine and resins [11]. Factors that affect the level of resistance of wood from wood destroying factors are the external factors and the internal factors. The external factors related to the environmental conditions where the wood was used, while the internal factors the influence of the chemical components of wood in question. Extractive substances have most important role than the wood density. Extractive substances are presence in the cell cavities and also within the cell wall of wood. Therefore, the presence of extractive substances in cell walls was contributed to the value of wood density. The content of extractive substances in the wood is very small compared with the content of cellulose, hemicellulose and lignin. Extractive substances have considerable influence on properties of wood and properties of processing. It was a very important influence on the properties of the natural durability of wood [12]. It can be concluded that the higher content of extractive substances contained in wood, then the level of resistance or durability against destructive

organisms such as fungi will also be getting better. The content of extractive substances contained in rubber wood, among others, amirin (triterpena) in latex sap, acid sumaresinolat in sumatra benzoin and resin acids in elemi elemolat [13], resins, fats, waxes, tannins, lignin, pentosan and heksosan [14]. The content of extractive substances contained in wood sengon include cellulose, lignin, pentosan, ash and silica.

C. Durability of Wood against Fungus P. ostreatus

The results of analysis of variance (Table II) states that the interaction between method x direction x type of wood fiber to give real effect to the percentage decrease in weight of the specimen at $\alpha = 0.05$. This means that both methods have different levels of weight reduction on the test sample timber either by using the direction of long fiber and cross fiber direction. In addition, the methods and types also influence the level of weight reduction.

The results of further tests Fisher's LSD (Table III) shows that at $\alpha = 0.05$ both the SNI and JIS methods provide significant effect on the percentage reduction in weight of wood samples. This means that both methods have different levels of weight reduction.

The results of further tests Fisher's LSD (Table IV) shows that at $\alpha = 0.05$ for both types of rubber wood and sengon provide a noticeable effect on weight reduction. This means that both types of wood have different levels of weight loss. Average value of weight loss of rubber wood was higher than average value of weight loss of wood sengon on SNI and JIS methods. This is consistent with [15] decreased the weight of rubber wood (40.2%) was higher than with wood sengon (36.3%) using the fungus *Schizophyllum commune*.

IV. CONCLUSION

1. Based on the results of the test method SNI with the fungus *P. ostreatus* known that rubber wood durable belong to a class IV (no resistance to wood destroying organisms) with an average value of 23.12% weight loss (fiber longitudinal direction), 20.77% (cross fiber direction) and wood sengon classified into durable grade IV (no resistance to wood destroying organisms) with an average weight loss of 22.25% (fiber longitudinal direction) and 18.76% (cross fiber direction).
2. Based on the average weight loss of wood, SNI 01.7207-2006 method used should be the direction of the fiber longitudinal direction of fibers and fiber direction JIS K 1571-2004 are used should be the direction of the fiber cross section.
3. *P. ostreatus* cannot be used in the standard test fungi by using test samples of rubber wood and sengon on the method of SNI 01.7207-2006.

SUGGESTION

1. Further research needs to be done by replacing the culture media making it easier to compare the effect of fungal culture media to lose weight sample timber.

2. In preparation for the test sample timber needs to be done with the oven drying and weighing of the specimen timber to get the value of the dry weight of specimen before testing.
3. In preparation for the test sample requires sterilization using gas sterilization to reduce sample damage from natural materials like wood.
4. The conditions under room tests need to be done to improve the testing standards that have been set.

ACKNOWLEDGMENT

The authors wish to express their appreciation to: (1) Ministry of National Education of Indonesia for sponsorship so that this research could be undertaken and (2) The Research Institute for Sustainable Humanosphere (RISH) Kyoto University Japan.

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