

ISSN: 2459-9867

Bandung, November 5-6, 2015

PROCEEDINGS

The 7th INTERNATIONAL SYMPOSIUM
INDONESIAN WOOD RESEARCH SOCIETY
(IWoRS)

**“Role Acceleration and Synergy of
Wood Research Society to Support Sustainable Forest Industry
Based on Science and Technology”**

Organized by:



PROCEEDINGS

THE 7th INTERNATIONAL SYMPOSIUM OF INDONESIAN WOOD RESEARCH SOCIETY

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INDONESIAN WOOD RESEARCH SOCIETY (IWORS)

2016

Preface

Indonesia is the third largest area of tropical rainforest in the world with forest land occupies around 60% of its land area. Indonesia's forest is therefore important not only for the national economy and local livelihoods, but also for the global environment. Biodiversity of Indonesian rainforests is among the richest in the world. On the other hand, Indonesia is also the world's third largest emitter of greenhouse gases, mainly due to the conversion of its forests and carbon-rich peatlands. These shifts in land use have ecological and social consequences, as Indonesia's forests are home to thousands of plant and animal species, and 50-60 million Indonesians depend directly on the forests for their livelihoods.

Recognizing the domestic and international importance of its tropical landscape and the people in it, the Indonesian government has made encouraging decisions; it has voluntarily committed to a minimum 26% reduction in greenhouse gas emissions by 2020 and developed a strategy for land use and forestry emissions, extended a moratorium on new clearing of primary forests and peat lands from 2 to 4 years (2013-2015), and increasingly recognized the rights of forest communities and indigenous peoples.

Adding to the above environmental action, an environmentally sound forest industry also has to be established. Nowadays, Indonesian forest industry has been improved which is greatly supported by the issued government regulation (sustainable forest management certification and timber legality verification). This regulation has played an important role in recovering the reputation and selling values of Indonesian forest products internationally. With this positive outcome, Indonesia has to be able to take this opportunity and momentum to produce highly innovative, high quality and high competitive value products. The utilization of non-woody forest product also has to be improved to reduce dependence on woody forest products and also to offer various products from renewable resources. Research on non-woody forest products such as in bioenergy and natural product extraction having potential health benefit, has grown enormously.

Indonesian Wood Research Society (IWoRS) tries to answer this challenge by producing research in various fields of forest science and conducting a seminar to share the results, knowledge and experiences among members and non-members. Therefore, this seminar that was initially held on 2009 is expected as an effort to accelerate the role and synergy of wood research society either from research institution and university to be able to produce research that is highly needed toward sustainable forest utilization. In this year of 2015, this IWoRS Symposium VII has been held on 5-6 November 2015 in Bandung with the theme of "Role acceleration and synergy of wood research society to support environmentally-friendly - science and technology based forest industry" while Research Center for Biomaterials LIPI and Indonesian Wood Research Society takes the role as the organizer. This year, the committee has received 37 fullpaper submissions covering the field of 4 wood properties papers, 2 biocomposite papers, 4 material engineering papers, 3 papers of biodegradation and non wood forest product, 1 paper of forest product chemistry and biorefinery, 10 general forestry papers and 13 poster presentation papers.

Bandung, April 2016

Editor

Table of Content

Preface	ii
Table of Content	iii

Oral Presentation	
A. WOOD PROPERTIES	
Selected Properties of Malaysian Bamboo <i>Schizostachyum grande</i> (Buluh Semeliang) and <i>Schizostachyum brachycladum</i> (Buluh Lemang) <i>Nordahlia Abdullah Siam*, Mohd Khairun Anwar Uyup, Hamdan Husain, and Mohd Tamizi Mustafa</i>	8-15
Anatomical Properties and Density of 8 and 15-year-old <i>Khaya ivorensis</i> <i>Nordahlia Abdullah Siam*, Mohd Khairun Anwar Uyup and Hamdan Husain</i>	16-22
Variation of Anatomical Features between Two Acacia Hybrid (<i>Acacia mangium</i> x <i>auriculiformis</i>) with (<i>Acacia auriculiformis</i> x <i>mangium</i>) from Wonogiri. <i>Harry Praptoyo</i>	23-31
Wood Formation in <i>Shorea leprosula</i> and <i>Shorea parvifolia</i> in Tropical Rainforest <i>Norline Zarnudin*, Mohd Hamami Sahri, Ab. Rasip Ab. Ghani</i>	32-38
B. BIOCOMPOSITES	
Physical and Mechanical Properties of Ply-Bamboo Made from Sembilang (<i>Dendrocalamus giganteus</i>) and Andong (<i>Gigantochloa pseudoarundinacea</i>) Bamboos <i>Subyakto*, Endang Romansyah, Achmad Zakaria, Gina Bachtiar, Nira Nasution, Prihantono</i>	40-48
The Particle Board from Oyster Mushroom Planting Media Waste and Its Physical and Mechanical Properties <i>Lisman Suryanegara*, Maulana Rizki, and Gina Bachtiar</i>	49-54
C. MATERIAL ENGINEERING	
Compressive Strength of Wooden Glulam Short Column based on National Indonesian Standard SNI 7973-2013 versus Experimental Test <i>Lilies Widojoko*, Johannes Adhijoso Tjondro</i>	56-61
Evaluation of In-plane Shear Performance for CLT Panel <i>Shoichi Nakashima*, Yasuhiro Araki, Shiro Nakajima, Atsushi Miyatake, Hiroshi Isoda</i>	62-68
The Effect of Different Method to Determine Log Volume and Their Impacts to Veneer Recovery <i>Benoni Kewilaa* and Suciyanti Mala Kailul</i>	69-78
Planing Characteristics of Laminated Bamboo Timber (LBT) Bonded with Phenol Formaldehyde Resin <i>Rogerson Anokye, Edi Suhaimi Bakar* and Muhammad Firdaus Bin Ariffin</i>	79-86

D. BIODEGRADATION AND NON WOOD FOREST PRODUCT	
Determination of Agarwood Resin Content from Different Formation Method and Grades in Peninsular Malaysia <i>Abd. Majid J,*, Paridah MT , Nor Azah MA , Anwar UMK , and Saidatul Husni S</i>	88-93
Potential Development of Termite Control Systems for Land Productivity Improvement <i>Yuliati Indrayani*, Musrizal Muin, Tsuyoshi Yoshimura</i>	94-98
Identification of Metabolite Products from Biotransformation of PAHs Mixture by a pH-saline Tolerant Fungus, <i>Pestalotiopsis</i> sp. NG007 <i>Dede Heri Yuli Yanto,*, and Sanro Tachibana</i>	99-103
E. FOREST PRODUCT CHEMISTRY AND BIOREFINERY	
Characterization of Liquid Product from the Result of Biomass Material Pyrolysis: Rice Hull and Bagasse <i>Setiadi*, Ayu Saputri and Widya Ardiani</i>	105-112
F. GENERAL FORESTRY	
Belowground Carbon Stored in Riam Berasap Peatland Forest of Ketapang West Kalimantan: Natural Resources that Must Be Saved <i>Dwi Astiani*, Mujiman, Andjar Rafiastanto, Edy Nurdiansyah, Muhammad Hatta, Darkono</i>	114-123
Variability of Mercury Contents in Plants among Age of Tailings of Ex-Gold Mining Area <i>Wiwik Ekyastuti* and Dwi Astiani</i>	124-130
Potential Utilization on Patent Wood Product to Fulfill the Needs from Renewable Resources <i>Tommy Hendrix*, Ferianto</i>	131-139
Mercury Accumulation and Arbuscular Mycorrhizal Colonization in Several Pioneer Plants on Ex-Gold Mining Area <i>Hanna Artuti Ekamawanti*, Dwi Astiani, Fajar Novisa</i>	140-147
Design of Performance Measurement for Company in Forestry Sector based on MBNQA Criteria <i>Muh. Azwar Massijaya</i>	148-154
The Comparison of Demographic Parameters Population of Long-tailed Macaque in West Java and Yogyakarta Province <i>Cory Wulan*and Yanto Santosa</i>	155-162
Pangolins Zoo-culture (<i>Manis javanica</i> Desmarest 1822) in Orang Rimba Bukit 12 Jambi Province <i>Novriyanti*, Burhanuddin Masy'ud, and M. Bismark</i>	163-171

Inventory of Non-commercial Plants in Peat Swamp Land in West Kalimantan – Its Potency as Sustainable Bioenergy Raw Materials <i>Evy Wardenaar, Fathul Yusro*, Yeni Mariani, Hikma Yanti</i>	172-180
Competitive Advantages of Indonesian Plywood Industry: A Perspective from Porter’s Five Forces Model <i>Makkarennu</i>	181-187
Enhancing the Adaptive Capacity of the Indigenous Peoples by Promoting Sustainable and Community-Based Resin Tapping of Almaciga (<i>Agathis philippinensis</i> Warb.) in Selected Certificate of Ancestral Domain Title Areas in Palawan and Sierra Madre, Philippines <i>Arsenio B. Ella* & Florena B. Samiano</i>	188-196
POSTER PRESENTATION	
Crystal Structure and Functional Groups of Distilled Vetiver Root (<i>Vetiveria zizanioides</i>) Soda Pulp <i>Firda Aulya Syamani*, Subyakto</i>	198-206
Anatomy and Ultrastructure of Simpup Wood (<i>Dillenia</i> Sp.) <i>Ismail Budimana*, Renny Purnawati, and Imam Wahyudi</i>	207-214
Antifungal Activities of Some Components of Teak Wood Extractives <i>Ganis Lukmandaru*</i>	215-222
Feasibility Analysis of Composites Industry based on Coconut Coir for Vertical Garden Media <i>Muhamad Gopar*, Kurnia Wiji Prasetyo, Muhammad Adhe Putra</i>	223-228
Composites of Coconut Coir and Betung Bamboo Fiber: The Effect of Mixture Composition and Citric Acid Concentration <i>Kurnia Wiji Prasetyo*, Anisah and Yudha Prasetya</i>	229-235
Functional Stretchable Hydrogels by Combining Cellulose Nanofiber and Polymer <i>Ryosuke Kobe, Kouzou Yoshitani, and Yoshikuni Teramoto*</i>	236-242
Improvement of Thermal Processing and Controlling Orientation for Structural Polysaccharide Nanofiber Incorporated with Flexible Polymer <i>Tetsuya Katsuragawa, Morihiko Yokoi, Ryosuke Kobe, and Yoshikuni Teramoto*</i>	243-250
Anatomical Features and Fiber Characteristics of 2 and 5 Years-old Platignum Teak Wood <i>Danang Sudarwoko Adi*, Yusup Amin, Teguh Darmawan, Dwi Ajias Pramasari, Wahyu Dwianto</i>	251-255
The Substitution Effect of Oil Palm Shell Charcoal, Coconut Fiber and Empty Fruit Bunched Fiber for Physical and Mechanical Properties of Composite for Railway Brake Block <i>Ismail Budiman*, Ismadi, Subyakto, Sasa Sofyan Munawar, Wida Banar Kusumaningrum, Hilman Saeful Alam, Agus Edy Pramono, and Jayadi</i>	256-263
Identification of Actors in Rattan Industry Development in Ambon Island (Case Study in the Village of Suli, District Salahutu, Central Moluccas) <i>Messalina L Salampessy*, Indra G Febriano, Marlina Hutubessy, and Martha Siahaya</i>	264-270

Physical and Mechanical Properties of Bent-Laminated Veneer Lumber <i>Teguh Darmawan*, Danang S. A, Ismadi, Yusup Amin, Sukma S. K, and Wahyu Dwianto</i>	271-276
Wood Materials in Ecology Architecture <i>James Rilatupa</i>	277-280
Termite Biodiversity and Intensity of Residential Houses Deterioration in Taman Darmaga Permai I Ciampea Bogor <i>Arinana*, Noor Farikhah Haneda, Dodi Nandika, Sari Dewi Widi Lestari, Effendi Tri Bahtiar, Idham Sakti Harahap, Aunu Rauf, and I Made Sumertajaya</i>	281-289

A. WOOD PROPERTIES

Selected Properties of Malaysian Bamboo *Schizostachyum grande* (Buluh Semeliang) and *Schizostachyum brachycladum* (Buluh Lemang)

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Abstract

This study gave the results on the fibre morphology, physical and strength properties of *S. grande* and *S. brachycladum*. The results showed that *S. grande* had type III vascular bundle, whilst *S. brachycladum* was type II vascular bundle. The average value for fibre length, width, thickness and fibre lumen diameter for *S. grande* were 2451 µm, 15.1 µm, 6.5 µm and 3.3 µm, respectively. Whereas, the average value of fibre length, width, thickness and fibre lumen diameter for *S. brachycladum* were 2840 µm, 23.7 µm, 9.2 µm and 6.4 µm respectively. The fibre morphology showed decreasing trend from basal towards the top of the culm in *S. grande* and *S. brachycladum*. The moisture content of *S. grande* and *S. brachycladum* was 80 and 93%, respectively and the moisture content significantly decreased towards the top in both species. The average results for density, MOR and MOE of *S. grande* were 633 kg/m³, 189 N/mm² and 21036 N/mm² and *S. brachycladum*'s, results were 589 kg/m³, 262 N/mm², 22922 N/mm², respectively. The top portion of the bamboo culm gave the highest value of density, MOR and MOE whilst the lowest value was at the bottom in both species. There was no significant difference in the longitudinal shrinkage between the two species. However, *S. grande* showed slightly higher value in radial and tangential shrinkage compared to *S. brachycladum*. The shrinkage value decreased from basal to the top of the bamboo culm in both species study.

Keywords: Bamboo culm, Density, Moisture Content, Shrinkage, Strength, Vascular Bundle

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1. Introduction

Bamboo has become an ideal raw material for wood-based industry due to the shortage of raw material supplies. Besides that, it is the most suitable alternative material since bamboo is a fast growing, easy to propagate, widely available and its properties are far superior to most juvenile fast growing timbers (Jayanetti & Follet, 1998). With increasing interest in the usage of bamboo for various products, the basic properties of bamboo, including its anatomical, physical, and strength properties, need to be studied to assess its suitability for various end products and usage. The study on the anatomical properties of bamboo, such as fibre morphology is very important since it has direct relationship with strength, preservative absorption and also it influences the strength properties of paper (Wangard & Woodson 1973;

Razak et al., 2002; Razak et al., 2005). On the other hand, the moisture content, density, and shrinkage are considered to be important factors in determining the suitability of bamboo for various applications and its amenability to chemical treatments (Razak et al., 2010). Besides that, examination on the strength properties of bamboo is also important for the use of suitable bamboo for industrial usage and structural applications (Espiloy, 1987; Bodig & Jayne, 1982; Shahril & Mansur, 2009). Many studies have been carried out on the anatomical, physical, chemical and strength properties of bamboo (Abd Latif et al., 1990; Abd Latif et al., 1993; Anwar et al., 2005; Razak et al., 2010; Shao et al., 2010; Nordahlia et al. 2012).

Malaysia has more than 50 species of bamboo of which only 14 species are known to be commercially utilized (Wong, 1989). *Schizostachyum brachycladum*, locally known as buluh leman, is indigenous to Malaysia and is one of the most popular tropical bamboo species for plantation. Its culms are commonly used for crafting baskets and mats (Wong, 1995; Abd. Razak & Abd Latif, 1995). *S.grande* locally known as buluh semeliang has been commercially used in Malaysia. It is the only species that has internodes length longer than any other commercial Malaysian Bamboo. The culms are commonly used as crafts, sticks and toothpicks and its broad and long leaves are favored for wrapping of some delicacies. Utilization the bamboos have progressed from traditional into advanced products such as laminated bamboo and plybamboo (Azmy et al., 2011). The objective of the present study was to determine the anatomical structure, fibre morphology, physical and strength properties of 4-year old *S.brachycladum* and *S.grande*. The trend differences in the properties along the bamboo culm height were also examined.

2. Materials and Methods

2.1 Field sampling

Three culms each of 4-year old *S. brachycladum* and *S. grande*, were obtained from the Forest Research Institute of Malaysia (FRIM), and used for this study. The 4-year old bamboo was chosen for this study due to the maturity of the culms. Latif et al., (1990) and Sattar et al., (1992) illustrated that the bamboo culm starts maturing at the age of three years. The culm age was determined from the tag placed earlier during the shoot's sprouting stage. The bamboo culms were cut at about 20 cm above ground level. Each culm was then cut to a length of 12 m and was later subdivided into three equal lengths corresponding to the basal, middle and top portion at of 4 m each. For the assessment of the physical properties, MOR and MOE were evaluated using samples in the form of splits and tested at 12 % moisture content. A split refers to bamboo samples with intact periphery and inner skin.

2.2 Determination of the anatomical structure and fibre morphology

The anatomical structure determination was carried out according to the methods outlined by Latif & Tamizi (1992), and Tamizi (2009). Bamboo sample blocks were cut into sections of 10 mm x 10 mm x culm wall thickness and boiled with distilled water until the bamboo samples had softened. Then, 25-µm thick sections were cut in a sledge microtome. Each section was stained with aqueous safranin-O. These sections were washed with 50% ethanol and dehydrated using a series of alcohol solutions having the concentrations of 70, 80, 90, and 95% followed by three rinses using absolute ethanol. After that, the sections were washed with xylen

for two minutes. Then, one drop of Canada Balsam was placed on top of the section and covered with cover slip. The slides were dried in an oven at 60 °C for a few days.

Maceration technique was used to determine the fibre morphology. Bamboo splits of 20 mm x 10 mm x culm wall thickness were chipped into match stick size slivers. The slivers were macerated using a mixture of 30% hydrogen peroxide:glacial acetic acid ratio (1:1) at 45 °C (Abasolo et al., 2005) for 2 to 3 hours until all the lignin dissolved and the cellulose fibres appear whitish (Catling & Grayson, 1982). The macerating solution was then carefully washed in distilled water until all traces of the acid disappeared. The vials were then gently agitated to ensure sufficient separation of cellulose fibres (Dinwoodie, 1974). The vials were then half-filled with distilled water and capped securely. Prior to measurement, macerated fibres were spread out on a glass slide and drops of safranin-O were applied and a cover slip was placed.

Quantitative measurement of fibre length, diameter, thickness, lumen diameter and anatomical structure observation were obtained using an optical microscope (Olympus). Magnifications of 40x were used for fibre length and 400x for fibre diameter and lumen diameter. The fibre wall thickness was obtained by subtracting the value of lumen diameter from fibre diameter and dividing by two. A total of 60 unbroken fibres were measured and averaged for analysis. The vascular bundle type classification was as described by Liese (1998).

2.3 Determination of the physical properties, MOR and MOE

Physical properties were tested using the Indian Standards (Anonymous, 1976). Samples size of 20 mm x 20 mm x culm wall thickness were obtained from the basal portion, middle portion and top portion, for analyses of moisture content, density and shrinkage from green to oven-dry. A total of 90 specimens were used in the study.

The moisture content was determined by green to oven-dry weight method using equation (1):

$$MC (\%) = \left(\frac{W_i - W_o}{W_o} \right) \times 100 \quad (1)$$

Where W_i = initial weight of sample, g; W_o = oven-dry weight of sample, g

Basic density was determined on the basis of the oven-dry weight to green volume basis. The green volume of each block was obtained using the water displacement method. The sample blocks were oven dried for 48 hours at 103 ± 2 °C until constant weights were attained. Then, the samples were cooled in a desiccators and oven-dry weight were obtained. The basic density was calculated using the following equation (2):

$$\text{Density (kg/m}^3\text{)} = \frac{W_o}{V_g} \quad (2)$$

Where W_o = oven-dry weight (kg) V_g = green volume, (m³)

The radial, longitudinal, tangential sections of each sample were marked and measured with digital veneer calipers to the nearest 0.01 mm. All samples were placed in an oven maintained at 103 ± 2 °C for 48 hours and shrinkage of samples was obtained at green and after it was oven-dried. The shrinkage percentage was calculated using the equation (3):

$$S_o(\%) = \left(\frac{D_i - D_o}{D_i} \right) \times 100 \quad (3)$$

Where S_o = shrinkage from green to oven-dry conditions; D_i = initial dimension (mm) and D_o = oven-dry dimension (mm).

For MOR and MOE the split samples were air-dried under the shade for about a month and then conditioned for two weeks in a conditioning room at 65% relative humidity and 20°C. Then, samples of 300 mm by 20 mm were cut. This material was obtained from the basal, middle, and top portions of the bamboo culms. A total of 60 specimens were used for this study. The samples were tested in accordance to the procedure described by Gnanaharan et al. (1994) and the Indian Standard Methods of Test for Split Bamboos (IS 8242:76, Anonymous, 1976). Statistical analysis was carried out using SAS version 9.1.3.

3. Results and Discussion

3.1 Anatomical structure and fibre morphology

The anatomical structure shows that *S. brachycladum* have the type II vascular bundle with the enlarged fibre sheath at the phloem side. Whilst *S. grande* has type III vascular bundle with one isolated fibre bundle (Figure 1).

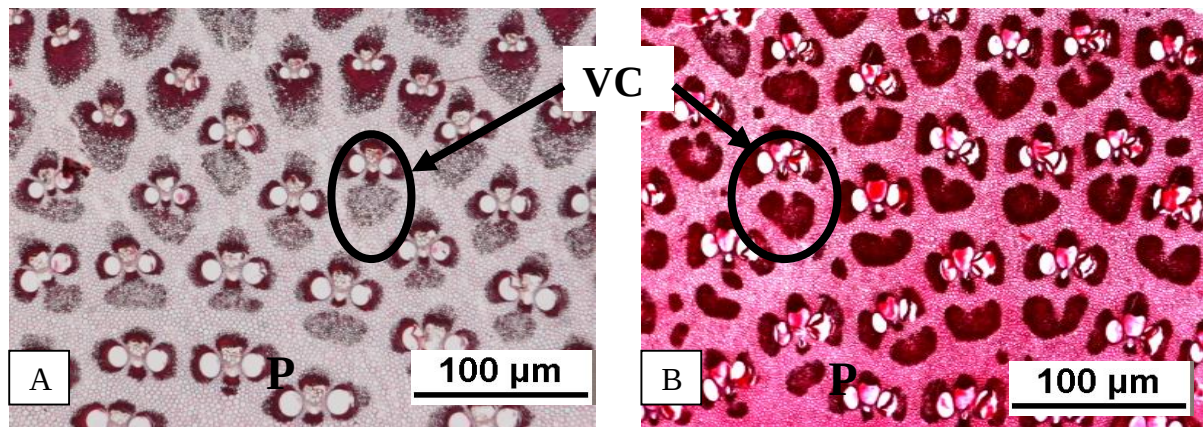


Fig. 1. (A) *S. brachycladum* with type II vascular bundle (B) *S. grande* with type III vascular bundle. Note: VC=Vascular bundle, P=Parenchyma

Table 1 presents the fibre morphology of the bamboo along the culm height and also the mean value of these properties between *S. brachycladum* and *S. grande*. The fibre length, width, thickness, and lumen diameter for both species decreased significantly at ($P \leq 0.05$) from the basal to the top of the culm. According to Liese (1998), the fibres diameter are generally bigger in the basal portion than in the middle and top portion of the bamboo culm. The mean values

of fiber length, width, thickness, and lumen diameter are significantly difference ($p \leq 0.05$) between the two species study. The results show that *S. brachycladum* have the higher value of fibre morphology as compared to *S. grande*.

Table 1. Fibre morphology of *S.brachycladum* and *S.grande* at three different portions

Positions	Fibre morphology							
	Fibre length (μm)		Fibre diameter (μm)		Lumen diameter (μm)		Cell wall thickness (μm)	
	B	G	B	G	B	G	B	G
Basal	3195 ^a (556.9)	2849 ^a (545.6)	25.6 ^a (3.67)	16.0 ^a (4.38)	6.4 ^a (4.53)	3.3 ^a (2.13)	10.1 ^a (2.65)	7.0 ^a (2.23)
Middle	2758 ^b (467.9)	2262 ^b (454.3)	22.9 ^b (2.68)	14.8 ^b (3.13)	6.9 ^a (4.53)	3.3 ^a (1.92)	9.0 ^b (2.36)	6.2 ^b (2.86)
Top	2566 ^c (493.6)	2242 ^b (376.1)	22.7 ^b (4.05)	14.5 ^b (3.57)	5.9 ^a (4.23)	3.2 ^a (1.59)	8.4 ^c (2.13)	6.1 ^b (2.56)
Mean	2840	2451	23.7	15.1	6.4	3.3	9.2	6.5

Values in parentheses are standard deviations. Cell values differing by a letter in the superscript in each column are significantly different at the 0.05 probability level. Note:

B = *S.brachycladum*, G = *S.grande*

3.2 Physical properties, MOR and MOE

The trend along the culm height and the mean value between the two species of *Schizostachyum* for physical properties, MOR and MOE are shown in Table 2. The results present that the moisture content (MC) trend between the three portions are the same in both species where the MC decreases from the basal to the top portion. According to Latif & Zin (1992), this is related to the decrease in culm wall thickness from the basal to the top of the bamboo culm. However, density increased towards the top of bamboo culm in both species studied. This result may be associated with the higher value of vascular bundles, in the same direction (Liese, 1987; Abd Latif & Mohd Tamizi, 1992). Besides, according to Correal et al., (2010) a high amount of schlerenchyma fibers at the top portion can also contribute to the high density at the top of the bamboo culm. Table 2 illustrates that the density of *S. brachycladum* is significantly lower compared to *S. grande* (Correal et al. 2010).

It can be seen that shrinkage value decreases from basal to the top of the bamboo culm in *S. brachycladum* and *S. grande*. According to Liese (1998), the basal portion shrinks more than the other bamboo culm portions probably due to the presence of higher initial moisture content and to the lower number of vascular bundles in this portion. *S.grande* shows slightly higher radial and tangential shrinkage compared to *S. brachycladum* as shown in Table 2 (Correal et al. 2010).

As regards to MOR and MOE, it shows an increasing trend from basal to the top of the bamboo culms. The tendency of increase in both properties is probably due to the higher amounts of vascular bundles present with height. Besides that, the high mean density at the top portion might also influence the increase in MOR and MOE. The mean values of MOR and MOE are higher in *S. brachycladum* compared to *S. grande*. This may be due to the longer and thicker fibre wall found in *S. brachycladum* that contributed to the higher value of MOR and MOE in this species.

Table 2. Physical and strength properties of *S.brachycladum* and *S.grande* at three height level

	Positions				Shrinkage from green to oven dry (%)						Modulus of rupture (N/mm ²)		Modulus of elasticity (N/mm ²)	
	Density (kg/m ³)		Moisture content (%)		Radial		Longitudinal		Tangential					
	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Basal	550 ^b (82.69)	533 ^c (72.56)	106 ^a (18.37)	106 ^a (12.67)	10.76 ^a (0.84)	13.1 ^a (2.91)	13.1 ^a (0.35)	0.70 ^a (0.19)	8.13 ^a (0.84)	10.4 ^a (1.12)	208 ^b (20.40)	157 ^b (21.59)	20550 ^c (2387)	14655 ^c (1139)
Middle	597 ^a (80.81)	638 ^b (85.07)	89 ^b (15.59)	74 ^b (14.80)	7.43 ^b (1.43)	6.6 ^b (2.42)	6.6 ^b (0.24)	0.50 ^b (0.19)	5.49 ^b (1.43)	6.8 ^b (1.23)	217 ^b (26.80)	175 ^b (24.73)	22665 ^b (1415)	22401 ^b (1789)
Top	619 ^a (75.09)	728 ^a (85.07)	84 ^b (10.54)	57 ^c (15.5)	6.31 ^c (1.62)	6.5 ^b (1.34)	6.5 ^b (0.19)	0.50 ^b (0.20)	3.73 ^c (1.62)	6.4 ^b (1.12)	362 ^a (33.78)	222 ^a (30.27)	25550 ^a (2291)	26051 ^a (2573)
Mean	589	633	93	80	8.17	8.81	0.52	0.51	5.78	7.81	262	189	22922	21036

Values in parentheses are standard deviations. Cell values differing by a letter in the superscript in each column are significantly different at the 0.05 probability level. Note: B = *S.brachycladum*, G = *S.grande*

4. Conclusion

S. brachycladum has higher value in fibre morphology, MOR and MOE whilst *S. grande* has higher value in density, radial and tangential shrinkage. Both species has potential to be converted into commercial products such as bamboo furniture and plybamboo. However, further research is need to be carried out to explore more potential usage and suitable product from these two species.

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Anatomical Properties and Density of 8 and 15-year-old *Khaya ivorensis*

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Abstract

Three trees of 8 and 15-year old *Khaya ivorensis* from the Forest Research Institute Malaysia were each extracted. A study on the anatomical properties and density of these trees was made to document the progress of its properties. Besides that, the trend of anatomical properties and density based on the tree height were also observed. The result showed that 15-year-old *K. ivorensis* wood had significantly longer and larger fibre, lumen and vessel diameter and also thicker cell wall compared to that of 8-year-old *K. ivorensis*. Subsequently, density of 15-year-old *K. ivorensis* is 554 kg/m³ which was significantly higher than 8-year-old (464 kg/m³) decreased significantly with height, while vessel density increased from the bottom towards the top of the tree in both age groups. Microscopic observation of *K. ivorensis* showed that growth ring boundaries indistinct or absent, wood diffuse porous, simple perforation plates, intervessel pits alternate, shape of alternate pits polygonal, intervessel pits minute, gums present in heartwood vessels, axial parenchyma scanty paratracheal, axial parenchyma vasicentric, rays of 4-10 seriate, fibres with simple to minutely bordered pits, non-septate, body ray cells heterocellular and prismatic crystal present in upright/square ray cells. From the result, it shows that *K. ivorensis* could be a promising plantation trees since 15-year-old of age because it showed comparable density and anatomical properties as the mature of *K. ivorensis*. In other hand, the *K. ivorensis* is a fast growth species with a light pinkish brown to reddish brown wood appearance making the wood is suitable for high end products.

Keywords: Fibre, Mature tree, Microscopic, Products, Properties

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1. Introduction

In Malaysia, to relieve the pressure from over harvesting the natural forest as well as to supplement the future wood supply of the country, forests plantations which are capable of yielding high volumes of timber per unit area and with shorter rotations are being established. The need for the development of forest plantations has long been recognised as an important step towards ensuring sustainable supply of timber from the natural forest (Thai, 2000). In 1992, the Forest Research Institute Malaysia (FRIM) organised an important conference on forest plantations whereby a comprehensive forest plantation research programme was formulated (Abdul Rasip et al., 2004). Species for forest plantation were selected based on their growth performance, availability of seeds or planting materials, ability to grow under plantation

conditions, resistance to pests and diseases, and most importantly, their market potential as well (Ahmad Zuhaidi et al., 2002).

Khaya ivorensis is one of the species that has been promoted as a plantation tree in Malaysia since it was the fast growing trees. *K. ivorensis* is an exotic species to Malaysia being first introduced during the late 1950s and early 1960s (Lok & Ong, 2002). This species belong to the family Meliaceae which similar family with many other valuable timber trees such as *Toona* spp., *Azadirachta excelsa*, *Chukrasia tabularis*, *Swietenia macrophylla*, *Cedrela odorata* and *Chloroxylon* (Mabberly & Pannel, 1989). According to Lok & Ong (2002), *K. ivorensis* was brought to Malaysia to evaluate its potential and suitability as a species for future large-scale plantation forests. This species is suitable for high quality cabinet which is comparable to Honduras mahogany (*Swietenia macrophylla*). The purpose of the study is to examine anatomical properties and density of *Khaya ivorensis*. Generally, anatomical properties such as fibre morphology, vessel characteristics and rays have been widely used as indicators of wood quality (Bowyer et al., 2003). On the other hand, the study of density is also very important since this property is one of the most important considerations when using wood as a material (Baker, 1967; Monteoliva et al., 2005). This is because density is associated with cell dimensions, strength, stiffness, drying and machining as well as various papermaking properties (Donaldson et al., 1995; Igartua et al., 2003).

2. Materials and Methods

2.1 Field Sampling

Three trees of 8 and 15-year old *K. ivorensis* from the Forest Research Institute Malaysia were each extracted. Trees were felled at 15 cm above the ground. Discs of 3 cm thickness were cut from each tree in three portions: bottom, middle, and top. The discs were used for anatomical and density study.

2.2 Anatomical properties determination

Anatomical properties study of *K. ivorensis* was conducted along the tree height (bottom, middle and top). The anatomical properties were determined from microslides. Wood blocks from sapwood and heartwood portion with dimensions of 10 x 10 x 15 mm were used for slide preparation. Slides were prepared from thin sections cut in transverse, tangential and radial directions. Sections were stained with 1% safranin in 50% ethyl alcohol and mounted for permanent slides with Canada balsam. Wood blocks for maceration were split into small matchstick size pieces. The sticks were macerated using mixture of 30% hydrogen peroxide: glacial acetic acid at a ratio of 1:1 at 45 °C. Macerated fibres were thoroughly mixed and spread onto a glass slide. Microscopic observations of the wood structure and quantitative measurement of fibre length, fibre diameter, fibre lumen diameter, fibre wall thickness, vessel diameter, vessel density, ray height and ray width were taken from the slides using light microscopy. A total of 60 measurements were taken.

2.3 Physical properties determination

For density determination, samples of size 20 (radial) x 20 (longitudinal) x 40 (tangential) mm were used. Test samples were cut in accordance to British Standard 373:1957 Methods of Testing Small Clear Specimen of Timber (BS 373, 1957). Density was determined on the basis

of oven-dry weight and green volume. The basic density was calculated using the following equation:

$$\text{Density (kg/m}^3\text{)} = \frac{W_o}{V_g} \quad (1)$$

Where W_o = oven-dry weight (kg) V_g = green volume, (m³)

3. Result and Discussion

3.1 Anatomical properties

3.1.1 Wood anatomical structure

Growth ring boundaries indistinct or absent. Wood is characterized with diffuse porous, simple perforation plates, intervessel pits alternate, shape of alternate pits polygonal. Intervessel pits minute. Mean tangential diameter of vessel 180µm (range 145-215 µm). Average of 5 vessel per mm² (range 5-6). Gums present in heartwood vessels. Axial parenchyma scanty paratracheal, and axial parenchyma vasicentric. Rays are 4-10 seriate. Fibres with simple to minutely bordered pits. Fibres are non-septate with body ray cells are heterocellular. Prismatic crystal presents in upright/square ray cells (Figure 1).

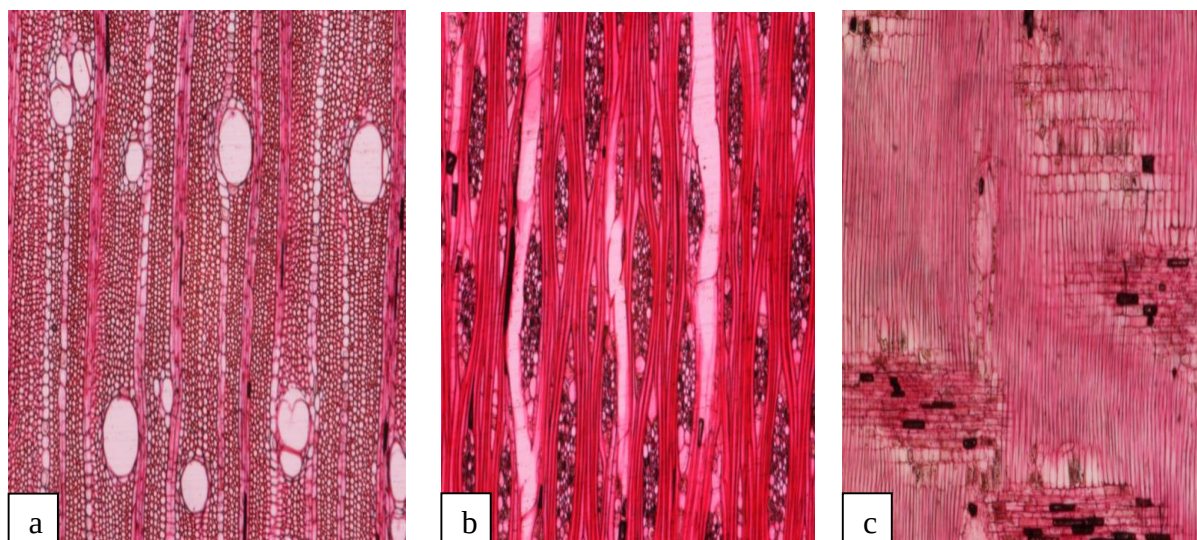


Figure 1. (a) transverse section (b) tangential section (c) radial section

3.1.2 Fibre morphology, vessel diameter, vessel density, ray height and ray width

Table 1 shows the anatomical properties result of 8 and 15-year-old *K. ivorensis*. From the result it shows that the average for fibre length, fibre diameter, fibre lumen diameter, fibre wall thickness, vessel diameter and ray height were higher in the 15-year-old as compared to that of the 8-year-old *K. ivorensis*. On the other hand, the anatomical properties of 15-year-old were comparable with the 30 year old mature wood of *K. ivorensis*.

Table 1. Anatomical properties of 8 and 15-year-old *K. ivorensis* and the comparison with the mature tree.

Age of <i>K. ivorensis</i>	Fibre Length (µm)	Fibre Diameter (µm)	Fibre Lumen Diameter (µm)	Fibre Wall Thickness (µm)	Vessel Diameter (µm)	Vessel Frequency (mm ²)	Ray Height (µm)	Ray width
8-year-old	1028 ^b (189)	19.9 ^b (4.2)	13.8 ^b (4.1)	3.0 ^b (0.82)	114 ^b (21.7)	14 ^a (3.90)	452 ^b (99)	4.0 ^b (1.14)
15-year-old	1300 ^a (98)	25 ^a (5.2)	16.0 ^a (2.8)	4.1 ^a (0.55)	126 ^a (15.5)	10 ^b (4.0)	515 ^a (88)	5.0 ^a (0.81)
Mature tree*	1400	23	17.4	4.6	180	6	650	7.0

*Source: Lok & Ong, 2002

Values in parentheses are standard deviations. Cell values differing by a letter in the superscript in each column are significantly different at the 0.05 probability level.

The variation along the tree height of fibre length, fibre diameter, fibre lumen diameter, fibre wall thickness, vessel diameter, vessel density, ray height and ray width were illustrated in Figure 2 to 9 respectively. From the graphs it can be seen that all the anatomical properties showed decreased trend from bottom towards the top of the tree excluding the vessel density which the trend is increased upwards.

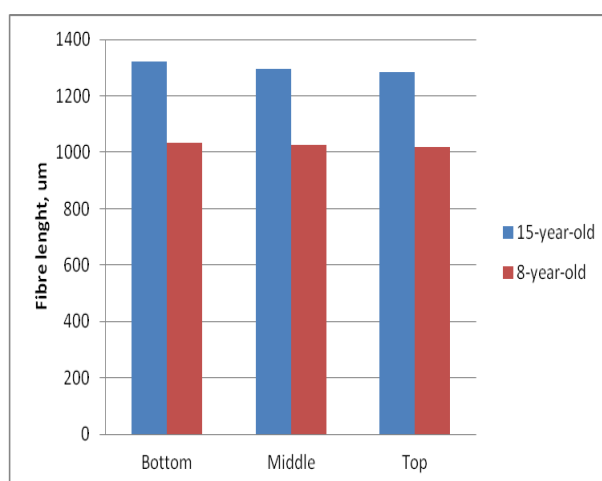


Figure 2. Fibre length along the tree height.

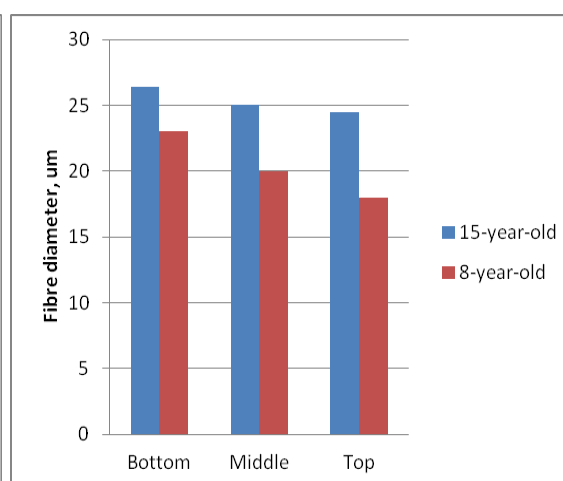


Figure 3. Fibre diameter along the tree height

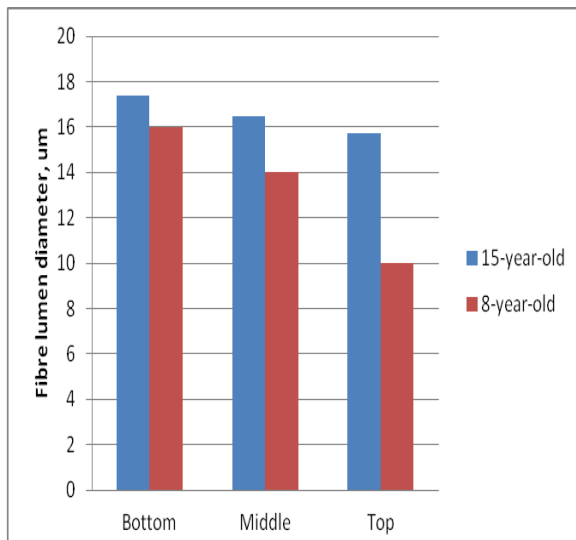


Figure 4. Fibre lumen diameter along the tree height

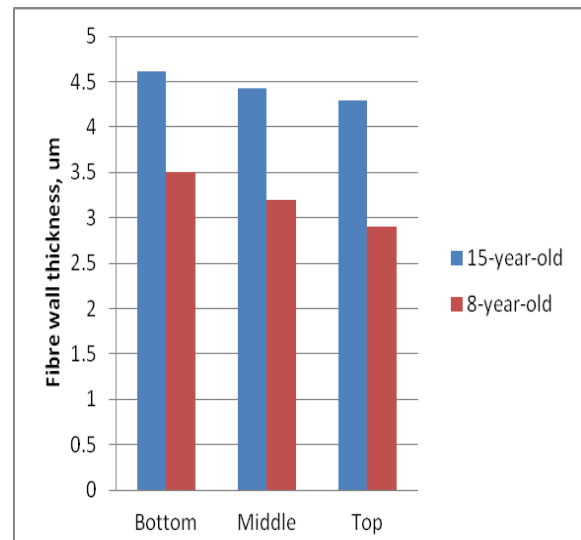


Figure 5. Fibre wall thickness along the tree height

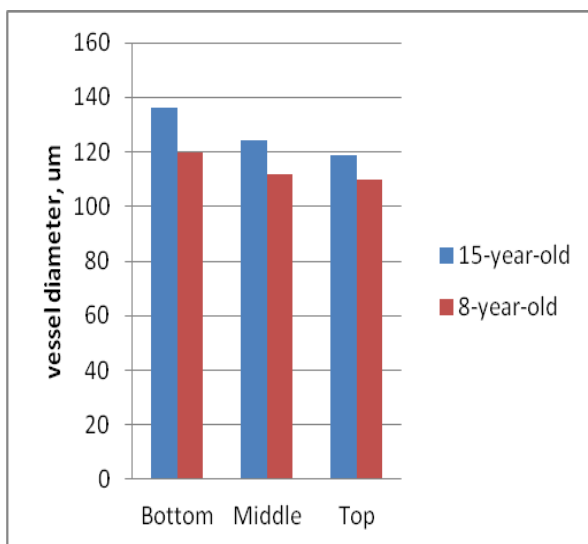


Figure 6. Vessel diameter along the tree height.

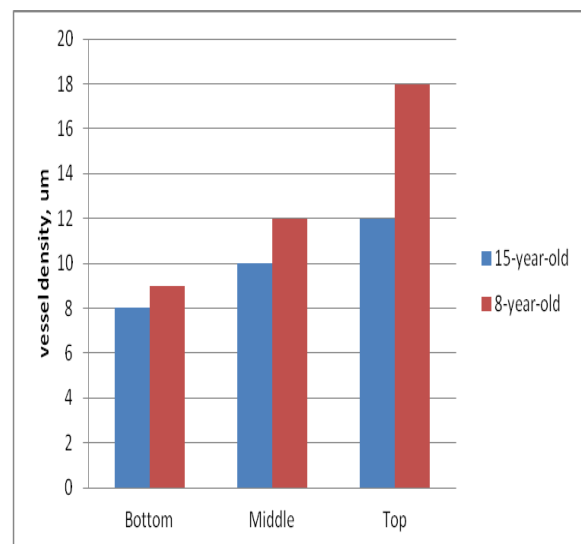
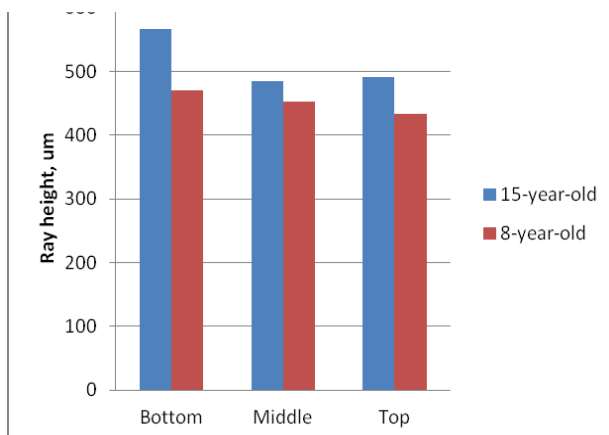


Figure 7. Vessel density along the tree height.

Figure 8. Ray height along the tree height.

Figure 9. Ray width along the tree height.



3.2 D Figure 8. Ray height along the tree height.

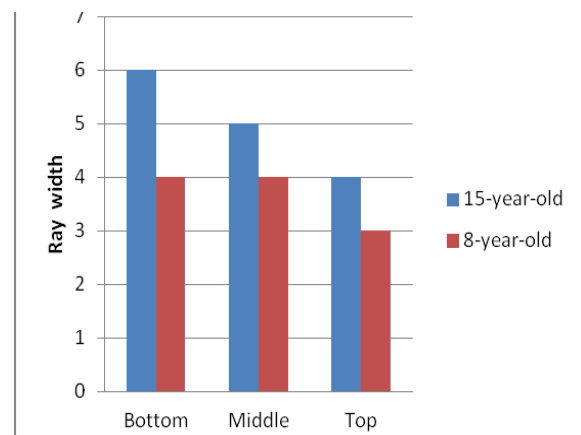


Figure 9. Ray width along the tree height.

Density of 15-year-old *K. ivorensis* is 508 – 600 kg/m³ with an average of 534 kg/m³. This result is comparable with the mature *K. ivorensis* wood which the density is ranges from 580 to 690 kg/m³ (Lok & Ong, 2002). Whilst the density of 8-year-old *K. ivorensis* is 416-512 kg/m³ with an average of 464 kg/m³. The density of both ages of *K. ivorensis* is decreased from bottom towards the top of the tree (Figure 10). As for this present study, thick fibre walls in the bottom portions of both ages of the wood might contribute to the highest density at the bottom. The finding is in good agreement with Bosman (1997), where a strong correlation was observed between fibre wall thickness and density in 6-year-old *Shorea* spp. In addition, the higher basic density could also be due to the longer fibre length at the bottom in both ages of wood. As stated by Butterfield et al. (1993) in diffuse-porous hardwoods an increase in specific gravity or density is related to fibre characteristics.

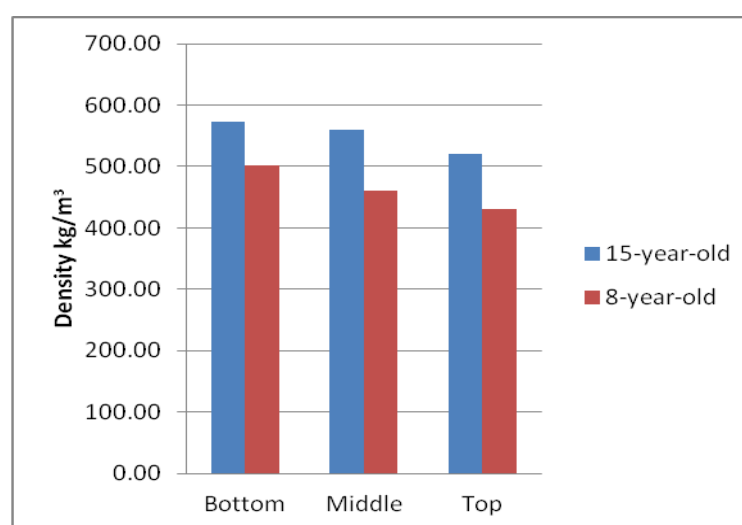


Figure 10. Density along the tree height.

4. Conclusion

K. ivorensis could be a promising plantation trees since 15-year-old of age because of the comparable density and anatomical properties as the mature of *K. ivorensis*. In addition, the *K. ivorensis* is a fast growth species with a light pinkish brown to reddish brown wood appearance making the wood is suitable for high end products.

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Variation of Anatomical Features between Two Acacia Hybrids (*Acacia mangium* x *auriculiformis*) and (*Acacia auriculiformis* x *mangium*) from Wonogiri

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Abstract

Research objectives of this study were to find out variation anatomical features between 2 species *Acacia hybrid*, which planted in trial forest, Ketu, Wonogiri, and to investigate tissue proportions and fiber dimensions. Anatomical features was observed using hand lens and microscope. Both tissue proportion (percentage of fiber, axial parenchyma, rays, vessel) and fiber dimension (fiber diameter, fiber length, cell wall thickness) were investigated under microscope fluorescence. Result showed that macroscopically, mangium hybrid (*mangium* x *auriculiformis*) showed bigger heartwood and more tight sapwood (3-4cm) while auri hybrid (*auriculiformis* x *mangium*) showed lower heartwood and wider sapwood (5-6cm). Mangium hybrid also more porous than auri hybrid based on vessel diameter. Vessel diameter of mangium hybrid were 130-200µ whereas auri hybrid only 113-120µ. Texture was fine to medium coarse. Grain was straight or shalowly interlocked. Microscopically, auri hybrid have higher fiber percentage compared to mangium hybrid. Mangium hybrid also higher wood density based on cell wall thikness. Cell wall thicknes mangium hybrid were 4.46µ whereas auri hybrid only 1.80µ. Two species Acacia hybrid have significant influence on almost all tissue proportions except rays proportion. Fiber dimensions of 2 species Acacia hybrid also affected significantly in cell diameter and wall thickness except fiber length. Based on higher fiber proportion and thinner cell wall tickness, auri hybrid was better wood quality for pulp and paper products compared to mangium hybrid

Keywords: Acacia hybrid, Anatomical features, Fiber dimensions, Tissue proportions

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1. Introduction

Hybrids between *Acacia auriculiformis* and *Acacia mangium* are considered as important fast-growing species for plantations in many tropical countries, due to their rapid growth. Acacia hybrid has a straight trunk and faster growth than the parent (Kim et al, 2009). Crossing the two species of acacia is expected to acquire good quality wood properties and better growth

than its parent. Wong et al (2012) said that the hybrid between *Acacia auriculiformis* x *Acacia mangium* as an important trees for wood pulp production in Southeast Asia.

Differences wood properties in radial direction were influenced between juvenile wood and mature wood. Juvenile wood differs from mature wood in several wood properties. Compared to mature wood, it is characterized by wide rings, short fiber, small diameter, low vessel percentage, wide microfibrillar angle (Bath 2001). Radial variations from pith to bark were investigated to clarify the effect of juvenile wood and mature wood. The aims of this study were to find out the anatomical features of 2 species *Acacia* hybrid namely Mangium hybrid (*mangium* x *auriculiformis*) and Auri hybrid (*auriculiformis* x *mangium*), were planted in trial forest Ketu, Wonogiri and also to determine variations of wood properties in the radial direction .

2. Materials and Method

Wood samples for this study were collected from 4 years age *Acacia* hybrid, which planted in trial forest, Ketu, Wonogiri, Central Java. Three healthy trees of Mangium hybrid (*mangium* x *auriculiformis*) wood and three healthy trees of Auri hybrid (*auriculiformis* x *mangium*) wood were selected and harvested for the observation. They have average diameter at breast height (Dbh) of 15cm-17cm.

A disk were cut at the bottom and divided radially to obtain small block of 1cm thick, from pith to bark. All the small blocks were cut to matching sampel length for cell proportion and fiber dimension. Samples preparation for fiber dimension used maceration process by mixtured hydrogen peroxide (H₂O₂) and glacial acetic acid. Transverse section of each small block was cut on a sliding microtome for cell proportion samples. Observation macroscopic features using hand lens 15-18x magnified. Observation cell proportion and fiber dimension under fluorescence microscope BX51. Measurement cell proportion and fiber dimension were using video image analyzer (*software image pro plus*)

3. Result and Discussion

3.1. Anatomical features of 2 species *Acacia* hybrids

Macroscopic features of auri hybrids (*auriculiformis* x *mangium*) has sapwood color of pale yellowish white, with wide about 5-6 cm. The heartwood colour pale brown, yellowish brown. Growth ring was not distinguished. Vessel distribution is solitary and radial multiple 2-3. Texture medium to rather fine. Grain orientation usually straight some times shallowly interlocked. Macroscopic features of mangium hybrids (*mangium* x *auriculiformis*) has sapwood colour pale yellowish white, pale yellow, usually about 3-4cm wide. The heartwood colour pale pinkish brown, dark brown or reddish brown. Growth ring was not distinguished. Grain orientation usually straight some times shallowly interlocked. Texture medium coarse to rather coarse. Figure 1 showed that auri hybrid have bigger percentage of sapwood compared to mangium hybrid.

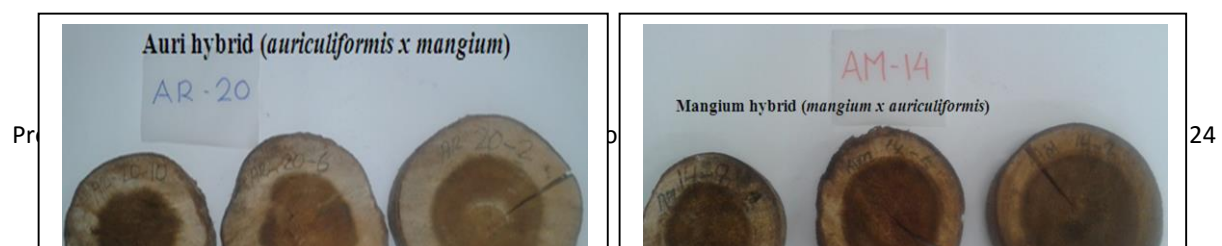


Figure 1. Macroscopic transverse section both Auri hybrids and Mangium hybrids

Microscopic features of Auri hybrids (*auriculiformis* x *mangium*) as follow vessel frequency 4-7/mm² usually 5/mm². Maximum tangential diameter of solitary vessel was 120µ, minimum tangential diameter 113µ. Rays were only 1 size, which were multi seriate with range 1-3 seriate mostly 1-2 seriate according to specimen. Axial parenchyma was usually scanty paratracheal or vasisentric surrounding vessel. Microscopic features of mangium hybrids (*mangium* x *auriculiformis*) were vessel distribution solitary and radial multiple 2-3. Average tangential diameter vessel was 180µ. Maximum tangential diameter of solitary vessel was 200µ, minimum tangential diameter was 130µ. Rays were only 1 size,, which were multi seriate mostly 1-2, sometimes 1-3 seriate according to specimen. Axial parenchyma not abundant, usually scanty paratracheal and some vasisentric, visible as narrow surrounding vessel. (Fig.2)

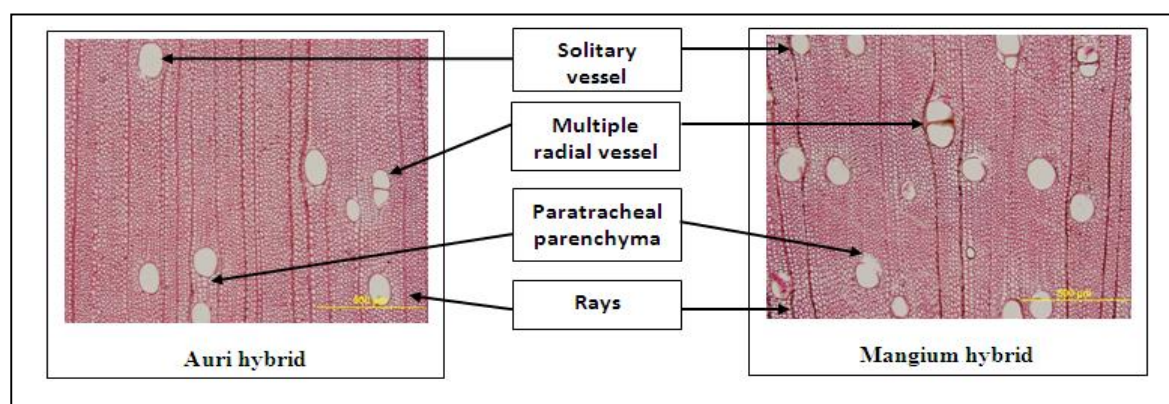


Figure 2. Microscopic transverse section both auri hybrid and mangium hybrid

3.2. Cell Proportion 2 species acacia hybrid

Leguminosae are large family comprising 670 genera and 12.000 woody species of cosmopolitan distribution (Ogata et al, 2008). Acacia hybrid both mangium hybrid (*mangium* x *auriculiformis*) and auri hybrid (*auriculiformis* x *mangium*) belong to leguminosae family. Proportion of various tissue of 2 species acacia hybrid at radial direction are presented in Table 1. Whilst variance analysis of cell proportion of 2 are presented in Table 2.

Table 1. Cell proportion 2 species hybrid at radial direction

Species Hybrid	Cells Proportion	Radial position from pith to bark (cm)						Average
		1	2	3	4	5	6	
Mangium Hybrid	Fibre (%)	64.18	70	64.33	68.43	61.47	65	65.57
	Vessel (%)	10.34	8.25	11.85	9.45	13.37	13.58	11.14
	Parenchyma (%)	17.57	12.84	14.11	13.94	17.81	14.87	15.19
	Rays (%)	7.92	8.92	9.71	8.17	7.35	6.55	8.10
Auri Hybrid	Fibre (%)	75.05	71.06	79.25	75.19	74.4	77.34	75.38
	Vessel (%)	7.97	7.84	6.67	7.96	8.55	9.16	8.03
	Parenchyma (%)	8.26	12.3	7.66	9.44	9.19	7.33	9.03
	Rays (%)	9.21	11.02	8.03	8.27	9.52	7.34	8.90

Table 2. ANOVA of cell proportion of the 2 hybrid

Cell proportion	F Value		Sig	
	Species hybrid	Radial	Species hybrid	Radial
Fibre	42.379**	0.654 ^{ns}	0.000	0.661
Vessel	26.286**	3.082*	0.000	0.027
Parenchyma	32.172**	0.621 ^{ns}	0.000	0.685
Rays	0.781 ^{ns}	0.787 ^{ns}	0.385	0.569

Note : ** : significant difference at $\alpha=0.01$; * : significant difference at $\alpha=0.05$; ns : not significant

Variance analysis showed in Table 2 indicate that fiber proportion between mangium hybrid and auri hybrid were significantly different at $\alpha=0.01$, where auri hybrid have a greater fibers proportion than mangium hybrid. The parent *Acacia mangium* generally have a greater proportion of fibers than *Acacia auriculiformis*, as presented by Rao et. al (2011) . Figure 3 showed that auri hybrid has the lowest fiber proportion (71.06%) at 2 cm from pith and the highest one (79.25%) at 3 cm from pith. Mangium hybrid has the lowest fiber proportion 61.47% at 5 cm from pith and the highest 70% at 2 cm from pith. Differences in the fiber proportion 2 species hybrid is related to both parents. Chowdhury et al (2013) reported that the proportion of fibers in *Acacia auriculiformis* the lowest 54 % and the highest 69 % with an average 63%.

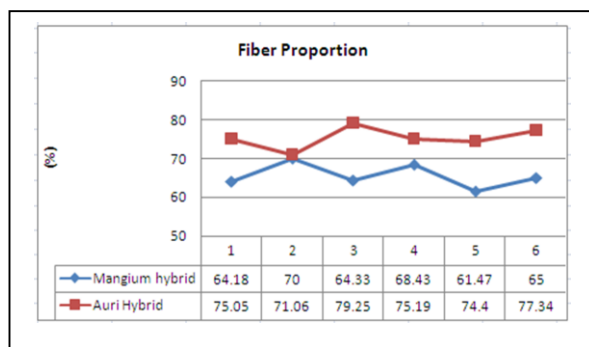


Figure 3. Graph of fiber proportion on radial direction

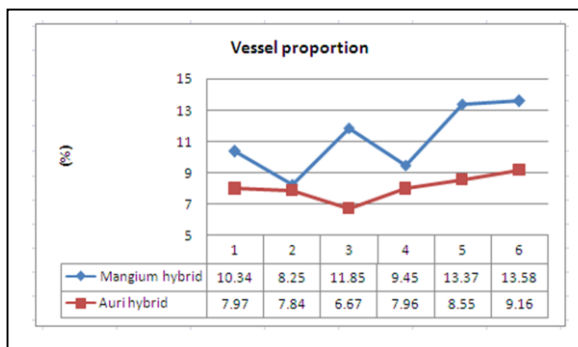


Figure 4. Graph of vessel proportion on radial direction

Variance analysis in Table 2 showed that the vessel proportion between mangium hybrid with auri hybrid has a significant difference, where auri hybrid has a lower vessel proportion than mangium hybrid. Average vessel proportion auri hybrid was about 8.03%, whereas mangium hybrid was about 11.14%. Differences on the vessel proportion in 2 species hybrid is related to fiber proportion. Auri hybrid has greater fiber proportion than mangium hybrid, and generally will reduce others tissue proportion as showed in Figure 5.

Figure 4 showed that auri hybrid has the lowest vessel proportion 6.67% at 3cm from pith and the highest 9.16% at 6 cm from pith. Mangium hybrid have lowest vessel proportion 8.25% at 2 cm from pith and highest 13.58% at 6 cm from pith. Chowdhury et al (2013) reported that the lowest vessel proportion of *Acacia auriculiformis* about 7 % and the highest 20 % with an average value of 13%. Variance analysis in Table 2 showed that radial direction affected significantly in vessel proportion. The graph vessel propotion in radial position increased from pith to bark for both mangium hybrid and auri hybrid (Fig.4). Rao *et al* (2011) said that vessel percentage were different at a radial direction both *Acacia mangium* and *Acacia auriculiformis*

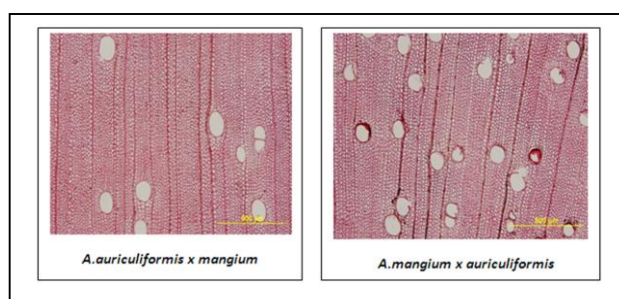


Figure 5. Tissue proportion of mangium hybrid and auri hybrid

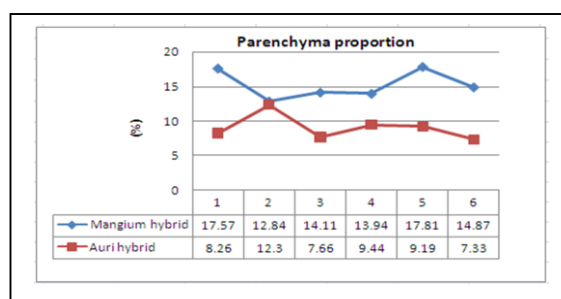


Figure 6. Graph of parenchyma proportion on radial direction

Variance analysis presented in Table 2 also indicate that the parenchyma proportion between mangium hybrid with auri hybrid has a significant difference. Mangium hybrid has parenchyma proportion about 15.19% whereas auri hybrid only about 9.03%. Figure 6 showed that auri hybrid has the lowest parenchyma proportion (7.66%) at 3 cm from pith and the highest one (12.13%) at 2 cm from pith. Mangium hybrid has lowest parenchyma proportion 12.84% at 2 cm from pith and the highest 17.81% at 5 cm from pith. *Acacia auriculiformis* generally have a higher parenchyma proportion than *Acacia mangium*. Rao *et al* (2011)

reported that minimum percentage of parenchyma founded in *Acacia mangium* 8.60% while maximum about 11.68% founded in *Acacia auriculiformis*.

3.3. Fiber Dimension 2 species acacia hybrids

Fiber dimension of 2 species acacia hybrid at radial direction are presented in Table 3. Variance analysis of fiber dimension are presented in Table 4.

Table 3. Fiber dimension 2 species acacia hybrids at radial direction

Species Hybrid	Fiber dimension	Radial position from pith to bark (cm)						Average
		1	2	3	4	5	6	
Mangium Hybrid	Fibres length (mm)	0.66	0.75	0.88	0.93	0.95	1.03	0.87
	Cells Diameter (μ)	23.39	23.76	23.96	25.04	19.37	22.57	23.02
	Wall Thickness (μ)	4.56	3.86	4.17	4.76	4.22	5.16	4.46
Auri Hybrid	Fibres length (mm)	0.779	0.807	0.908	0.968	0.977	1.04	0.91
	Cells Diameter (μ)	17.12	15.17	15.51	17.81	15.83	15.46	16.15
	Wall Thickness (μ)	1.84	1.69	1.77	1.83	1.69	1.98	1.80

Table 4. ANOVA of fiber dimension 2 species acacia hybrids at radial direction

Fiber dimension	F Value		Sig	
	Species hybrid	Radial	Species hybrid	Radial
Fibres length	3.790 ^{ns}	20.144 ^{**}	0.063	0.000
Cells diameter	107.168 ^{**}	2.470 ^{ns}	0.000	0.61
Wall thickness	140.077 ^{**}	1.075 ^{ns}	0.000	0.399

Note : ** : significant difference at $\alpha=0.01$; * : significant difference at $\alpha=0.05$; ns : not significant

Result presented in Table 3 showed that auri hybrid have longer fiber than mangium hybrid. Average fibres length auri hybrid about 0,91mm, whereas mangium hybrid only 0.87mm. Though have different average fibre length, but variance analysis presented in table 4 indicate that both auri hybrid and mangium hybrid have no significant differences in fibres length. Related to this data, Kim *et al* (2009) said that *Acacia auriculiformis* has fibres length about 0.92mm and *Acacia mangium* 0.87mm

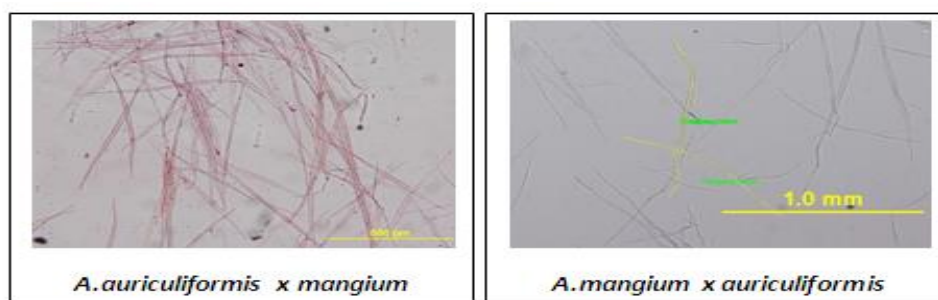


Figure 7. Fiber length auri hybrid and mangium hybrid

Figure 8 showed that auri hybrid has shortest fiber about 0.78mm at 1cm from pith and longest 1.04 at 6cm from pith. Mangium hybrid has shortest fiber about 0.66mm at 1 cm from pith and longest 1.03cm at 6 cm from pith. Variance analysis presented in table 4 showed that radial direction has a significant affected in fiber length. The graph also indicated that from 6 samples radial position have showed increased fiber length from pith to bark, both mangium hybrid and auri hybrid (Fig.8). Related to this data, Kim *et al* (2008) reported that fiber dimension from 6 clones on Acacia hybrid. showed increased in radial direction from pith to bark. The shortest fibres were 0.55mm founded at 1cm from pith and the longest were 1.2mm founded at 8-9cm from pith (near bark).

Research result presented in Table 3 showed that mangium hybrid have bigger cell diameter than auri hybrid. Mangium hybrid has range diameter 19.37 to 25.04 μ , whereas auri hybrid about 15.46 to 17.81 μ . Variance analysis presented in Table 4 indicate that the cell diameter between mangium hybrid with auri hybrid has a significant difference. Mangium hybrid has average cell diameter about 23.02 μ whereas auri hybrid only about 16.15 μ .

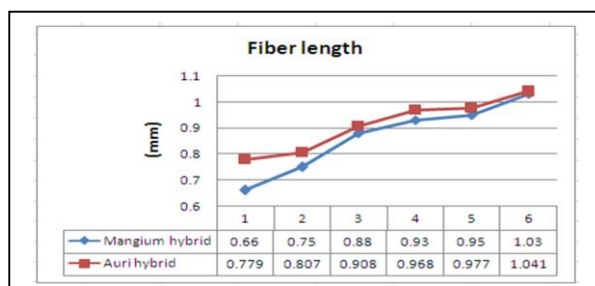


Figure 8. Graph of fiber length on radial direction

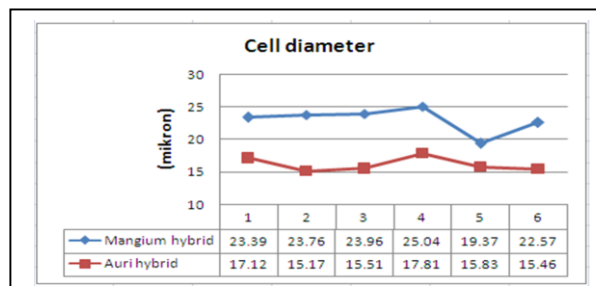


Figure 9. Graph of cell diameter on radial direction

Differences in the cell diameter 2 species hybrid is related to both its parents. Chowdhury *et al* (2013) reported that *Acacia auriculiformis* has average cell diameter about 12.6 μ . While *Acacia mangium* has average cell diameter 24.9 to 26.4 μ m in juvenil wood and 23.1 to 24.2 μ in mature wood (Nugroho *et al*, 2012). Figure 9 showed that auri hybrid has lowest cell diameter 15.46 μ at 6 cm from pith and highest 17.81 μ at 4 cm from pith. Mangium hybrid has lowest cell diameter 19.37 μ at 5 cm from pith and highest 25.04 at 4 cm from pith. Variance analysis presented in table 4 indicate that the cell diameter both mangium hybrid and auri hybrid has no significant difference in radial direction.

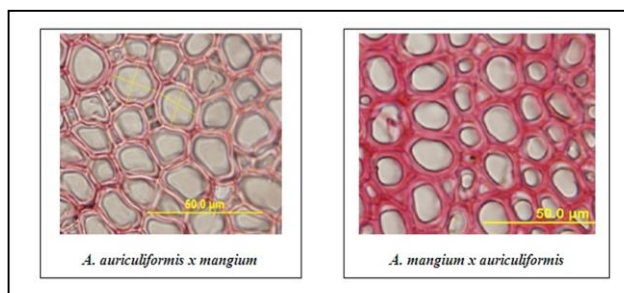


Figure 10. Transverse section of wall thickness 2 species hybrid

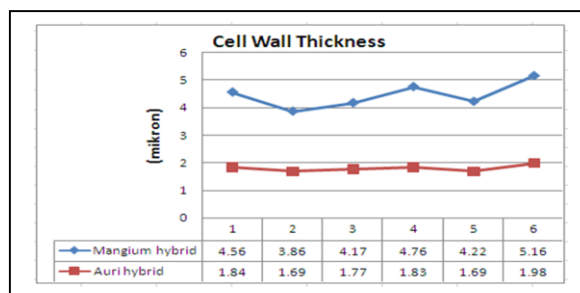


Figure 11. Graph of cell wall thickness on radial direction

Research result presented in Table 3 showed that mangium hybrid has thicker cell wall thickness than auri hybrid. Mangium hybrid has cell wall thickness range 3.86 to 5.16 μ , whereas auri hybrid about 1.69 to 1.98 μ . Variance analysis presented in Table 4 indicate that cell wall thickness between mangium hybrid with auri hybrid has a significant difference. Average cell wall thickness mangium hybrid about 4.46 μ whereas auri hybrid only about 1.80 μ . Differences in cell wall thickness of two species hybrid is related to both its parents. Chowdhury *et al* (2013) state that *Acacia auriculiformis* has maximum cell wall thickness about 2.4 μ and minimum 1.6 μ with average cell wall thickness about 2.0 μ . While Nugroho *et al* (2012) reported that *Acacia mangium* has average cell wall thickness 4.5 μ . Figure 11 showed that auri hybrid has thinnest cell wall about 1.69 μ at 2 cm and 5 cm from pith and thickest cell wall about 1.98 μ at 6 cm from pith. Mangium hybrid thinnest cell wall about 3.86 μ at 2 cm from pith and thickest cell wall about 5.16 μ at 6 cm from pith. Variance analysis presented in Table 4 showed that radial direction has no significant affected in cell wall thickness.

4. Conclusion

Macroscopically, mangium hybrid (*mangium x auriculiformis*) showed bigger heartwood and more tight sapwood (3-4 cm) while auri hybrid (*auriculiformis x mangium*) showed lower heartwood and wider sapwood (5-6 cm). Mangium hybrid also more porous than auri hybrid based on vessel diameter. Vessel diameter of mangium hybrid were 130-200 μ whereas auri hybrid only 113-120 μ . Texture was fine to medium coarse. Grain was straight or shallowly interlocked. Microscopically, auri hybrid have higher fiber percentage compared to mangium hybrid. Mangium hybrid higher wood density based on cell wall thickness. Cell wall thickness mangium hybrid were 4.46 μ whereas auri hybrid only 1.80 μ .

Two species *Acacia hybrid* have significant influence on almost all tissue proportions except rays proportion. Proportion of fiber, vessel, axial parenchyma and rays of mangium hybrid were 65.57%; 11.14%; 15.19% and 8.10% respectively, whereas auri hybrid were 75.38%; 8.03%; 9.03% and 8.90%. Fiber dimensions of 2 species *Acacia hybrid* also affected significantly in cell diameter and wall thickness except fiber length. Based on higher fiber proportion and thinner cell wall thickness, auri hybrid was better wood quality for pulp and paper products compared to mangium hybrid

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Wood Formation in *Shorea leprosula* and *Shorea parvifolia* in Tropical Rainforest

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Abstract

The tropical rainforest is categorised as a weak seasonal climate forest. Most tropical trees are not producing distinctive annual growth rings. By applying special techniques i.e. tissue injury around cambium layer during wood formation, we might be able to detect a minute or fine structural differences of growth periodicity in wood, which might be affected by the fluctuations of meteorological conditions. This study investigates the radial growths of *Shorea leprosula* and *Shorea parvifolia* for 12 months study periods. In this experiment, the dark one lines made up from the thick-walled fibres running continuously around the trunk near peripheral as a baseline to be used for measurement of radial growth. In this method, a comparison of vessel and ray width before and after the wounding was carried out. Average vessel and ray diameter changed from small to a large diameter once a pin was inserted. In *S. leprosula*, average vessel diameter changed from 153 μ m to 269 μ m. Average vessel diameter of *S. parvifolia* changed from 139 μ m to 256 μ m. Average rays width changed from 41 μ m to 59 μ m in *S. leprosula* and 39 μ m to 57 μ m in *S. parvifolia*. Traumatic resin canals usually occur sporadically due to injury, in concentric formation for these dipterocarp species. The relationship between radial growth in both species and meteorological data was also investigated.

Keywords: Anatomical characteristic, Pinning method, Radial growth, Tropical trees.

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1. Introduction

The differences between Tropical and temperate trees originate from environmental factors, especially meteorological conditions. The tree ring analysis in the temperate zones has been widely developed and is used for numerous purposes in forestry, botany, climatology, and the earth sciences. For Tropical regions, however, there is still assumed to be a general absence of annual rings in trees (Whitmore, 1990), despite several reports to contrary since the beginning of our century (Worbes, 1992; Killmann & Hong, 1995).

On the other hand, a major problem is the determination of wood formation in these species because these species do not form annual growth rings. To provide information on the growth potential of the species and to detect a possible periodicity of wood formation in response to the contemporary climatic conditions, the cambium of these trees was periodically marked by

wounding (Sass et al., 1995). By doing so, the dynamics of wood formation could be traced during a period of one year.

In this research, the pinning method was applied to two tropical tree species to investigate wood formation between these two species through pinning method. The pinning method is used in this investigation even though a knife was used. Pinning method (Wolter, 1968) has been a useful tool for studying the timing of events in wood formation. This method has been applied mostly to the study of temperate trees (Shimaji & Nagatsuka, 1971; Yoshimura et al., 1981, Kuroda & Shimaji, 1983; Kuroda & Shimaji, 1984) and rarely to seasonal tropical trees (Nobuchi et al., 1995) and very little in rainforest tropical trees (Sass et al., 1995).

2. Materials and Methods

One tree from each of two tropical tree species of Dipterocarpaceae, *Shorea leprosula* and *Shorea parvifolia*, grown in Forest Research Institute Malaysia, was selected for the experiment. These two species were planted in 1997 and the age of them around eleven years old. The planting distance of these two species is about 3 m x 3 m. The tree diameters at breast height were 19.2cm for *Shorea leprosula* and 18.1cm for *Shorea parvifolia*.

Pin insertion was performed, once a month from July 2008 to July 2009, using a knife 0.5 x 10 x 12 mm (thick x width x length). After a period of one year, the trees were felled. Using a hand saw, a cross section was obtained through the middle of every wound circle. The wood disks were fixed with 3% glutaraldehyde. Small blocks with pinned wood were sliced to section using a sliding microtome (20-30µm). They were stained with safranin and fast green for light microscopy.

3. Results and Discussion

3.1 Characteristic of radial growth

The anatomical structures of transverse sections of *Shorea leprosula* and *Shorea parvifolia* were observed. Detailed observation revealed that both species had a growth ring. Both species have aliform parenchyma with longer wings and narrower vessel elements. Nobuchi et al., (1995) detailed observation revealed that *Shorea* and *Hopea* had growth ring.

In this experiment, select one line made up from the vessel thick-walled fibers running continuously around the trunk near peripheral as a baseline to be used for measurement radial growth. Nobuchi et al., 1995 suggested that the latest growth ring boundary formed before the start of the pinning was used as a reference line.

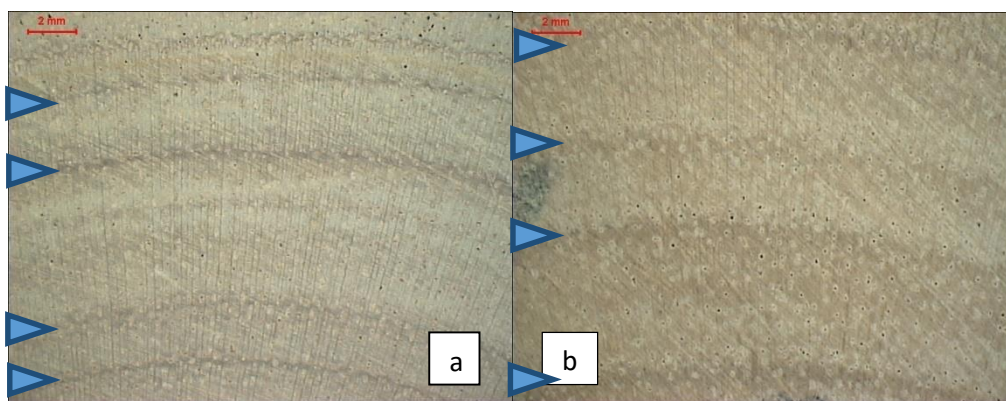


Figure 1. Characteristic growth ring; a.*S.leprosula*and b.*S. parvifolia*

3.2 Wood anatomical investigation

Anatomical characteristics were compared before and after pinning. The vessels showed smaller diameter after pinning than before. Table 1 shows vessel and ray diameter ranges of before and after pinning for the two selected species.

Table 1. Average diameter vessel and rays before and after pinning method

Tree species	Before pinning		After pinning	
	Vessel	Rays	Vessel	Rays
<i>S.leprosula</i>	267.02	41.20	152.84	58.86
<i>S. parvifolia</i>	256.05	39.23	139.34	56.74

From Table 1, it was showed the anatomical features before and after wounding of both species. Once the pin was inserted, cambial initials and cells of the differentiating were affected. In *Shorea leprosula*, average vessel diameter changed from to 153 μm 269 μm . Average vessel diameter of *S. parvifolia* changed from 139 μm to 256 μm Average rays width changed from 41 μm to 59 μm in *Shorea leprosula*and 39 μm to 57 μm in *Shorea parvifolia*. However, their physiological activities were considered to continue. This is because of plasma membranes were not destroyed. All species have small vessel elements after pinning method. Callus tissues were formed surrounding the pin inserted. Nobuchi et al., (1995) reported callus like cells were considered to have been formed by ray parenchyma cells filling the gap formed after injury. The cell debris was supposed to have originated from cells differentiating and enlarging at the time of pinning, and to correspond with “the stripe of cell wall residue” as reported by Yoshimura et al., (1981).

All tissues reacting capability reflect environmental influences in their behaviour. In this experiment, vessels and rays diameter of each species are limited by genetic factors. Most reactions to climatic ecological factors can be seen in microscopic anatomy of the plant. A few time consuming investigations have been carried out on parameters of cells elements in earlywood and latewood such as vessels and tracheids and on the portion of several of cell types such as vessels parenchyma and ray cells (Schweingruber, 1988).

3.3 Traumatic resin canal

In this experiment, traumatic resin canals were occasionally observed in the two species. Figure 2 shows the example of traumatic resin canals in both species. The traumatic resin canals located towards the bark side of the line of estimated cambial initials at the time of pinning. According to Zarnudin et al., (2011) knowing the extent of traumatic resin canals formation, suitable distances can be determined to avoid overlapping formation of traumatic resin canals between the two pins.

Kuroda & Shimaji (1983) reported that the estimated position of cambial initials at the time of pinning was located towards the bark side of epithelial cells constituting resin canals. Shiokura (1989) also used gum/resin canals as the marker of the pinning.

In this experiment, traumatic resin canals were judged useful as a marker of the position because they reveal the exact position of cambium at the time of pinning. Even they were delayed in a certain condition. This was because, they were the main characteristic of cells formed after the pin was inserted. *Shorea leprosula* shows that cambium zone was detected closely to the inner of traumatic resin canals formed according to Zarnudin et al., (2011).

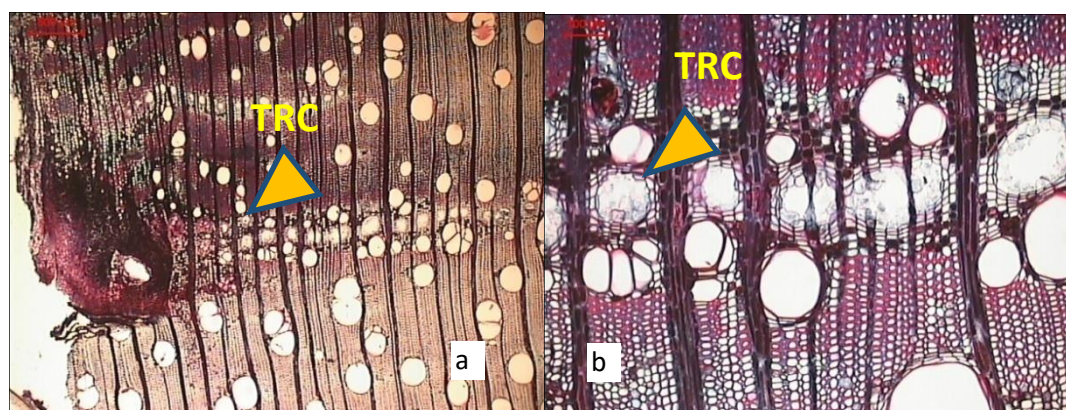


Figure 2. Transverse sections of a); *S. leprosula* showing traumatic resin canals were arranged in tangential series (arrowhead) b); TRC located on the bark side of the deduced site of cambial initials

Two or three tangential lines of canals were formed at once after one wound. This indicates that the numerous tangential lines of resin canals observed in the trees affected by the time of pinning were formed in a short time (Fig. 2).

This study revealed that traumatic resin canals were induced in the outward to the bark sides after injury. This anatomical information on traumatic resin canal formation will be useful as an indicator at the time of pinning.

3.4 Relationship between radial growth and meteorological conditions

Each environment factor can involve in numerous interacting relationships in different parts of the plant, at different times throughout the year and at different times throughout the life of the tree.

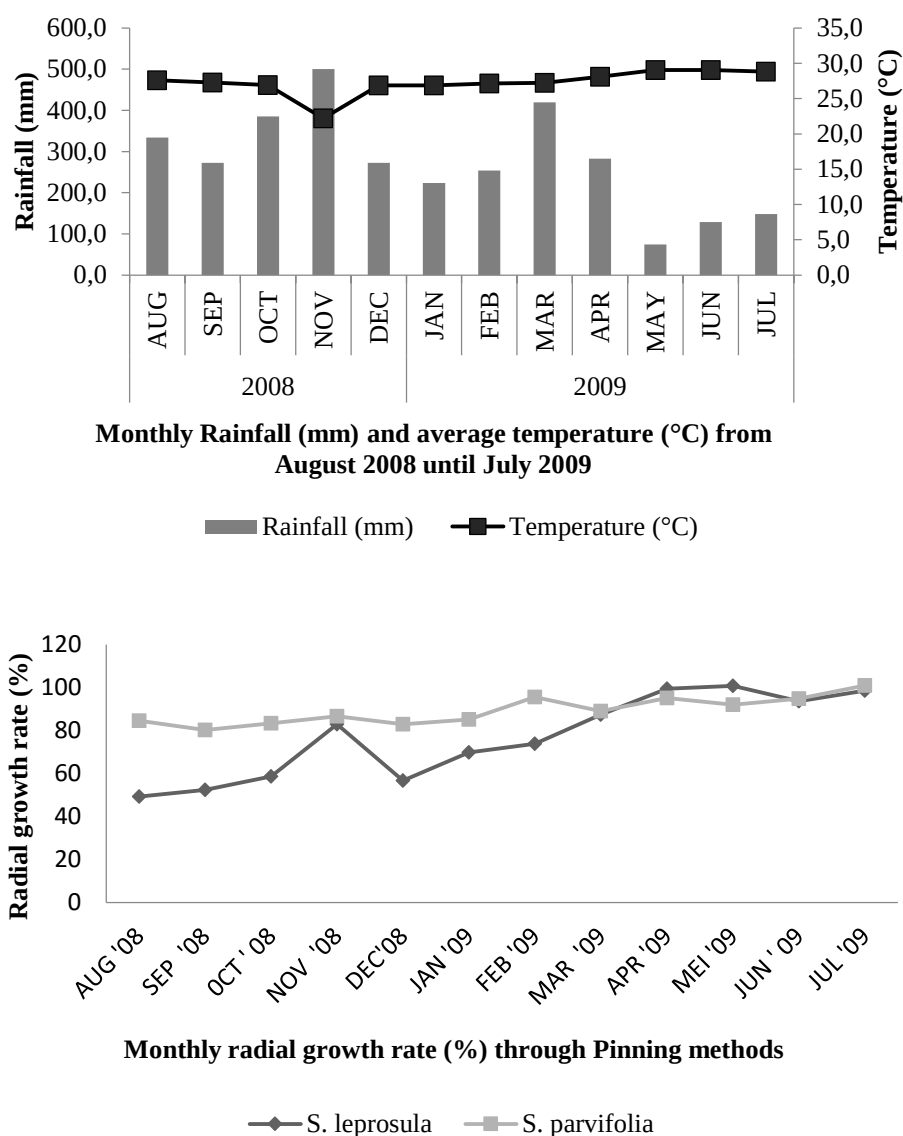


Figure 3. Relationship between the wood formation and meteorological data *Shorea leprosula* and *Shorea parvifolia*.

Figure 3 shows monthly rainfall and monthly average temperature. The purpose of this data analysis was to check the relationship between wood formation and meteorological factors. Many factors were considered to be related with the wood formation. Meteorological phenomenon explained that the highest amount of rainfall was in November 2008 (500.30 mm). Meanwhile, the monthly average temperature on November 2008 was the lowest (22.19°C).

This phenomenon were influenced tree growth where a higher rainfall will significantly increase the wood formation. In *Shorea leprosula*, wood formation was highest on November 2008 while the lowest was on May 2009 due to the amount of monthly rainfall.

The statistical analysis was carried out with both species. Among them, the correlations between monthly radial growth and monthly rainfall or monthly average temperature in *Shorea leprosula* were investigated in a scatter diagram.

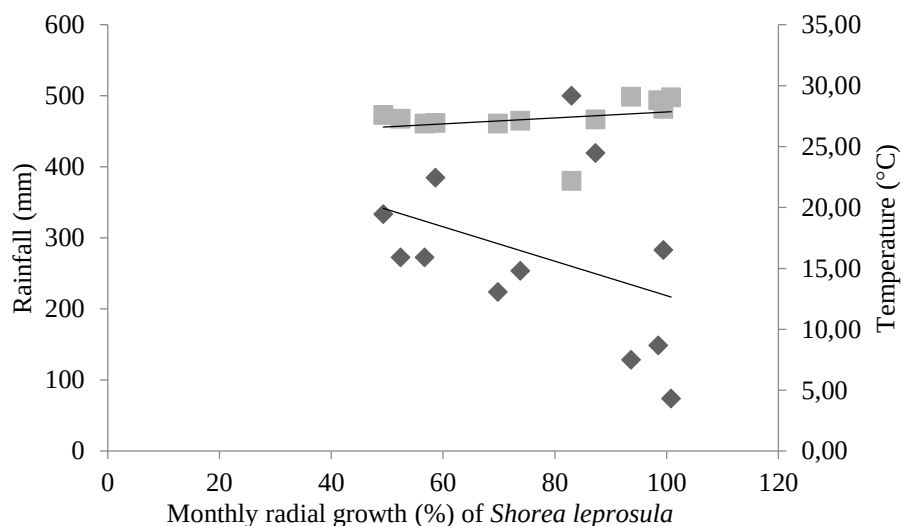


Figure 4. Correlation coefficient between monthly radial growths of *Shorea leprosula* and monthly rainfall or average temperature.

Figure 4 shows that the monthly radial growth for *Shorea leprosula* has a higher coefficient of correlation with monthly rainfall ($r=-0.38$) than with monthly average temperature ($r=0.26$).

The monthly radial growth measured by pinning method has a higher coefficient of correlation with monthly rainfall than monthly average temperature. They were significantly correlated with the monthly rainfall. Meanwhile in Malaysia temperature remained relatively high throughout the year according to Ogata et al., (2001).

4. Conclusions

In this investigation of the wood formation using pinning method for marking radial growth has proven helpful as a “timer” during the ongoing growth process. Whereas the performance of the pinning in the forest is easy and fast, the laboratory work is time consuming and microscopic evaluation requires experience in wood anatomy.

Acknowledgements

The authors express their sincere thanks for Prof Dr Nobuchi, T. for supervising her early work. Special thank for Dr Amir Affan Abdul Azim for his suggestions. We thank the Meteorological station at Petaling Jaya for providing climate data.

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B. BIOCOMPOSITES

The 7th International Symposium of IWoRS

Physical and Mechanical Properties of Ply-Bamboo Made from Sembilang (*Dendrocalamus giganteous*) and Andong (*Gigantochloa pseudoarundinacea*) Bamboos

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Abstract

Bamboo especially its culm part has been used as durable and strong building materials. Utilization of bamboo culm for plybamboo could be intended for a substitute of plywood. Raw materials of plywood that mainly come from natural forest have been decreasing and becoming much expensive. Therefore new raw materials such as bamboo and other natural fibers are needed to be developed. In this research plybamboo was made from sembilang (*Dendrocalamus giganteous*) and andong (*Gigantochloa pseudoarundinacea*) bamboos glued with phenol formaldehyde. Plybamboo was firstly made by processed fresh bamboo into flat shape (zephyr) using a bamboo crusher. Zephyr was dried until reached moisture content of below 5% then mixed with phenol formaldehyde resin. Resin content was varied at 10, 12, and 14% of the board dry weight for sembilang or 8, 10, and 12% for andong. Mat was formed by arranged the zephyr in three layers with the second layer perpendicular to the first and third layers. The board was hot pressed at temperature of 140 °C, pressure of 25 kg/cm² for 20 minutes. The board size was 170 cm x 60 cm x 2 cm, with a target density of 0.7 g/cm³. The physical and mechanical properties tested were density, moisture content, thickness swelling, water absorption, bending strength (modulus of rupture and modulus of elasticity), internal bond, and screw withdrawal. The result shown that the physical and mechanical properties of plybamboo were better at higher resin content. Plybamboo made from sembilang exhibited higher physical and mechanical properties than that of andong.

Keywords: Andong, Phenol formaldehyde, Physical-mechanical properties Plybamboo, Sembilang

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1. Introduction

Indonesia has a huge potential of bamboo, more than 162 bamboo species are found however only some are planted that have a high economic value (Dransfield & Widjaja 1995; Subyakto et al., 1997). Bamboo has some advantages such as can be harvest at 3 years, straight culm, high strength, easy to process, and relatively cheap (Dransfield & Widjaja 1995; Scurlok et al., 2000; Khalil et al., 2012). The culm part of bamboo have been used as a durable and strong building materials for long time (Morisco, 2006). Utilization of bamboo culm for plybamboo product can be used as alternative of plywood (Subiyanto & Subyakto, 1995; Sudijono et al., 2001). Wood from natural forest as raw material for plywood become scarce and expensive, there it is needed to develop other raw materials. The development of plybamboo has been done in China and India. In these two countries, much amount of waste is generated in the product processing, because the bark and inner part of bamboo are removed first. In our patent ID P0028883 (Subiyanto et al., 2011), the whole part of bamboo is used therefore the waste can be reduced. The whole bamboo part is crushed using bamboo crusher without removing the bark, so the waste can be minimized. Phenol formaldehyde (PF) resin is used to produce exterior materials, this resin is water resistant. Research on plybamboo made from gombong and tali bamboo using PF resin have been conducted (Subyakto et al., 1995; Subiyanto & Subyakto 1995; Sudijono et al., 2000; Sudijono et al., 2001; Gopar et al., 2001; Gopar & Subyakto 2002; Sudijono & Subyakto, 2002). While in the current research, we used sembilang and andong bamboos that have not been used before. The purpose of this research is to observe effect of resin content on the physical and mechanical properties of plybamboo made from sembilang and andong bamboos.

2. Materials and Methods

Materials used in this research were two bamboo species: sembilang (*Dendrocalamus giganteous*) and andong (*Gigantochloa pseudoarundinacea*), 3 years old originated from Bogor, West Java, Indonesia. The resin used was phenol formaldehyde PA-302 type, provided by PT Palmolite Adhesive Industries, Indonesia. Preparation of plybamboo was started with crushing fresh bamboo using bamboo crusher to make a flat shape (zephyr). Zephyr was dried until reached moisture content of below 5%. Adhesive was spread in the zephyr using glue spreader machine. The resin spread rate were 10, 12, 14% of board dry weight for sembilang bamboo; and 8, 10, 12% of board dry weight for andong bamboo. Mat was formed by arranged the zephyr in three layers with the second layer perpendicular to the first and third layers. Plybamboo was made by hot pressing the mat at temperature of 140 °C, under pressure of 25 kg/cm² for 20 minutes. The board size was 170 cm x 60 cm x 2 cm, with density target of 0.7 g/cm³. After the board was taken from the press, it was conditioned at room temperatures for 2 weeks. The board was tested for their physical (density, moisture content, thickness swelling, water absorption) and mechanical (modulus of rupture, modulus of elasticity, internal bond, screw withdrawal) properties.

3. Results and Discussion

3.1. The physical properties of plybamboo

Results of physical properties measurements (density, moisture content, thickness swelling, and water absorption) are presented in Figures 1, 2, 3, and 4. It can be seen in Figure 1 that the density target of 0,7 g/cm³ could be achieved only at plybamboo made from sembilang with 14% PF resin content, while for other treatments the density were lower. This may caused by the condition of the pressing machine that could not reached the target pressure.

Results of moisture content measurements (Fig. 2) showed that plybamboo made of sembilang exhibited slightly lower moisture content compared to that of andong. Resin spread rate was not significantly affect the moisture content of the board. The moisture content of all the boards were below 14%. Thickness swelling values (Fig. 3) of all boards were considered to be good (below 6%). Higher resin content yielded in lower thickness swelling of boards. At resin content of 12% plybamboo of sembilang has lower thickness swelling compare to that of andong. Water absorption values (Fig. 4) of all board were below 40%. Similar to thickness swelling trend, the water absorption of plybamboo made of sembilang was lower compare to that of andong. Water absroption values of sembilang plybamboo were the same for all resin contents, while those of andong plybamboo the water absorption values were lower with increasing of resin content.

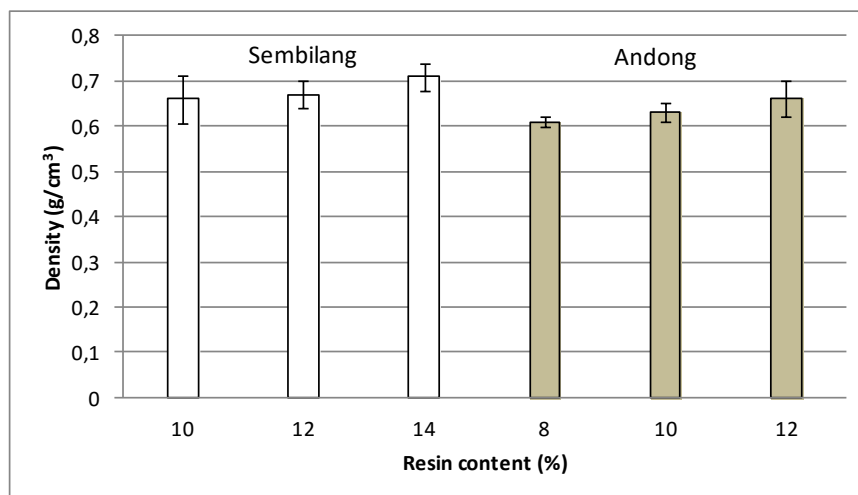


Figure 1. Density of plybamboo.

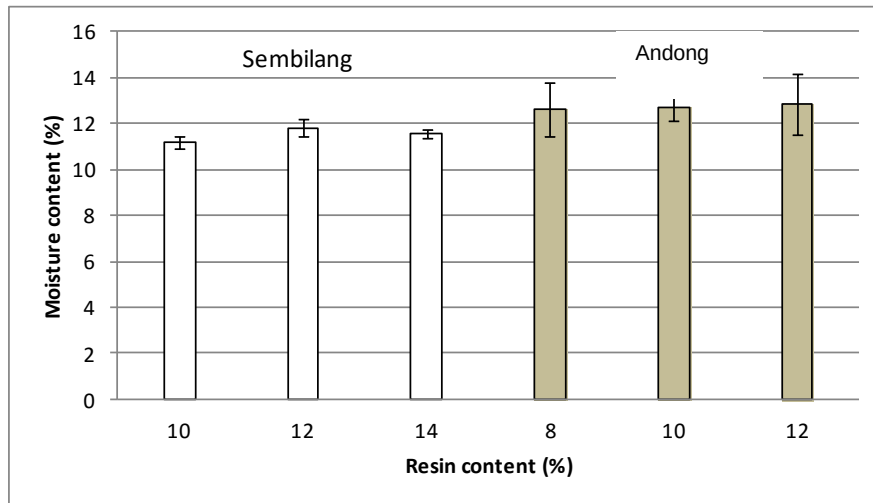


Figure 2. Moisture content of plybamboo.

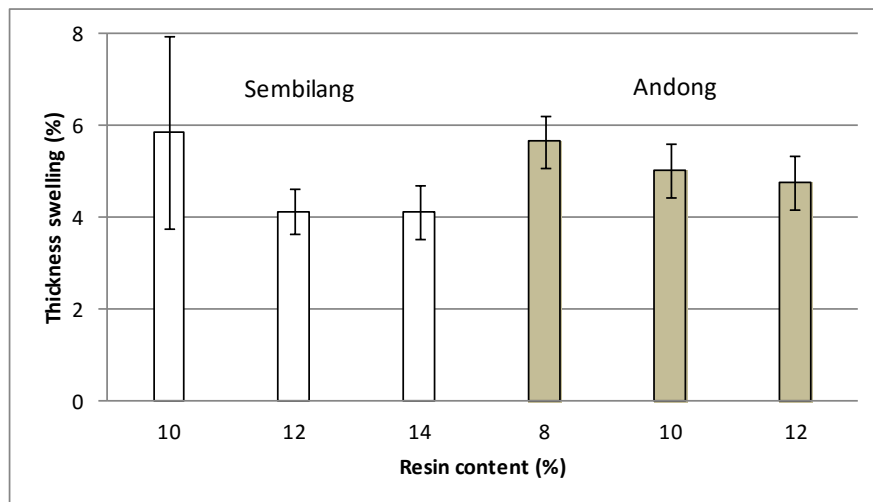


Figure 3. Thickness swelling of plybamboo.

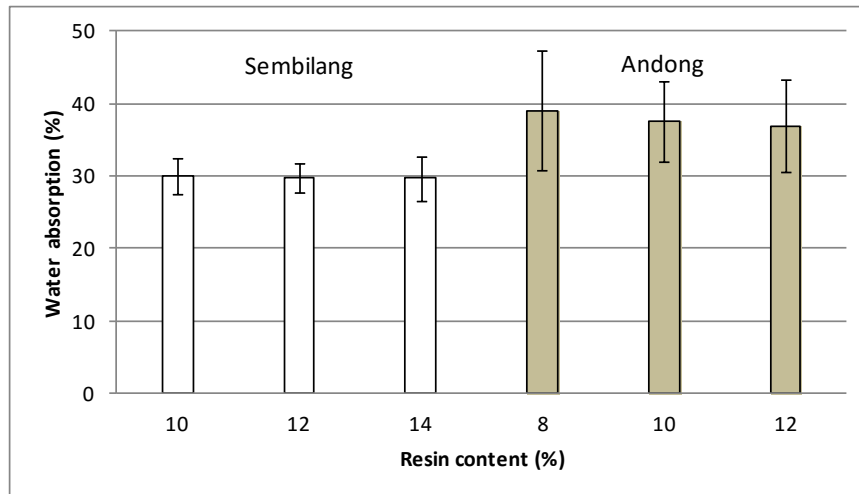


Figure 4. Water absorption of plybamboo.

3.2. The mechanical properties of plybamboo

Results of mechanical measurements of plybamboo (internal bond, screw withdrawal, MOR parallel to grain, MOR perpendicular to grain, MOE parallel to grain, MOE perpendicular to grain) are presented in Figures 5, 6, 7, 8, 9, 10, respectively. Internal bond values (Fig. 5) of plybamboo made from sembilang were higher than that of andong. Increases of resin content yielded in increases of internal bond of plybamboo.

Results of screw withdrawal measurements (Fig. 6) showed that plybamboo made from andong exhibited higher values compare to that of sembilang. This may caused by the different fibers inherent properties of the two species, therefore an anatomical analysis should be done to clarify this. While the higher of resin content resulted in higher screw withdrawal values of plybamboo both of the two bamboo species.

The bending properties of plybamboo (MOR and MOE) showed that the parallel to grain strength were higher than that of perpendicular to grain (Figure 7, 8, 9, 10), this was due to the load at parallel to grain was received on wider surface of the sampel. The values of MOR and MOE of plybamboo made from sembilang were higher compare to those of andong. While effect of resin content showed that higher resin content resulted in higher MOR and MOE.

Previous results (Subiyanto et al., 2011) of plybamboo using tali (*Gigantochloa apus*) with PF resin at higher density (0.8 g/cm^3) showed higher MOR (715 kgf/cm^2) but lower MOE (64.336 kgf/cm^2) compared to the present results. This may due to the different inherent characteristics of bamboo species used.

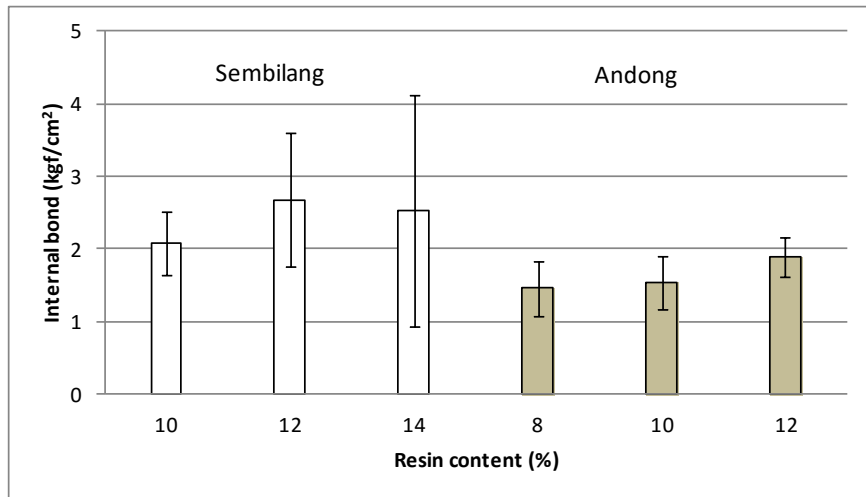


Figure 5. Internal bond of plybamboo.

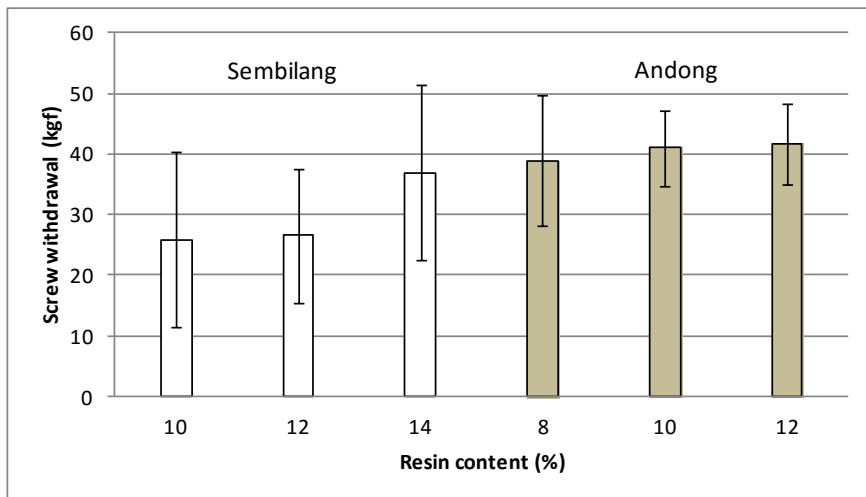


Figure 6. Screw withdrawal of plybamboo.

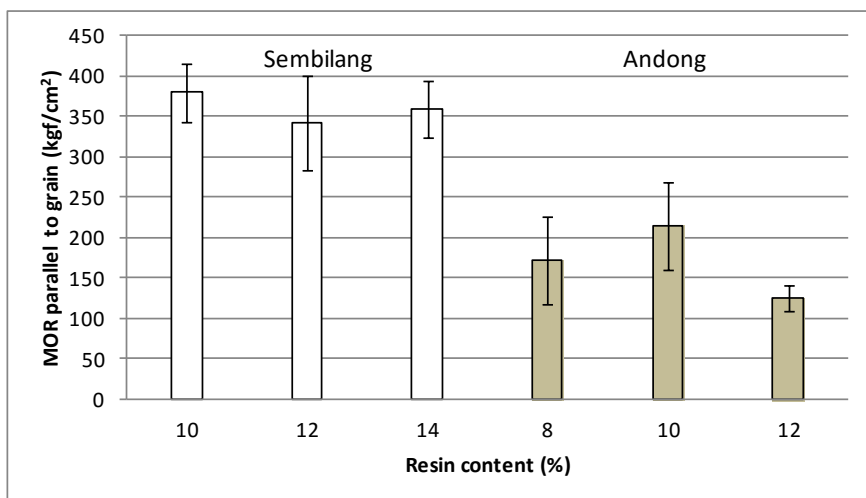


Figure 7. MOR parallel to grain of plybamboo.

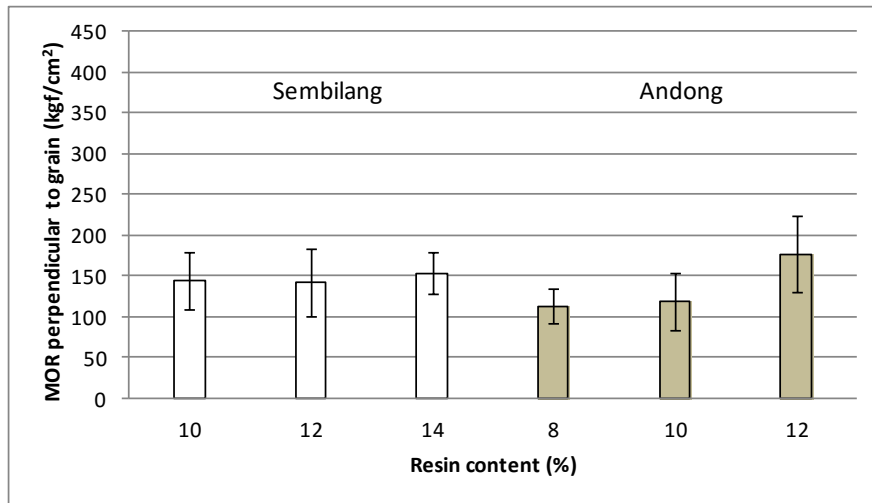


Figure 8.MOR perpendicular to grain of plybamboo.

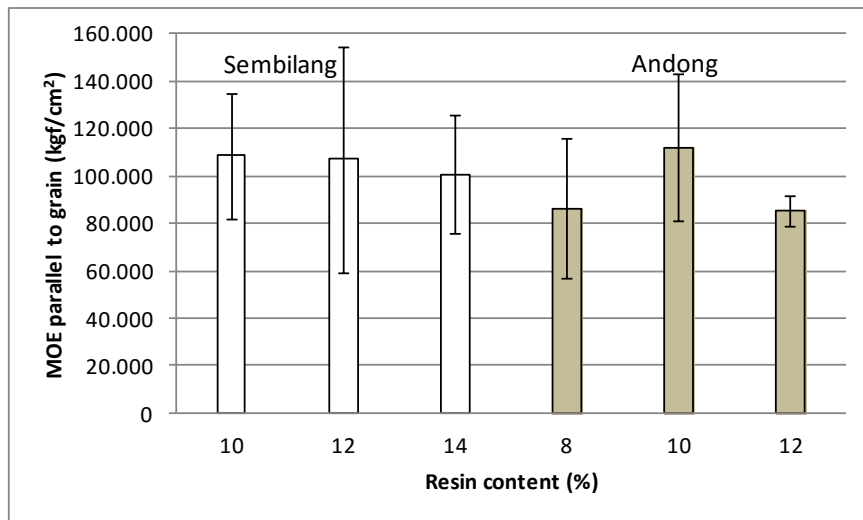


Figure 9.MOE parallel to grain of plybamboo.

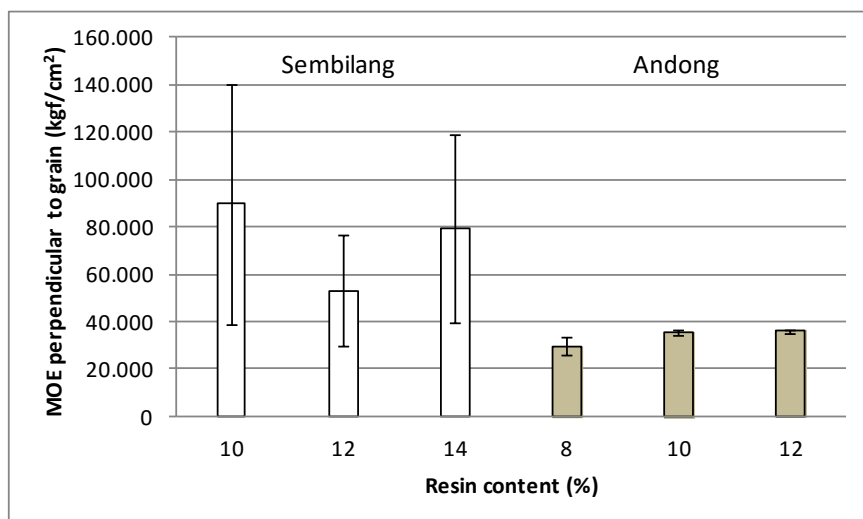


Figure 10.MOE perpendicular to grain of plybamboo.

4. Conclusion

It can be concluded that the physical and mechanical properties of plybamboo made from sembilang is better compared to that of andong. Generally the higher the resin content the better the physical and mechanical properties of plybamboo.

Acknowledgment

The authors gratefully acknowledge technical support from Sudarmanto, Saipul, and Fazhar Akbar of Research Center for Biomaterials – LIPI.

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The Particle Board from Oyster Mushroom Planting Media Waste and Its Physical and Mechanical Properties

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Abstract

This study was to optimize the phenol formaldehyde (PF) resin content in manufacturing of particle board made of oyster mushroom planting media waste. The content of PF adhesives used were varied (10%, 12.5% and 15%) w/w to the particle board weight. Experimental method refers to SNI 03-2105-2006 about particle board. The size of the oyster mushroom was less than 10 mesh planting media waste. The particle furnish was formed into 25 cm x 25 cm x 0.9 cm mat and hot pressed to particle board with target density of 0.6 g/cm³. The physical properties measurement result showed that when the amount of PF increased, the physical properties, internal bond, and screw withdrawal were also increase, except in 15% PF. The optimum resin content was 15% PF resulting with density of 0.56 g/cm³, moisture content of 11.11%, water absorption of 112%, thickness swelling of 9%, MOE of 2,484.01 kgf/cm², MOR of 16.95 kgf/cm², internal bond of 2.54 kgf/cm² and screw withdrawal of 8.33 kgf. Particle board with this resin content has met the requirement of particle boards based on SNI 03-2105-2006.

Keywords: Mechanical properties, Particle board, Phenol formaldehyde, Physical properties, Waste baglog.

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1. Introduction

Recently, the demand of wood in Indonesia is increasing due to the growth of population. The Indonesian Central Organization for Statistics said that the wood production from the forest in 2011 was 47.429.335 m³. This high production is caused by many factors, one of them is the increasing need of building materials, such as partition walls and ceiling. This excessively high wood production will give a bad impact on the environment, such as global warming.

One alternative materials for replacing wood in furniture applications is particle board which can be made from oyster mushroom planting media waste (baglog). Particle board is a composite products/wood panels made from wood particles or other lingocellulosic materials

that was bonded with synthetic adhesive or other bonding material then hot pressed (Maloney, 1993). Baglog composition consist of 80% mushroom sawdust, 10% rice bran, 1.8% limestone, and 0.4% gypsum TS (Chazali&Pratiwi, 2009).

The result of Surachman (2013) showing that 16% (w/w) adhesive content of urea formaldehyde (UF) in particle board from oyster mushroom planting media waste resulted in some physical properties that met the standard. However the mechanical properties were not met the standard, yet. To improve the mechanical properties, we used PF as the adhesive. In this study, particle board was produced from baglog and phenol formaldehyde (PF). The advantages of PF is resistant to weather, especially water, so that it can be used for exterior application. Phenol formaldehyde is a synthetic resin as a result of phenol and formaldehyde polymerization reaction (Putra, 2011).

The content of PF adhesive in particle board were 10%, 12.5% and 15% of oven-dried particle weight. The purpose of this study was to determine the optimum PF resin content of particle board made from oyster mushroom planting media waste, based on the physical and mechanical properties of board refers to the SNI 03-2105-2006.

The physical and mechanical properties measurement of particle board were referred to SNI 03-2105-2006. The physical properties measurement was included density, moisture content, the thickness swelling, and water absorption while the measurement mechanical properties were included modulus of elasticity (MOE), modulus of rupture (MOR), internal bond strength, and screw withdrawal.

2. Materials and Methods

2.1 Materials

The raw material was oyster mushroom planting media waste obtained from the Research Center for Biology, LIPI-Cibinong. The adhesive material was phenol formaldehyde (PF) 50 % solid content. PF obtained from PT Pamolite Adhesive Industry, East Java.

2.2 Methods

2.2.1 Sample preparation

Oyster mushroom planting media waste with moisture content below 10% had been weighed according to the requirements were blend with PF using blender with rotational speed of 60 rpm for $\pm$ 5 minutes. While the blender was rotated the PF was sprayed into the machine at the same time. Adhesive contents were 10%, 12.5% and 15% of total particle weight.

The obtained mixture was hotpressed at 155 °C for 10 minutes and the pressure of 25 kgf/cm² with the size 25 cm x 25 cm x 1 cm. The sample was placed for 14 days at room temperature according to SNI 03-2104-2006 guidelines. The sample size and cutting pattern can be seen in Table 1 and Figure 1.

Table. 1 The particle board sample size according to SNI 03-2105-2006

No	Properties tested	Size (cm)	Amount	Alternative Stock
1	Density	10 x 10	4	1
2	Moisture Content			
3	Thickness swelling			
4	Water absorption	5 x 5	4	1
5	Modulus of elasticity (MOE)	5 x 20	4	1
6	Modulus of rupture (MOR)			
7	Internal bond strength	5 x 5	4	1
8	Screw withdrawal	5 x 10	4	1

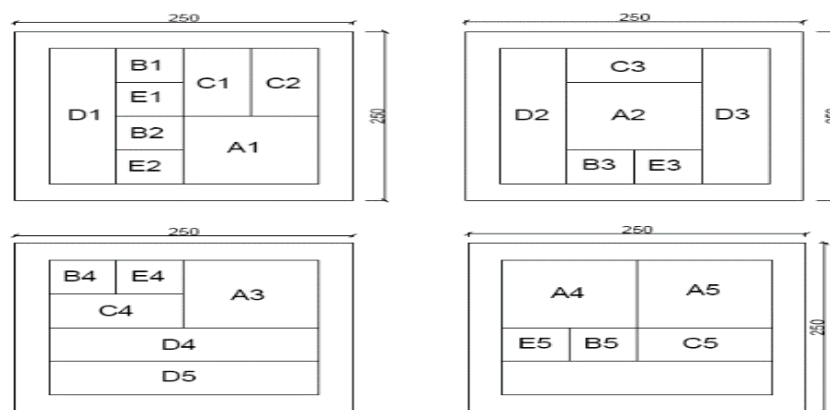


Figure 1. The particle board sample pattern according to SNI 03-2105-2006

(A = Specimens density and moisture content; B = Specimens water absorption and thickness swelling; C = Specimens strong pull screws; D = Specimens MOE and MOR; and E = Specimens internal bond adhesion strength test).

2.2.2. Sample measurements

The physical properties measurements of particle board which were density, moisture content, thickness swelling and water absorption. The mechanical properties measurement were modulus of elasticity (MOE), modulus of rupture (MOR), internal bond strength, and screw withdrawal using Shimadze Universal Testing Machine (UTM) referred to SNI 03-2105-2006. The amount of particle board prepared for the physical and mechanical properties tested were 5 specimens for each level of adhesive content.

3. Results and Discussion

3.1. Physical properties

The physical properties of particle boards with different adhesive content is shown in Table 2.

Table 2. Physical properties of particle boards with different adhesive content

Properties	Adhesive content (w/w)				SNI 03-2105-2006
	PF 10%	PF 12,5%	PF 15%	UF 16%	
Density (g/cm ³)	0.55 ± 0.03	0.53 ± 0.03	0.56 ± 0.02	0.45 ± 0.03	0.4 - 0.9
Moisture content(%)	10.04 ± 0.15	10.28 ± 0.38	11.11 ± 0.31	8.13 ± 0.25	< 14
Thickness swelling(%)	18 ± 3	11 ± 2	9 ± 2	8 ± 2	< 12
Water Absorption (%)	134 ± 3	115 ± 13	112 ± 16	164 ± 11	Not present

The target density of the particle boards which was 0.60 g/cm³ was not achieved, all of the sample were showing below the target. The reason might be caused by the fact that some of mixture particle board were left in the blender machine and some other portion was out casted during hot compression in the hot press engine. Particle board with material oyster mushroom planting media waste with PF adhesive has met the SNI 03-2105-2006 in term of density criteria which are between 0.40 to 0.90 g/cm³. The results also showed that particle board was included in the category of low density particle board, with a density below 0.59 g/cm³.

The test results of moisture content can be seen in Tabel 2. The highest moisture content was found in the particle board with PF 15% and the lowest was in particle board with UF 16%. From this results, it was suggested that the moisture content was strongly influenced by the content of PF adhesive. Third variation of PF adhesive content has fulfilled SNI 03-2105-2006 that describes the maximum moisture content was <14%.

Based on Table 2, particle board with adhesive PF 10% obtained 18% of thicknes swelling was not met standard. This is mainly because the oyster mushroom planting media waste can't cover the entire surface perfectly and the amount of adhesive used not able to depend heavy development. In contrast to particle board with 10% PF, particle board used 12.5% and 15% PF have quite satisfactory thickness swelling results. Based on the table, particle board contained 12.5% and 15% concentration of PF resulted in 11% and 9% thickness swelling, respectively, has fulfilled SNI 03-2105-2006 with the maximum thickness swelling percentage was 12%.

Water absorption test results can also be seen in Table 2. Particle board used 16% UF was the highest water absorption while compared to all boards used PF adhesive (PF 10%, 12.5% and 15%). In other words, the amount of baglog affected the value of water absorption on the particle board due to the hygroscopicity of oyster mushroom planting media waste.

3.2. Mechanical properties

The mechanical properties of particle boards with different adhesive content is shown in Table 3.

Table 3. Mechanical properties of particle boards with different adhesive content

Properties	Adhesive content (w/w)				SNI 03-2105-2006
	PF 10%	PF 12,5%	PF 15%	UF 16%	
MOE (kgf/cm ²)	2092.21 ± 204.4	2526.59± 269.28	2444.01 ± 366.75	3039.73 ± 255.87	≥ 20,400
MOR (kgf/cm ²)	14.18 ± 1.32	17.52 ± 2.29	16.95 ± 2.78	14.63 ± 1.26	≥ 82
Internal bond (kgf/cm ²)	1.39 ± 0.21	2.2 ± 0.15	2.54 ± 0.18	1.98 ± 0.25	≥ 1.5
Unplug strong screws (kgf)	5.09 ± 0.5	6.87 ± 0.62	8.33 ± 0.94	5.63 ± 0.67	≥ 31

The value of flexural modulus of elasticity was ranged between 2092.21–2526.59 kgf/cm². The highest elasticity modulus values obtained in the control of particle board with UF 16%. All MOE values of the board using PF adhesives were smaller than that of concentration 12.5%. However, MOE of all particle boards using variation concentration of PF adhesives were smaller when compared with adhesive UF 16% by 3039.73 kgf/cm². Particle board using adhesive PF was more brittle than the particle board using adhesives UF. The results showed that the MOE of the all board made with various PF were not met SNI 03-2105-2006 that requiring a minimum MOE of 20400 kgf/cm². This may be related to imperfect mixing baglog with PF during the blending. It was often found that adhesive was agglomerated during the mixing, Enhance of reformulated PF resin should be used to solve this problem.

MOR test result in Table 3 shows that PF 12.5% has the highest value which was 17.52 kgf/cm². However, all types and level of adhesive could not met the minimum requirement that stipulated in SNI 03-2105-2006 which is 82 kgf/cm².

Strong internal bond test results can be seen in Table 3. The two PF content levels (12.5% and 15%) already fulfill the minimum requirement stipulated by SNI 03-2105-2006 with the value of 1.5 kgf/cm². Generally, the more the adhesive is used, the greater the value value of internal bond.

For the screw withdrawal strength, all the three resin levels was fail to fulfill the minimum standard stipulated by SNI 03-2105-2006 with the value of of 31 kgf. However, there was the trend that the screw withdrawal strength increased with the resin content.

In general, particle board made from oyster mushroom planting media waste with PF resin content of 12.5% or more met all the physical properties but only one mechanical property (internal bond) that met minimum requirement stipulated by SNI 03-2105-2006.

4. Conclusion

In this research, used particle board from oyster mushroom media waste with PF adhesive 10%, 12.5% and 15% of total particle weight. Based on results, the best physical and mechanical properties of particle boards from oyster mushroom planting media waste was adhesive content with PF 15%, consist of density of 0.56 g / cm³, water content of 11.11%, 112% water absorption, thickness swelling 9%, MOE 2444.01 kgf / cm², MOR 16.95 kgf / cm², internal bond 2.54 kgf/cm² and a screw withdrawal strength 8,33 kgf. Particle board made from oyster mushroom planting media waste with PF resin content of 10%, 12.5%, 15% met all the physical properties but only one mechanical property (internal bond) that met minimum requirement stipulated by SNI 03-2105-2006.

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C. MATERIAL ENGINEERING

Compressive Strength of Wooden Glulam Short Column based on National Indonesian Standard SNI 7973-2013 versus Experimental Test

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Abstract

Compressive failure of wooden column is a combination of the buckling failure and crushing failure. To accommodate it, National Indonesian Standard SNI 7973-2013 uses a column stability factor i.e C_p . This paper compared the compressive failure of column calculated by two methods, i.e using the SNI standard and the experimental methods to find out the accuracy of the standard. Column studied were short glulam column of different cross section (rectangular, I-shape, and box shape) with the same cross-sectional area. The results show that the calculations using the methods of SNI 7973-2013 gave lower column capacity readings than those of experimental test. Then it can be concluded that determining the column capacity using SNI standard is on the safe side.

Keywords : Wooden column, Column stability factor, Glulam column

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1. Introduction

Recently it was difficult to get a large cross section dimension of wood structural element such as a column. Laminated timber column was became one of the solution as an engineered wood product to increase cross sectional dimension. It was common that people use glue adhesive, nail or bolt to laminate the lamina into a large cross sectional column. This study used a glue adhesive to form a column. Indonesian Standard SNI 7973-2013 was used to determine the strength of the column.

2. Materials and Methods

The hardwood fast growing species namely *Albasia* was used to prepare wooden columns. The urea formaldehyde glue-laminated column was prepared in shapes of cross sectional types, namely rectangular (R), I and box-shape (B). All specimens were made from 4 *Albasia* wood planks with approximately has the same cross section area of about 128 cm² as illustrated in

Fig. 1 and 2. The original cross section dimension of each wood plank was 180 x 20 mm. All of lamina has a 20 mm of thickness. The properties of wood material was determined by the ASTM D143-94 (ASTM, 2008). The average specific gravity of Albasia was 0.33 that mean the wood was belong to class number 3 or 4 (See Table 1). The average modulus of elasticity from bending test was 6000 MPa. The moisture content during the test was in between 12% - 15%. That fulfill the requirement of Indonesian Standard for the test. Moment inertia and the slenderness of column are shown in Table 2.



Figure 1. The three variations of glue-laminated column cross sections

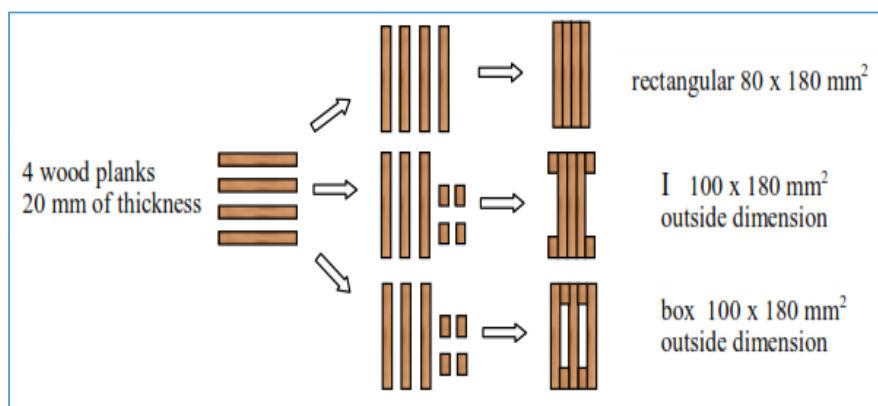


Figure 2. The arrangement of 4 wood planks on the glue-laminated beam cross sections

Table 1. Basic physical information of samples

No	Length (cm)	Width (cm)	Thickness (cm)	Moisture (%)	Specific gravity (gr/cm ³)
1	7.1	7.2	1.9	13.79	0.27
2	7.0.5	7.2	1.9	14.23	0.32
3	7.3	7.1	2	12.05	0.36
4	6.9	7.2	2.1	12.20	0.35
5	7.2	7	2.1	14.15	0.34
6	6.9	7.2	2.1	12.65	0.35
Average				13.18	0.33

Table 2. Moment inertia and the slenderness of column

No	Specimen	Cross Section	Area (A) (cm ²)	Height (L). (cm)	Moment of Inersia Iy (cm ⁴)	Slenderness factor (-)
1	R-1	Rectangular	132.44	70.5	654	31.73
2	R-2		129.2	69.7	498	35.50
3	R-3		134.19	70.4	564	34.34
Average	R		131.94	70.20	572	33.86
4	I-1	I	127.88	69.2	672	30.19
5	I-2		125.945	71	636	32.09
6	I-3		125.29	70	570	32.82
Average	I		126.37	70.07	626	31.70
7	B-1	Box	124.31	70.3	1002	24.76
8	B-2		122.94	70.5	942	25.47
Average	B		123.63	70.40	972	25.12

The compression or buckling strength of the column at proportional limit and ultimate load from the experimental test was investigated. The beam specimen was tested under compression loading as was illustrated in Figure 3. The support can rotate and assumed as hinges. The clear height of the specimen was around $L = 70$ cm. The speed of loading was 1 mm/min and failure was happened after approximately 5 minutes.

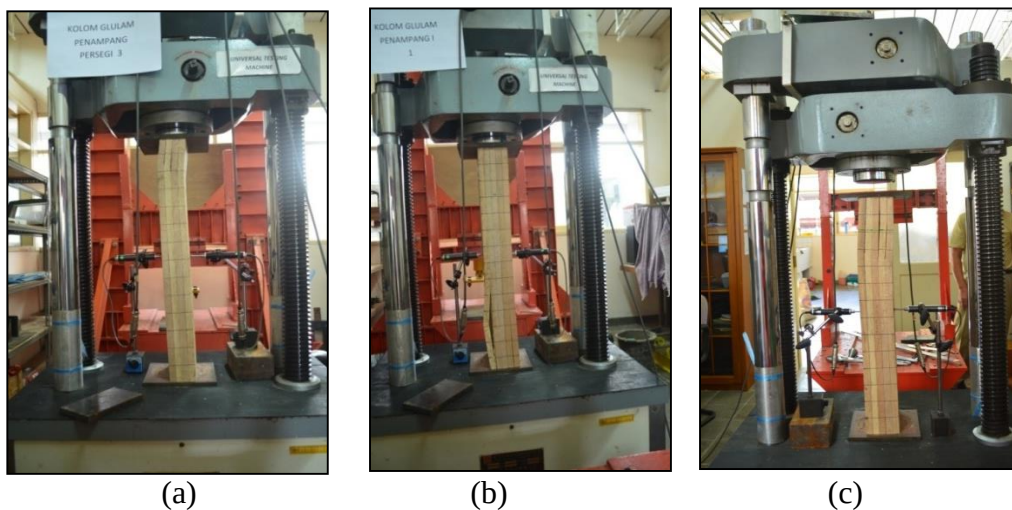


Figure 3. The glue-laminated columns under compression test on the universal testing machine, from left to the right: rectangular, I and box section

3. Results and Discussion

Being a compression member, a column generally is sufficiently long that the possibility of buckling needs to be considered. On the other hand, the short column term usually implies that a compression member will not buckle, and its strength is related to the crushing capacity of the material. Zahn (1991) explained that the behavior of wood columns as given by the Ylinen formula which is the result of the interaction of two modes of failure: buckling and crushing. Pure buckling is defined by the Euler critical buckling stress.

The second mode of failure is crushing of the wood fibers. When a compression member fails by pure crushing, there is no column buckling. Therefore, crushing is measured by the reference compressive design value parallel to grain multiplied by all applicable adjustment factors except stability column factor, C_p . As the slenderness ratio increases, the column expression makes a transition from a design value based on the crushing strength of wood (at a zero slenderness ratio) to a design value based on the Euler curve (for large slenderness ratios). The Ylinen column curve closely fits the results of column tests. Compared with previously used column formulas, the Ylinen equation gives slightly more conservative values for compressive members with intermediate slenderness ratios (Fig. 4).

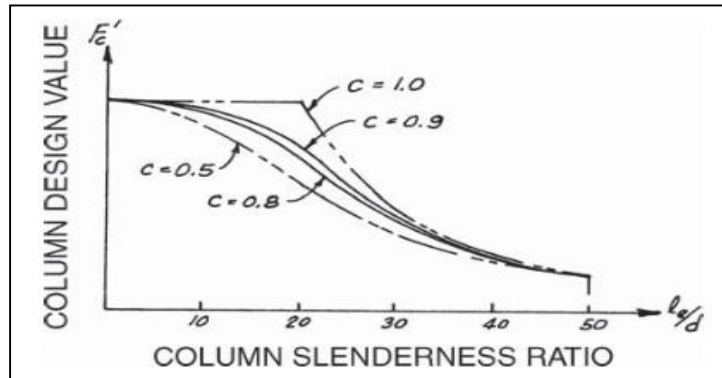
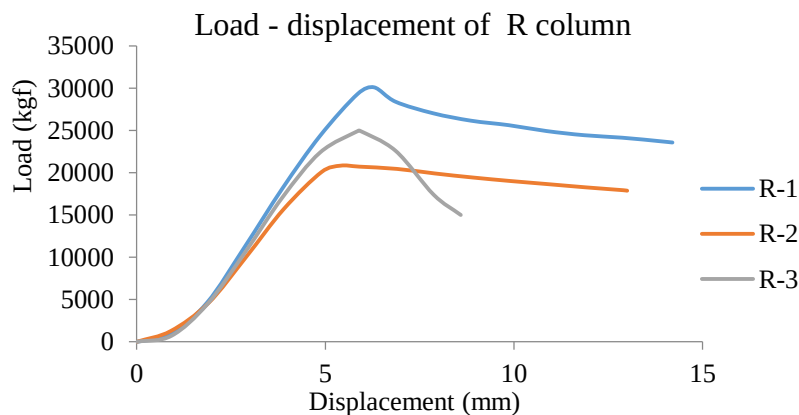


Figure 4. Plot of F'_c versus l_e/d showing the effect of different values of c . The parameter measures the interaction between crushing and buckling in wood column (Zahn, 1991)

The load vs displacement curves from the tests were presented in the Fig. 5. Tables 3 presented the experimental proportional load, experimental ultimate load, and theoretical ultimate load computed using SNI 7973-2013 and ratio of loads. Procedure of SNI method is shown in Fig. 6.

The failure mode was due to the buckling in the weak axis. The buckling stress was still lower than the compression strength of the materials, that means the elastic buckling was occurred. At early state of loading some slip was occurred and the displacement was corrected in the analysis of the modulus of elasticity. Tjondro (2007) has conducted research using nail-laminated column and got almost the same type of failure.



(a)

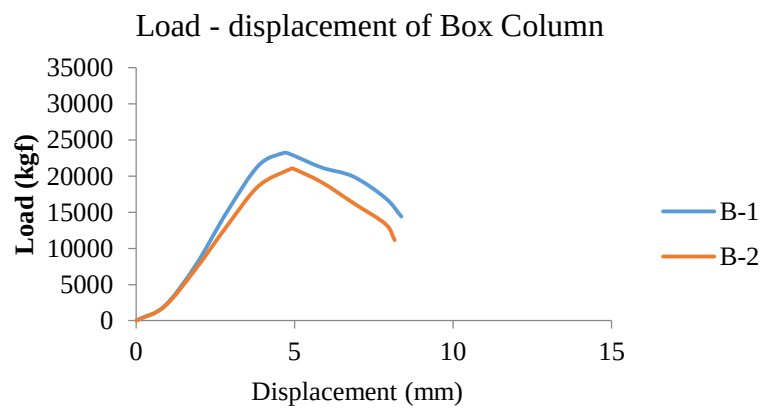
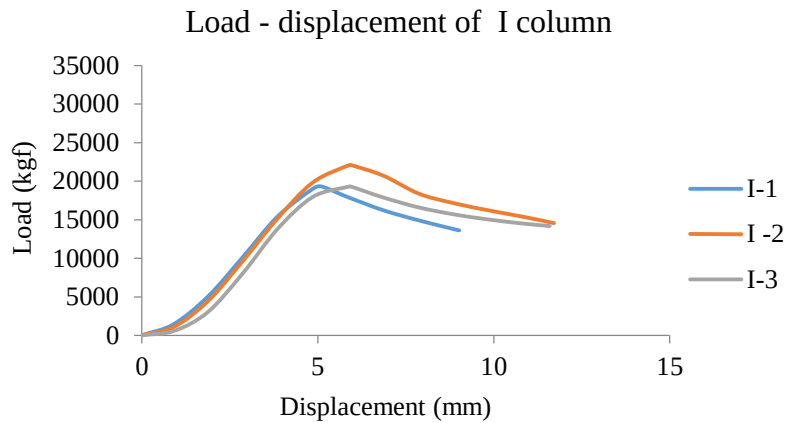
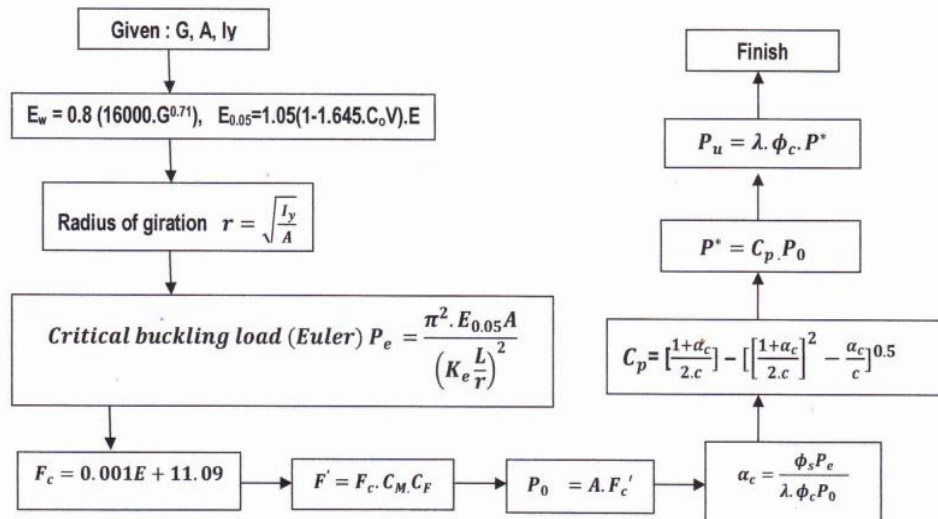


Figure 5. Load – displacement curve of column (a) Rectangular, (b) I, (c) Box

Table 3. Comparison between experimental ultimate load and “SNI” ultimate load

Specimen	G Gr/cm ³	I _y (cm ⁴)	E//Hooke (MPa)	P _p eks (kN)	P _u eks (kN)	P _u SNI (kN)	P _u SNI/eks (-)
R-1	0.33	654	3571	242.85	300.92	214.57	0.71
R-1	0.30	498	3031	160.71	208.26	200.64	0.96
R-1	0.30	564	3305	205.35	249.66	209.58	0.84
I-1	0.28	672	2963	157.69	193.05	199.57	1.03
I-2	0.30	636	3013	176.92	220.76	204.95	0.93
I-3	0.32	570	3115	150	193.04	200.46	1.04
B1	0.35	1002	3873	200	231.95	208.63	0.90
B2	0.30	972	3273	176.92	210.29	198.02	0.94



Where : G = specific gravity, A =cross section area (cm²), Iy = moment of inertia (cm⁴), E_{0.05} =corrected elastic modulus at 5%tail, L = length of column (cm), F_c= compression strength parallel to the grain (MPa), F' = corrected F_c, P₀=crushing load (N), φ_c = compression resistance factor, φ_s = stability resistance factor, λ = time factor, Pu = theoretical ultimate buckling load (N)

Figure 6. Procedure of SNI method to compute ultimate load (SNI, 2013)

4. Conclusion

The mode of failure was first mode of buckling in the elastic range. Research shows that the calculations using the methods of SNI 7973-2013 resulted in lower column capacity than in the experimental test. Thus the column design using such methods can be considered as to be the safe side.

Acknowledgement

The authors would like to thank to Laboratory of Department of Civil Engineering staff, Parahyangan Catholic University, Bandung for technical support.

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Evaluation of In-plane Shear Performance for CLT Panel

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Abstract

Walls made of cross laminated timber (CLT) offer several advantages over conventional timber structural walls due to their simplicity on construction and high rigidity. One benefit of CLT wall is high horizontal shear stiffness and strength against in-plane loading. Therefore, we might have possibility to design mid-rise or high-rise timber building with large openings by CLT walls. In earthquake-prone countries, that kind of in-plane shear stiffness and strength of CLT walls are one of important structural properties. To evaluate the load carrying capacity of them, the finite element analyses and element tests were performed and confirmed by horizontal loading shear tests. The models for the calculation were consisted of beam and spring elements. The test results were in agreement with the Flaig's theoretical solution.

Keywords: Cross laminated timber, FEM, In-plane deformation, Shear test, Shear wall

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1. Introduction

CLT structures became in common gradually. As Fig. 1 shows, in-plane shear strength of CLT panel is one of important value to design the structure, but the calculation method is not in general. Horizontal loading test of CLT panels were performed (Nakashima, 2015) and compared with the theoretical value applied by Flaig (2013). Element tests were performed to determine the material properties for the calculations.



Figure 1. Three stories CLT building (Seismic test specimen)

2. Materials and Method

2.1 In-plane shear strength

2.1.1 In plane shear strength equation

In-plane shear strength of CLT panels were obtained from the shear strength of laminae, the shear strength of crossing areas and the shape of CLT according to the reports of Flaig (2013). Three failure modes were defined as follows;

Failure mode I: Shear failure on longitudinal laminae

Failure mode II: Shear failure on lateral laminae

Failure mode III: Shear failure on crossing area between longitudinal and lateral laminae.

$$f_{v,CLT} = \min \begin{cases} f_{v,lam} & \text{modeI} \\ f_{v,lam,90} \cdot \frac{t_{net}}{t_{gross}} & \text{modeII} \\ \frac{b \cdot n_{CA}}{2 \cdot t_{gross}} \cdot \frac{1}{\frac{1}{f_{v,tor} \cdot \left(1 - \frac{1}{m^2}\right)} + \frac{2}{f_R} \cdot \left(\frac{1}{m} - \frac{1}{m^2}\right)} & \text{modeIII} \end{cases} \quad (1)$$

Here, $f_{v,lam}$: shear strength of laminae that parallel to the beam axis (N/mm²),

$f_{v,lam,90}$: shear strength of laminae that perpendicular to the beam axis,

$f_{v,tor}$: torsional shear strength between longitudinal and lateral laminae (N/mm²),

f_R : rolling shear strength (N/mm²),

b : laminae thickness (mm),

t_{gross} : CLT thickness (mm),

n_{ca} : numbers of crossing area along the thickness,

m : numbers of laminae along the height of CLT beam.

2.2 Material properties for the calculations

Table 1 and Table 2 show the characteristic values for the calculation of shear strength with Eqs.(1).

Table 1. Characteristic material properties for the Eqs.(1).

$f_{v,lam}$		$f_{v,lam,90}$	$f_{v,tor}$	f_R^*
N/mm ²		N/mm ²	N/mm ²	N/mm ²
Japanese Cedar	Cypress			
3	4	9	4	1.6

* The value based on the element test (Okabe, 2014).

Table 2. Characteristic values for the Eqs.(1).

n_{ca}				b		m
90mm	120mm □ Mx1	120mm □ Mx6	150mm	mm	mm	-
	20	0		Mx120	Mx60	
2	2	3	4	102	105	8

2.3 Inner laminae shear test

Fig. 2 shows the test set up of inner lamina shear test. The specimen cut from SS90K. The shear strength $f_{v, \text{lam}, 90}$, that is defined as load divided by shear area, was 9.27 N/mm^2



Figure 2. Shear test set up

2.4 Torsional test of glued layer

Fig.3 shows the torsional test to obtain the torsional shear strength $f_{v, \text{tor}}$. The specimens cut from SS150K. Test parameter was the length of one side of the square cross section a (50, 60, 70, 80 mm). The repetition of the tests (n) was 10. Total tested specimens were 40. The obtained shear strengths $f_{v, \text{tor}}$ were 3.67, 4.38, 4.16, 4.11 N/mm^2 , respectively.

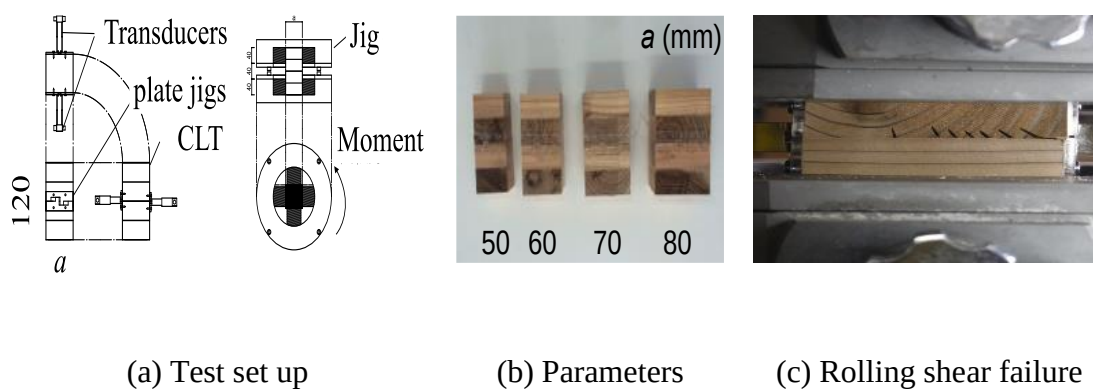


Figure 3. Torsional tests

2.5. Experiments

Fig. 4 shows the test set up. Table 3 shows the test parameters. Specimens were cut as I shape. The parameters were grain direction of outer laminae (vertical and horizontal), layout

of lamination (3 layer 3ply, 3layer 4 ply, and 5 layer 5 ply) and layout of grade (Japanese cedar only (Mx60) and combination of Japanese cedar and Cypress (Mx120)). The total number of repetition was one on each specimen. Narrow sides of laminae were not glued. Horizontal load was applied at the center of specimen.

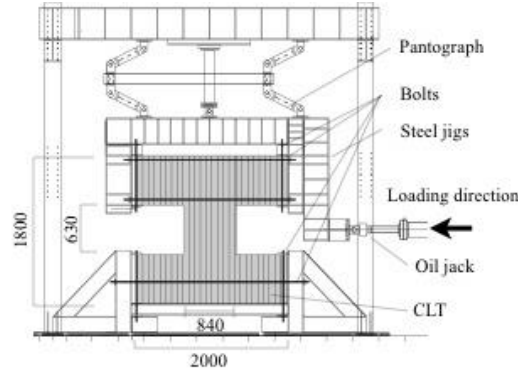


Figure 4. Horizontal loading test setup

The definitions of symbols are shown in Fig. 5 and Fig. 6. Shear stress was determined as horizontal load P divided by cross sectional area Bt .

$$\tau = \frac{P}{Bt} \quad (2)$$

$$\gamma = \frac{\Delta_{hs}}{l_v} \quad (3)$$

Here, P : Horizontal load (kN)
 B : Specimen width (mm)
 t : specimen width (mm)
 Δ_{hs} : Shear deformation (mm)
 l_v : height (mm)

Δ_{hs} is defined as follows;

$$\Delta_{hs} = \frac{\Delta_{ds}}{\cos R} \quad (4)$$

$$\Delta_{ds} = \frac{\Delta_{dL} - \Delta_{dR}}{2} - \frac{\Delta_{hU} + \Delta_{hB}}{2} \cdot \cos R - \frac{\Delta_{vL} + \Delta_{vR}}{2} \cdot \sin R \quad (5)$$

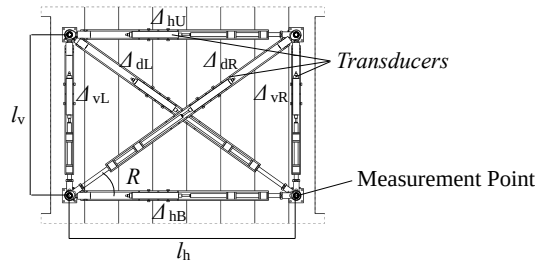


Figure 5. Definitions of shear deformation

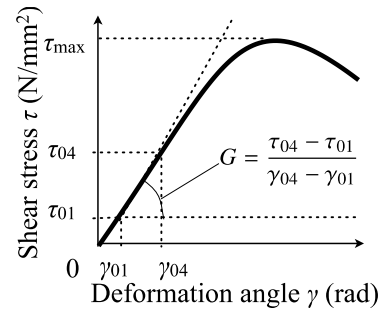


Figure 6. Definitions of strength and stiffness measurement

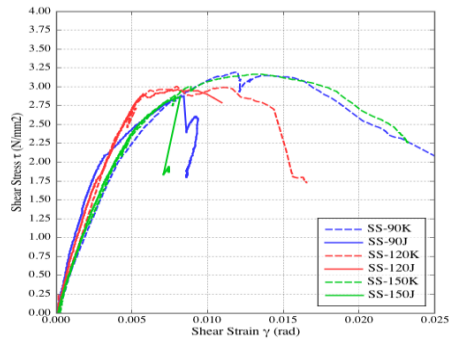
Table 3. Parameters of specimen

Specimen Name	Layer	Ply*	CLT Thickness t_{gross} (mm)	Lamina Thickness (mm)	Lamina Width b (mm)	Outer Laminae Direction	Grade (JAS)	Species
HS-150K	5	5	150	30	102	Vertical	Mx120	Y-E-E-E-Y
HS-150J	5	5	150	30	102	Horizon	Mx120	Y-E-E-E-Y
HS-120K	3	4*	120	30	102	Vertical	Mx120	Y-E-E-E-Y
HS-120J	3	4*	120	30	102	Horizon	Mx120	Y-E-E-E-Y
HS-90K	3	3	90	30	102	Vertical	Mx120	Y-E-E-E-Y
HS-90J	3	3	90	30	102	Horizon	Mx120	Y-E-E-E-Y
SS-150K	5	5	150	30	105	Vertical	Mx60	E-E-E-E-E
SS-150J	5	5	150	30	105	Horizon	Mx60	E-E-E-E-E
SS-120K	3	4**	120	30	105	Vertical	Mx60	E-E-E-E-E
SS-120J	3	4**	120	30	105	Horizon	Mx60	E-E-E-E-E
SS-90K	3	3	90	30	105	Vertical	Mx60	E-E-E-E-E
SS-90J	3	3	90	30	105	Horizon	Mx60	E-E-E-E-E

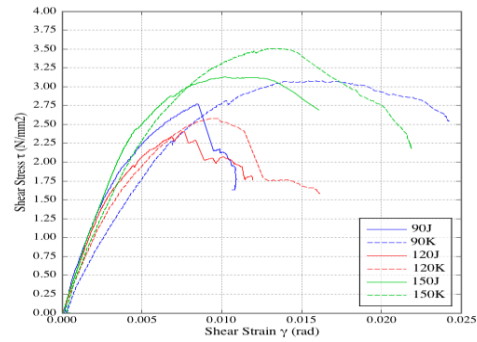
Species: Y = Cypress; E = Japanese Cedar. Asterisk: *the inner two-ply of HS-120K and HS-120J (3 layers 4 ply, Mx120) are glued parallel. That means laminae thickness of inner layer is 60mm; **the inner two-ply of SS-120K and SS-120J (3 layers 4 ply, Mx60) are glued alternately.

3. Results and Discussion

Fig. 7 shows the shear stress (τ) and shear strain (γ) relationship. The curves of 3 layers 4 ply, Mx60 (SS120J and SS120K) were not similar with the others because the composition of inner two-ply. The others showed non-linear curves with gradual plasticity. Horizontal specimens (J series) showed brittle failure because of the tensile failure of inner laminae.



(a) Mx60 (Japanese cedar)



(b) Mx120(Outer layer: Cypress, inner layer Japanese cedar)

Figure 7. Shear stress τ and shear deformation angle γ relationships



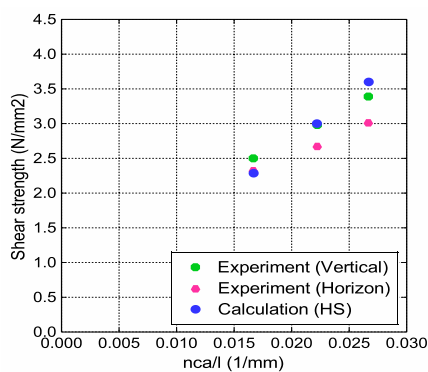
(a) Outer laminae direction: Vertical



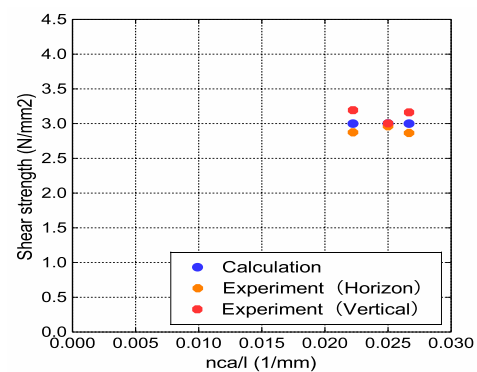
(b) Outer laminae direction: Horizontal

Figure 8. Rolling shear failure between vertical and horizontal laminae

Fig.8 shows the rolling shear failure, which is a mode III on chapter 2. The failure was caused by the torsion on the crossing between vertical and horizontal laminae.



(a) Mx60 (Japanese cedar)



(b) Mx120(Outer layer: Cypress)

Figure 9. Shear strength $\tau_{\max}$ and numbers of crossing along the CLT thickness n_{ca}/l relationships

The shear strength – ratio among the CLT glue width were shown in Fig.9. Calculated and experimental value showed a good agreement. The shear strength of horizontal specimens were lower than that of the vertical one. It seems that the stress concentration on inner laminae occurred on these one.

4. Conclusions

The in-plane shear test was performed to evaluate the shear strength of CLT panel. Test result was in agreement with the calculation applied by Flaig (2013).

Acknowledgements

This research is the part of the project of Forestry Agency, 2013 and 2014.

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The Effect of Different Methods to Determine Log Volume and Their Impacts to Veneer Recovery

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Abstract

Veneer production has not been determined accurately based on from the log consumption due to plywood production varies from year to year. This research has studied the influence of various factors of log (stem diameter, water content, density and form quotient) on the recovery of veneer. It was assumed that different methods in determining the volume of logs can lead to a different result of calculated veneer recovery. Model from the analysis of factors influencing the veneer recovery was found to be very useful to predict the number of veneers produced and thus to predict the number of plywood produced from the raw materials used. Allegedly, the determination of the volume of different methods will produce different veneer recovery. Determination of the volume with Brereton and Integral formula were selected as the best estimation for veneer recovery. Chi square test showed that the calculation of volume of log and veneer recovery by Brereton and Integral were not different.

Keywords: Log volume, Veneer recovery

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1. Introduction

As veneer is the raw material for plywood making, it is required to estimate the number of veneers produced from raw material available. Veneer yielded from log consumption is expressed as veneer recovery. The emphasis of this study was to determine the volume of logs as an input factor by Brereton and Integral formula to determine the veneer recovery by measuring the diameter and length of the log. It is known that different methods in determining the volume can produce different results of volumes (FAO, 2010). Among others, the methods of Brereton and Integral can be used in this case. Allegedly, different methods to state the volume will result in different veneer recovery. Results of previous studies mentioned that the factors that affect veneer recovery are log diameter, moisture content, density, and form quotient (Kewilaa, 2007a). However, in this research, only the effect of different methods to determine log volume and veneer recovery was investigated. Chi-square test for the significant rate of 5% and 1% was done to establish whether different methods to state log volumes will result in different veneer recovery.

The purpose of this research was to study whether there were differences in volume and veneer recovery due to the different methods of volume determination by Brereton and Integral. The benefits of this research were to understand the various methods to determine log volume

and its affect on veneer recovery and to predict the amount of plywood from raw materials available.

2. Materials and Methods

2.1 Materials, place, and time of study

Materials used in this research were 30 pieces of log of White Meranti (*Shorea spp*), Matoa (*Pometia piñata*), and Binuang (*Octomeles sumatrana*) ready for peeling. This research was conducted at The Plywood Industry, PT. Wainibe Wood Industry, Buru Regency, lasted for a month in December 2013.

2.2 Methods for Data Collection

Data collection included:

- 1) Measuring the diameter and length of the logs and then calculating the volume based on the Brereton and Integral formulas.
- 2) Calculating the volume by Brereton formula:

$$I = 0.7854 D^2 L / 10.000 (\text{input}) \quad (1)$$

where: I = volume of logs in m³; D = diameter of the logs in cm; L = length of logs in m.

- 3) The calculation of the volume by integral formula :
Bersand Karal (1976) suggested a formula to calculate the volume of a cone, which is:

$$V = \int_0^H \pi R^2 \left(t - \frac{t}{H}\right)^2 dt, \text{ or} \quad (2)$$

$$V(t) = \pi \int_0^H R^2 \left(t - \frac{t}{H}\right)^2 dt - \frac{1}{3} \pi \emptyset^2 (H - t), \text{ (input)} \quad (3)$$

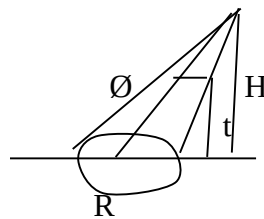


Figure 1. A pyramid

where: V = volume; 0 = lower height limit of the pyramid; H = upper height limit of the pyramid; t = height or length of the log; Ø = Radius of above plane; R = radius of the base plane; V(t) = stem volume.

- 4) Veneer volume measurements

Veneer volume is the number of veneer sheets x length x width x thickness (output)

- 5) Veneer recovery was calculated by the formula:

$$\text{Recovery} = \text{output} / \text{input} \times 100\% \quad (4)$$

- 6) Needs of veneer amount per sheet of plywood

Table1. Needs of total veneer per sheet of plywood.

Plywood (veneer core)	$\sum$ core veneers /sheet plywood	$\sum$ Face/Backveneers/sheet plywood
3-ply	1	2
5-ply	2	3
7-ply	3	4

2.3 Data Analysis

The statistical analysis used was the chi-square test (Steel and Torrie, 1991; Siagian and Sugiarto, 2006) with the formula:

$$fe = \frac{\sum \text{row} \times \sum \text{column}}{\sum \text{observations}} \quad (5)$$

$$X^2 \text{Cal} = \sum \frac{(fo - fe)^2}{fe} \quad (6)$$

where:

fe=expected value; fo=the value of the observation

$$\text{If } X^2 \text{Cal} \begin{cases} < X^2 \text{Table, receive } H_0 \\ > X^2 \text{Table, reject } H_0 \end{cases}$$

3. Results and Discussion

The study was conducted on 30 pieces of log, in which measurements of length and diameter of log follow the Regulation of the Director General of Forestry Production No.P.14/VI-BIKPHH /2009 (Anonymous, 2009).

This paper examined different log volumes by Brereton and Integral formulas (Appendix 1). The data shows that the volume obtained by the integral is 0.86 m³ while by Brereton is 0.87 m³. Veneer recovery based on volume by integral is 56.52% and by Brereton is 56.00%.

Chi-square test shows that X² calculation of log volume and veneer recovery are smaller than that of X² Table (Appendix 1 and 2), so it can be concluded that the volume calculation by Brereton did not have significant difference with the one by integral formula. Veneer recovery is a ratio between the volume of veneer to the volume of log as input factor.

The highest veneer recovery occurred on Matoa (55.55%) and the lowest one occurred on Benuang (42.41%). Data of veneer recovery, volume of veneer Face/Back and veneer cores per stem can be seen in Table 2 and 3.

Data in Table 3 reveals that the greater the diameter, the greater the veneer recovery except on the diameter class of 71cm - 80 cm. This means that the veneer recovery was not only influenced by the diameter but also by many other factors (Kewilaa, 2007b).

Table2. Veneer recovery, volumeFace/Backandcore/stem fordifferent wood species

No.	Wood sp	Σ pcs	Average Ø (cm)	Recovery (%)	Vol. Face/Back (m ³)	Vol. Core (m ³)
1	Binuang	4	68	42.41	0.266	0.139
2	Matoa	4	76	67.13	0.350	0.405
3	White Meranti	22	63	55.55	0.311	0.169
Average			66	56.00	0.3105	0.1961

Table3. Recovery, volume and the number of Face/Back and core veneer for interval classdiameter

No	Interval class Ø	Σ pcs	Average Ø (cm)	Recovery (%)	Vol. Face/ Back/log (m ³)	Vol. Core/ log (m ³)	Tot sheet Face/Back	Tot sheet core
1.	41-50	6	47	38.40	0.121	0.048	484	60
2.	51-60	4	56	57.13	0.252	0.102	671	92
3.	61-70	4	64	64.38	0.321	0.188	856	156
4.	71-80	15	75	59.36	0.383	0.269	3830	840
5.	81-up	1	83	69.12	0.554	0.404	369	84
Tot		30		1675.99	9.3162	5.8828	6211	1233
Av			66	56.00	0.31105	0.1961	207	41

3.1. Factors affecting veneer recovery

Factors that affect the level of veneer recovery are wood species, wood diameter, and volume resulted from different determination methods (Kewilaa, 2007a and FAO, 2010) as explained below:

1) Wood species

Different wood species has different physical properties includes density (Martawijaya et al. (1981), but it has little influence on veneer recovery (Feng,et al. 2013). Kewilaa (2007) stated that each species has specific physical properties and form quotient that lead to different volume and impact to veneer recovery. Martawijaya et al. (1981) and Kewilaa (2009) suggested that wood species which has a specific gravity ranging from 0.40-0.70 is suitable for plywood.

White Meranti (*Shorea assamica* and *Shorea virescens*) have a specific gravity ranging from 0.38 to 0.62, so that those species are classified as a good species for veneer face and back (Martawijaya et al., 1981). The data in Table 2 shows that the average volume of veneer Face/Back is bigger than the volume of veneer cores per stem.

Matoa has a specific gravity ranging from 0.50 - 0.99 (Martawijaya et al., 1981) so it is classified as unfavorable for plywood. The data in Table 2 shows that the average volume of veneer face and back per stem is smaller than the volume of veneer core per stem. This means that veneer generated by matoa has a low-quality.

Benuang has a specific gravity ranging from 0.16 to 0.48, so that it suitable when used only for core veneer (Martawijaya et al., 1989). Table 2 shows that the average volume of veneer

face and back is bigger than the average volume of veneer core per stem. The data in Table 2 also shows that veneer recovery of Binuang is lower than White Meranti while Matoa is the highest.

2) Wood diameter

The data in Table 3 shows that log diameter is positively correlated with veneer recovery, except for the diameter class of 71-80. Feng et al., (2013) stated that log diameter had significant influence on veneer recovery. Kainama (1997) and Sari (2009) stated that the greater the diameter of log, the greater the veneer recovery.

3) Volume by different method

Data on Appendix 1 reveals that volume obtained by the integral formula is smaller than by Brereton. These results was in agreement with the opinion of FAO (2010) that the volume obtained from different methods can be different, and it has impact on veneer recovery.

Brereton Metric Method is a method applied in Indonesia (Anonymous, 2009), but Integral method is not because it is so difficult to understand by those who are not mathematician, so it requires the preparation of a table to facilitate the reading and use.

Some formulas assume that the geometry of log into different shapes such as cylinders, cones, or paraboloid that can be used to estimate the volume (FAO, 2010). Some of these formulas generally do not give the same results in terms of the average diameter of the base and the end of the log, so that each has a bias of the real volume, depending on how many different geometric shapes assumed of the actual form log. Smalian formula assumes that the geometric shape of log is paraboloid. Huber formula assumes that the average cross-sectional area is at the midpoint of the log. Formula of subneiloid became the rules of Brereton. Bear and Karal (1976) assumed that the log is a cone shape geometry.

Below are the formulas of Smalian and Huber:

$$1. \text{ Smalian } V = f (d_s^2 + d_l^2) L / 2 \quad (7)$$

$$2. \text{ Huber } = f d_m^2 L \quad (8)$$

Compared to the formulas of Brereton and integral, Brereton formula assumes that the average diameter is:

$$D \text{ log} = \frac{1}{2} ((d_1 + d_2) + (d_3 + d_4)) / 2 \text{ and } I = 0.7854 \times D^2 \times L \quad (9)$$

The diameter measurement by Brereton is the same as Smalian, i.e. the measurements are conducted on diameter at the base and the end, but the calculation is similar with Huber, ie only calculates median diameter (D). Integral method assumes the geometry shape as a cone and the volume calculation is the same as Smalian, but using a variable radius and not the diameter.

Veneer volume resulting from the peels is generally smaller than the volume of log. Therefore, generally, output/input is usually expressed as veneer recovery. Many factors that are thought to affect the veneer recovery, however, on this occasion only investigated the influence of different methods, namely the method of Brereton and Integral on veneer recovery. Chi square test showed that the determination of the volume by these methods are not different,

as well as veneer recovery. It is showed that the differentiation between volume and veneer recovery by Brereton and integral method are near to zero (Appendix 1 and 2).

3.2. Total plywood produced

Data in Appendix 2 show that the sheets number of face and back veneer produced were as many as 6211 sheets while the core were 1233 sheets. The analysis was based on the data in Table 1 which can predict the realization of the number of plywood as follows:

Table 4. Actual amount of plywood produced from 30 pieces logs

Type of plywood	Σ sheet core veneer	Σ sheet Face/Back veneer	Σ sheet plywood
3-ply	1233	2466	1233
5-ply	1232	1848	616
7-ply	1233	1644	411

It can be concluded that from 30 pieces logs, it can produce 1,233 pieces of 3-ply plywoods or 616 of 5-ply plywoods or 411 of 7-ply plywood of type. This means that there is an excess amount of veneer Face/Back of 3.745 sheets that must be prepared by providing at least 1,872 pieces veneer cores again for 3-ply. This amount can be prepared by providing a low density of raw materials or inferior species to provide the core veneer.

4. Conclusions

Log volume obtained by the integral formula is smaller than by Brereton, but the chi-square test showed that both the volume and veneer recovery generated by these two methods were not different. From 30 pieces of logs, 1,233 sheets plywood type 3-ply, or 616 sheets plywood type 5-ply, or 411 sheets plywood type 7-ply can be generated. There is an excess amount of veneer Face/Back of 3.745 sheets that must be prepared by providing at least 1,872 pieces veneer cores again for 3-ply. This amount can be prepared by providing a low density of raw materials or inferior species.

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Appendix 1. Chi square test on different in volume by Brereton and Integral method

	Ø2	Ø1	Avr.	Length	V.real	H=Pj*R2/	H-t	V(H)	V(H-t)	V pred	Y+	feY	fe	(f0-fe)2/	(f0-fe)2/	Total Chi	Diff.
N0	(X1)	(X2)	Ø		(Y)	(R2-R1_				Integral	Ypred		Ypred	fe Vol	fe V.Pred	Square	Volume
1	44	38	41	2.50	0.3301	18.3333	15.8333	0.9195	0.5923	0.3272	0.6572	0.3302	0.3271	0.00000003	0.00000003	0.00000005	0.003
2	50	44	47	2.49	0.4320	20.7500	18.2600	1.3438	0.9158	0.4280	0.8600	0.4320	0.4280	0.00000000	0.00000000	0.00000000	0.004
3	50	46	48	2.50	0.4524	31.2500	28.7500	2.0238	1.5759	0.4479	0.9003	0.4522	0.4480	0.00000005	0.00000005	0.00000009	0.004
4	53	43	48	2.50	0.4524	13.2500	10.7500	0.9642	0.5149	0.4493	0.9016	0.4529	0.4487	0.00000064	0.00000064	0.00000128	0.003
5	50	48	49	2.49	0.4696	62.2500	59.7600	4.0315	3.5668	0.4647	0.9342	0.4693	0.4649	0.00000014	0.00000014	0.00000028	0.005
6	56	44	50	2.50	0.4909	11.6667	9.1667	0.9478	0.4597	0.4881	0.9789	0.4917	0.4872	0.00000154	0.00000156	0.00000310	0.003
7	57	45	51	2.50	0.5107	11.8750	9.3750	0.9995	0.4918	0.5077	1.0184	0.5116	0.5068	0.00000144	0.00000146	0.00000290	0.003
8	60	52	56	2.49	0.6133	18.6750	16.1850	1.7416	1.1337	0.6079	1.2212	0.6134	0.6077	0.00000003	0.00000003	0.00000007	0.005
9	61	53	57	2.50	0.6379	19.0625	16.5625	1.8375	1.2052	0.6323	1.2702	0.6381	0.6321	0.00000003	0.00000003	0.00000005	0.006
10	62	58	60	2.49	0.7040	38.5950	36.1050	3.8432	3.1463	0.6969	1.4009	0.7037	0.6972	0.00000013	0.00000013	0.00000026	0.007
11	68	56	62	2.50	0.7548	14.1667	11.6667	1.6970	0.9478	0.7492	1.5039	0.7555	0.7485	0.00000067	0.00000067	0.00000134	0.006
12	69	57	63	2.50	0.7793	14.3750	11.8750	1.7729	0.9995	0.7735	1.5528	0.7800	0.7728	0.00000062	0.00000063	0.00000125	0.006
13	65	63	64	2.50	0.8042	81.2500	78.7500	8.8927	8.0968	0.7959	1.6001	0.8038	0.7963	0.00000026	0.00000026	0.00000053	0.008
14	69	61	65	2.48	0.8229	21.3900	18.9100	2.6381	1.8228	0.8153	1.6383	0.8230	0.8153	0.00000000	0.00000000	0.00000000	0.008
15	76	66	71	2.49	0.9858	18.9240	16.4340	2.8315	1.8544	0.9771	1.9629	0.9860	0.9769	0.00000004	0.00000004	0.00000009	0.009
16	73	69	71	2.49	0.9858	45.4425	42.9525	6.2732	5.2975	0.9757	1.9616	0.9854	0.9762	0.00000023	0.00000023	0.00000045	0.010
17	76	68	72	2.50	1.0179	23.7500	21.2500	3.5536	2.5454	1.0082	2.0261	1.0178	1.0083	0.00000001	0.00000001	0.00000002	0.010
18	77	69	73	2.49	1.0422	23.9663	21.4763	3.6810	2.6487	1.0322	2.0744	1.0420	1.0324	0.00000001	0.00000001	0.00000003	0.010

19	76	70	73	2.48	1.0380	31.4133	28.9333	4.7003	3.6726	1.0277	2.0656	1.0376	1.0280	0.00000011	0.00000011	0.00000023	0.010
20	78	70	74	2.50	1.0752	24.3750	21.8750	3.8416	2.7767	1.0650	2.1402	1.0751	1.0651	0.00000002	0.00000002	0.00000003	0.010
21	78	70	74	2.50	1.0752	24.3750	21.8750	3.8416	2.7767	1.0650	2.1402	1.0751	1.0651	0.00000002	0.00000002	0.00000003	0.010
22	79	71	75	2.50	1.1045	24.6875	22.1875	3.9913	2.8974	1.0939	2.1984	1.1043	1.0941	0.00000002	0.00000002	0.00000004	0.011
23	79	71	75	2.50	1.1045	24.6875	22.1875	3.9913	2.8974	1.0939	2.1984	1.1043	1.0941	0.00000002	0.00000002	0.00000004	0.011
24	79	73	76	2.50	1.1341	32.9167	30.4167	5.3217	4.1990	1.1228	2.2569	1.1337	1.1232	0.00000014	0.00000014	0.00000028	0.011
25	80	72	76	2.50	1.1341	25.0000	22.5000	4.1448	3.0216	1.1232	2.2574	1.1339	1.1234	0.00000003	0.00000003	0.00000005	0.011
26	81	73	77	2.50	1.1642	25.3125	22.8125	4.3022	3.1492	1.1530	2.3171	1.1640	1.1532	0.00000003	0.00000003	0.00000006	0.011
27	81	73	77	2.50	1.1642	25.3125	22.8125	4.3022	3.1492	1.1530	2.3171	1.1640	1.1532	0.00000003	0.00000003	0.00000006	0.011
28	86	74	80	2.49	1.2516	17.8450	15.3550	3.4190	2.1782	1.2408	2.4924	1.2520	1.2404	0.00000013	0.00000013	0.00000026	0.011
29	80	74	77	2.48	1.1548	33.0667	30.5867	5.4822	4.3389	1.1433	2.2981	1.1544	1.1437	0.00000015	0.00000015	0.00000030	0.012
30	87	81	84	2.50	1.3854	36.2500	33.7500	7.1077	5.7362	1.3715	2.7569	1.3849	1.3720	0.00000022	0.00000022	0.00000044	0.014
Σ	2080	1852	1966	74.86	26.072	814.214	739.354	104.438	78.6085	25.839	51.902	26.072	25.8299	0.00000679	0.00000685	0.00001364	0.242
Av	69	62	66	2.495	0.8691	27.1405	24.6451	3.4813	2.6203	0.8610	1.7301	0.8691	0.8610	0.00000023	0.00000023	0.00000045	0.008

$$X^2 \text{ Cal. (Vol)} = 0.000014$$

$$\left\{ \begin{array}{l} \leq X^2(0.05;29) = 42.6 \\ \leq X^2(0.01;29) = 49.6 \end{array} \right.$$

Appendix 2. Chi Square test on different in veneer recovery based on volume by Brereton and Integral Method

	sp	Ø2	Ø1	Aver.	Length	Vol.	Vol.	Vol.	Σ sht	Σ sht	Recov.	Recov.	Recov. +	fe	fe recv.	(f0-fe)2/	(f0-fe)2/	Total Chi	Diff
N0		(X1)	(X2)	Ø	m3	(Y)	Int	Vnr	F/B	core	(%)	Pred	Rec.Pred	Recovery	Predict	fe recov	fe Rec Pred	Square	Rec.
1	M	44	38	41	2.50	0.330	0.327	0.133	65	7	40.204	40.581	80.785	40.207	40.579	0.000000	0.000000	0.000000	0.38
2	M	50	44	47	2.49	0.432	0.428	0.143	70	8	33.032	33.341	66.373	33.034	33.340	0.000000	0.000000	0.000000	0.31
3	M	50	46	48	2.50	0.452	0.448	0.153	75	9	33.842	34.174	68.017	33.852	34.165	0.000003	0.000002	0.000005	0.33
4	M	53	43	48	2.50	0.452	0.449	0.149	70	9	32.958	33.207	66.165	32.930	33.235	0.000024	0.000023	0.000047	0.25
5	B	50	48	49	2.49	0.470	0.465	0.160	70	12	34.011	34.344	68.355	34.020	34.335	0.000002	0.000002	0.000005	0.33
6	M	56	44	50	2.50	0.491	0.488	0.277	135	15	56.389	56.721	113.110	56.295	56.816	0.000158	0.000157	0.000315	0.33
7	M	57	45	51	2.50	0.511	0.508	0.291	142	16	57.019	57.323	114.342	56.908	57.434	0.000218	0.000216	0.000434	0.30
8	M	60	52	56	2.49	0.613	0.608	0.306	137	28	49.830	50.263	100.093	49.816	50.277	0.000004	0.000004	0.000007	0.43
9	M	61	53	57	2.50	0.638	0.632	0.381	167	27	59.661	60.222	119.882	59.665	60.217	0.000000	0.000000	0.000001	0.56
10	M	62	58	60	2.49	0.704	0.697	0.437	225	21	62.028	62.654	124.683	62.054	62.628	0.000011	0.000011	0.000021	0.63
11	M	68	56	62	2.50	0.755	0.749	0.483	202	37	63.980	64.473	128.452	63.930	64.522	0.000038	0.000038	0.000076	0.49
12	M	69	57	63	2.50	0.779	0.773	0.510	216	39	65.455	65.990	131.445	65.420	66.025	0.000019	0.000019	0.000038	0.53
13	M	65	63	64	2.50	0.804	0.796	0.500	212	38	62.132	62.776	124.909	62.167	62.742	0.000019	0.000019	0.000038	0.64
14	M	69	61	65	2.48	0.823	0.815	0.543	226	43	65.958	66.601	132.560	65.975	66.585	0.000004	0.000004	0.000008	0.64
15	M	76	66	71	2.49	0.986	0.977	0.570	235	45	57.778	58.301	116.079	57.772	58.307	0.000001	0.000001	0.000001	0.52
16	B	73	69	71	2.49	0.986	0.976	0.429	182	32	43.476	43.914	87.389	43.494	43.896	0.000007	0.000007	0.000015	0.44
17	M	76	68	72	2.50	1.018	1.008	0.663	273	53	65.086	65.724	130.811	65.104	65.706	0.000005	0.000005	0.000010	0.64
18	M	77	69	73	2.49	1.042	1.032	0.589	253	35	56.488	57.045	113.533	56.505	57.028	0.000005	0.000005	0.000010	0.56
19	Mt	76	70	73	2.48	1.038	1.028	0.648	183	78	62.391	62.996	125.387	62.405	62.982	0.000003	0.000003	0.000006	0.61
20	B	78	70	74	2.50	1.075	1.065	0.717	287	60	66.666	67.305	133.971	66.677	67.294	0.000002	0.000002	0.000004	0.64
21	M	78	70	74	2.50	1.075	1.065	0.467	203	34	43.470	43.887	87.358	43.478	43.880	0.000001	0.000001	0.000002	0.42

22	M	79	71	75	2.50	1.104	1.094	0.736	295	61	66.602	67.239	133.842	66.613	67.229	0.000002	0.000002	0.000003	0.64
23	M	79	71	75	2.50	1.104	1.094	0.737	297	61	66.747	67.386	134.133	66.758	67.375	0.000002	0.000002	0.000003	0.64
24	M	79	73	76	2.50	1.134	1.123	0.626	293	39	55.224	55.770	110.994	55.241	55.752	0.000006	0.000006	0.000011	0.55
25	Mt	80	72	76	2.50	1.134	1.123	0.722	214	84	63.644	64.274	127.918	63.665	64.254	0.000007	0.000007	0.000013	0.63
26	Mt	81	73	77	2.50	1.164	1.153	0.773	245	85	66.383	67.025	133.408	66.397	67.011	0.000003	0.000003	0.000006	0.64
27	B	81	73	77	2.50	1.164	1.153	0.566	255	38	48.653	49.124	97.777	48.663	49.114	0.000002	0.000002	0.000004	0.47
28	M	86	74	80	2.49	1.252	1.241	0.701	325	45	56.040	56.519	112.559	56.020	56.538	0.000007	0.000007	0.000014	0.48
29	Mt	80	74	77	2.48	1.155	1.143	0.876	292	91	75.820	76.605	152.425	75.862	76.564	0.000023	0.000023	0.000046	0.79
30	M	87	81	84	2.50	1.385	1.371	0.958	369	84	69.119	69.847	138.965	69.163	69.803	0.000028	0.000028	0.000056	0.73
Σ		2080	1852	1966	74.860	26.072	25.829	15.240	6211	1233	1680.087	1695.633	3375.720	1680.087	1695.633	0.000603	0.000597	0.001200	15.55
		69	62	66	2.495	0.869	0.861	0.508	207	41	56.0029	56.5211	112.5240	56.0029	56.5211	0.000020	0.000020	0.000040	0.52

χ^2 Cal = 0.0012

$$\left\{ \begin{array}{l} \leq \chi^2 (0.05; 29) = 42.6 \\ \leq \chi^2 (0.01; 29) = 49.6 \end{array} \right.$$

Planing Characteristics of Laminated Bamboo Timber (LBT) Bonded with Phenol Formaldehyde Resin

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Abstract

Planing characteristics and quality of Laminated Bamboo Timber (LBT) for high performance furniture production was determined. Two sets of samples (LBT and White Meranti timber), each with 40 replications, were prepared and cut into a common sizes of 50 x 10 x 2 cm. The planing test procedures were based on a modified ASTM D1666-87 standard. The planing tests were carried out with a standard single-faced planing machine (SCM S630) equipped with 40 cm long cutterhead consisted of 4 blades. The surface qualities were classified into five different grades, e.g. grade I as excellent; grade II as good; grade III as fair; grade IV as poor and grade V as very poor. It was acknowledged in this study, that the planing quality of the LBT was of equal grade to that of White Meranti which has become one of the common furniture producing material. In general, the planing of the LBT and the white meranti fell into the grade I (very good). The LBT therefore appears to have a plausible opportunity of being a competitive wood substitute in furniture industry.

Keywords: High-grade furniture material, Laminated bamboo timber, phenol formaldehyde resin, Planing

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1. Introduction

Laminated bamboo timber (LBT) has been one of the popular bamboo products commonly produced and traded in the world nowadays as an alternative material to wood. This is as a result of the fact that, LBT seems to find a solution to the natural shape problem of bamboo since it is formed in rectangular sections called strips that are more suitable for use in traditional structural applications. It also reveals the natural and unique features of the bamboo material. Bamboo based panels has been reported to be superior to wood based panels in almost all performance indexes (Yang et al., 2014).

Literature has emphasized several differences that occur between bamboo and wood. Chaowana (2013) for example stressed the differences in the macroscopic and microscopic characteristics, chemical composition, physical and mechanical properties. For this reason, the methods of technology and equipment for wood processing cannot be directly and perfectly applied in the bamboo processing.

The LBT is still new especially in Malaysia despite the available stock of bamboo in the region and being ranked the second to rattan as the most important non timber forest product in the Peninsula (Razak & Latif, 1995). The low popularity of the LBT utilization is due to lack of detailed information about the machining properties that hardly exist. There are so many factors that influence the quality and possibility of the LBT to be utilized widely and commercially as the wood material. Since the anatomical and chemical composition of this material is different, the machining characteristics are also different from that of wood. A detailed investigation into the machining properties of LBT is therefore necessary especially when the material is to be used as wood alternative for furniture application.

The purpose of this study was therefore set to examine the machining characteristics of LBT, especially its planing process. This was specifically to determine the types of planing defects and defective area of the LBT and to compare such characteristics to that of White Meranti.

2. Materials and Methods

The study was conducted at Faculty of Forestry, University Putra Malaysia, Serdang and Forest Research Institute Malaysia (FRIM), Kepong, all in Selangor, Malaysia. The *Gigantochloa scortechinii* (Buluh Semantan) bamboo was used in this study. They were harvested from mature bamboo culms, having the age of 4 years old and above at FRIM which were planted for the purpose of study. This species is very common in Malaysia and suitable for making Laminated Bamboo Timber (LBT). The matured culms were identified and selected based on the characteristics stated by Razak et al. (2012).

Selected culms were harvested about 30 cm above the ground level and only about 9 m long from the base were used in the production of a four layered laminated boards for this study. The remaining upper portion was discarded due to its small diameter and thin wall. They were cross-cut into smaller segments. Each segment was split longitudinally into a small size containing both nodes and internodes. These splits were treated with 2% borax solution, air-dried and conditioned at 65% relative humidity for several weeks until equilibrium moisture content (EMC) was achieved. The splits were planed on both the inner and outer surfaces in order to remove the bamboo skin and then squared into bamboo strips. The strips were glued edge-to-edge to form a wide sheet with polyvinyl acetate (PVAc). The wide sheets bamboo were then plied into four parallel layered LBT using phenol formaldehyde (PF). The LBT formation was done with hot press at 140°C and pressure 14 kg/cm². The dimension of the LBT samples used for the testing were reduced into 50 cm x 10 cm x 2 cm. Fig.1 shows the manufacturing process of the LBT samples.



Figure 1. Preparation of test samples

2.1 Planing characteristics

The planing characteristic of LBT was tested in comparison with that of White Meranti (*Shorea spp.*). White Meranti was selected for comparison because of its popularity in the furniture production in Malaysia. It is in itself easy to work, but it has a very severe blunting effect on tools due to its high silica content just like bamboo. Bendikiene et al. (2015), related the effectiveness of wood machining to the blunting effect on the tools. Also, its grain are interlocked and can sometimes present problems during planing, and sawn or planed surfaces can be left fuzzy or ragged (Meier, 2015).

Two sets of samples (LBT and White Meranti), each with 40 replications, were prepared and cut into a common sizes of 50 cm x 10 cm x 2 cm, for the planing test. The test procedures were based on a modified ASTM D1666-87 standard (ASTM, 1994). Due to the limitation of material preparation, the length of the sample was reduced from 100 cm to 50 cm while the number of replications for test samples was also reduced from 50 samples to 40 samples for each treatment. All the samples were dried to a moisture content of $12 \pm 2\%$ and prepared with the grain orientation along the main axis of the specimen (parallel). The White Meranti samples were obtained from a local supplier in Malaysia.

The planing tests were conducted with a standard single-faced thicknesser machine (SCM S630) equipped with a 40 cm long cutterhead block having 4 blades. The rotational speed of the cutterhead was 4500 rpm. Two of 2.0 mm depth planings were made for each sample with a standard feed rate of 18 m/minute, giving a 0.8-mm knife mark interval. This is typical of immediate planing operations. The first planing was discarded, and only the second planing was taken for observation to ensure that all the samples were same in condition.

To minimize the gradual knife blunting effect on the planing test, the samples among the two material types were randomly fed into the machine. Knives and tools were kept in good cutting condition before the test. After planing, each specimen was visually examined and defective areas were measured as the defect type was also determined. Based on the total of defective area, the samples were classified into five quality grades (grade I = excellent or defect-free; grade II = good or less defective; grade III = fair or moderately defective; grade IV = poor or defective; grade V = very poor or highly defective). The grade classification was based on Abdulrachman & Karnasudirdja (1982) as shown in Table 1.

Table 1. Classification of wood machining characteristics

Defect Free Area (%)	Machining Quality	Quality Grade
0 – 20	Very bad	V
21 – 40	Bad	IV
41 – 60	Average	III
61 – 80	Good	II
81 – 100	Very Good	I

Source: Abdulrachman & Karnasudirdja (1982)

Transparent plastic sheets of the same area of the test sample were used to calculate the defective area. The plastic was carefully superimposed on the sample and all types of defect were carefully drawn on the plastic with a fine permanent marker. Each type of defect identified was labeled with number. Each type of drawn defect on the plastic was cut out and weighed. The defective areas and total defective area we calculated as follow:

$$\text{Defective area "n"} = \frac{\text{weight of plastic "n" defect}}{\text{weight of plastic}} \times 100\% \quad (1)$$

$$\text{Total defective area} = \text{Defective area "1"} + \text{defective area "2"} + \dots + \text{defective area "n"} \quad (2)$$

Defective free area was calculated as follow:

$$\text{Defective free area} = 1 - \text{Total defective area} \quad (3)$$

3. Results and Discussion

3.1 Defective area

The results from the planing test on the two different test materials are summarized in Fig. 2 and Table 2. Proportion of defects for each material was obvious. The LBT was better in terms of its overall planing quality (94% defect free area) than the White Meranti (89% defect free area). The overall defect free areas of the White Meranti were slightly lower than that of LBT. Torn grains were the major defects observed in LBT, while for White Meranti, fuzzy and torn grains were the type of defects detected with the torn grain as the main defect. Torn grains were observed in White Meranti at a much lesser extent. Out of the two types of defects, only one type—torn grain was present in LBT.

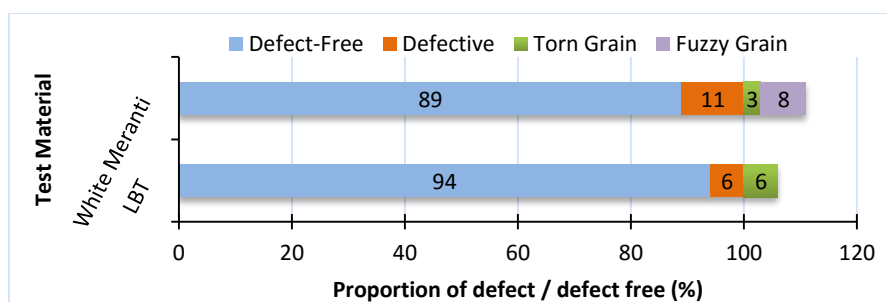


Fig. 2 Types and proportions of defect on the planing of the two different materials

Table 2. Machining class for LBT and White Meranti in planing test

Material Type	Number of Sample				
	Grade I*	Grade II*	Grade III*	Grade IV*	Grade V*
LBT	40(100%)	0	0	0	0
White Meranti	31(77.5%) **	6(15%) **	3(7.5%) **	0	0

Asterisk: * Grade I = (81-100) %; Grade II = (61-80) %; Grade III = (41-60) %; Grade IV = (21-40) %; Grade V = (0-20) %.

** Values in bracket is percentage of defect free area

3.2 LBT

The LBT experienced a very well planed surface with high defect free area. All the 40 samples tested in the grade I category (Table 2). Generally, out of the 40 samples, 6% of their surfaces were defective. The defects were consisted of torn grains. With this amount of defective areas, the LBT fall into grade I - excellent category (Table 2). Fig.3 shows the planed surface of the LBT with very fine surface finish. The LBT were much harder to plan, more vibration and much louder cutting noise were emitted during the cutting suggesting more torque was used during planing. Largely, the defects on the LBT were found at the nodes. This may be due to the inherent fibre structure of nodes, which is made up of irregular fibre orientation.



Fig. 3 The planed surface of LBT showing torn grain on the node of bamboo

3.3 White Meranti

The White Meranti as a control species perform as expected, where, out of the 40 samples tested (100%) were found to be in grade I, II and III (Table 2). Taken as a whole, 31 of White Meranti samples were in the grade I category(77.5%), 6 of them were in grade II (15%) and 3 of them were in the grade III category(7.5%). This justifies why it is highly sort after by the wood industry for furniture making. The defect types are mainly fuzzy and torn grains (Fig. 4) which were 8 and 3% respectively.



Fig. 4 The planed surface of White Meranti showing torn grain (left), and fuzzy grain (right)

3.4 Chips formation

Chip formation during the planing and its geometry on the two different material samples were analyzed. This was to give more insight into the planing characteristics of each tested material samples. The dust extractor hood was purposely removed from the thicknesser machine to allow better observation on the exit chips.

Fig. 5 shows the formation of exit chip among the two types of wood sample was obviously different. The exit chips were characterized with chips of shavings mixed with few dust and strands. The LBT produced more chips and strands with little dust while the White Meranti gave out shavings with dusted particles. The dusted particles were as a result of the planing of soft, thin-walled parenchyma cells, whilst relatively long strands were resulted from the planing of vascular bundles. Though bamboo consist of high density vascular bundles embedded in soft, thin-walled parenchyma tissues (Yu et al.2011).

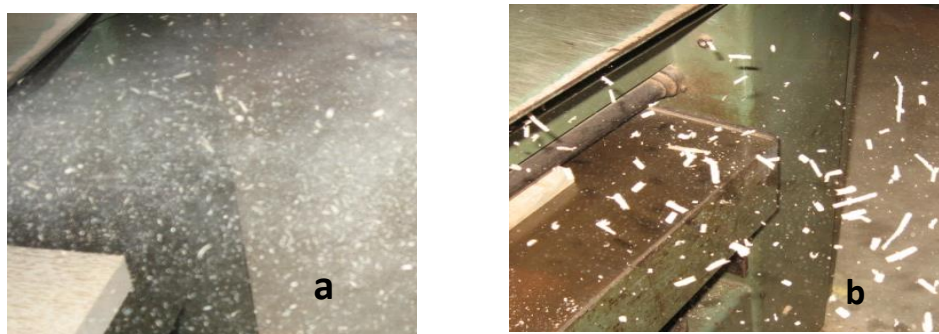


Fig. 5 Comparison of exit chip formation in the planning of (a) White Meranti and (b) LBT

The higher concentration of vascular bundles in bamboo (LBT) is expected to have produced a much long strands while the dried thin-walled parenchyma tissues usually break into dust-like particles. However, the penetration of the PF resin which was applied during lamination process stuck greater part of the vascular bundles to the parenchymatous tissues, making it more compact, and denser to prevent it from breaking into dusty particles. According to Bakar et al. (2008), the resin penetration also helps the parenchyma tissues and vascular bundles to reduce their density gradient and adhered tightly to each other. Consequently, more clean-cut shavings by the knives in the cutterhead were produced than strands and dusty particles (Fig. 6a). On the part of the White Meranti, the dried thin-walled parenchyma tissues were removed in broken dust-like particles since they were loosely adhered to themselves and the vascular bundles and hence producing shorter shavings with dust but devoid of strands (Fig. 6b).



Fig. 6 Comparison of exit particles in the planing of (a) LBT and (b) White Meranti

4. Conclusions

Laminated bamboo timber possesses higher strength properties and usage, as well as having well for machining characteristic. It is belonging to the machining grade I (very good), even better than the White Meranti that fall into grade I (very good) to 3 (average). Having such characteristics, these LBT are expected to be more important in the future furniture. With the sourcing of wood from natural forest becoming increasingly scarce, the used of LBT for future substitute to the wood industry is expected to receive good respond by the public. It is admitted in this study, that the planing quality of the LBT is of equal grade to that of White Meranti which has become one of the common furniture producing material. In general, the planing of the LBT and the White Meranti fell into the Grade I (very good). The LBT therefore appears to have a plausible opportunity of being a competitive wood substitute in furniture industry. A typical surface tracing is however recommended as a subject for further studies for higher improvement.

Acknowledgements

The work described in this paper is part of a project which was fully supported by a grant from the Universiti Putra Malaysia (RUG Grant no GP-IPB/2013/9413401). The authors also wish to express their gratitude to the staff of Faculty of Forestry and FRIM for their support in this study.

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D. BIODEGRADATION AND NON WOOD FOREST PRODUCT

The 7th International Symposium of IWoRS

Determination of Agarwood Resin Content from Different Formation Methods and Grades in Peninsular Malaysia

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Abstract

The objective of this investigation was to evaluate the effects of agarwood formation method and grade on the resin content of agarwood. Two types of agarwood formation were used in this study, inoculated and natural. A total of six agarwood samples were collected from *Aquilaria malaccensis* tree from different sources. The resin content of agarwood was determined based on extractable and alcohol method. The results show that the formation method and grade has significant effect on the total resin content in agarwood. The resin content obtained from inoculated agarwood for grade A, B and C value of 26.03%, 27.24% and 25.67% respectively. While, resin content from natural agarwood observed were 27.97%, 24.43%, 19.61% for grade A, B and C. Generally, inoculated agarwood are more consistent in terms of total resin content distribution irrespective of grades.

Keywords: *Aquilaria malaccensis*, Innoculation, Natural, Resin content

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1. Introduction

Agarwood is the fragrant resinous wood obtained from certain trees of *Aquilaria* species (Thymelaeaceae). This species also called as agarwood, eaglewood, gaharu, kanankoh, kyara, jinkoh or chen xiang in different cultures and used as incense and traditional medicine (Mei et al., 2013). According to Chakrabarty et al., (1994), agarwood is the trade name of fragrant wood which is used for incense, perfume, traditional medicines and other products. For centuries, trees of *Aquilaria* spp. have been harvested from the wild for the purpose of collecting agarwood, a highly commercial resinous wood used as incense (Yamada, 1995; Ng et al., 1997). The agarwood tree produces a resin as a defence mechanism against infection or injury – this is valued in many cultures for its distinctive fragrance, and is used as a principal component in incense and perfumes as well as in traditional medicines (Saikia & Khan, 2012). Throughout the range states (producer countries), there are 25 species of *Aquilaria* and 15 species are reported to form gaharu (Barden et al., 2000). But only *A. malaccensis* (syn. *A.*

agallocha) and *A. crassna* are more frequently associated with agarwood or gaharu. Agarwood has also been reported from species in several other genera (Burkill, 1966) within the same family. Among those species, five are found in Malaysia, i.e. *Aquilaria malaccensis*, *A. microcarpa*, *A. hirta*, *A. sub-integra* and *A. crassna*. (Suharti et al., 2011). According to Oldfield et al., (1998), *A. malaccensis* is found in 10 countries: Bangladesh, Bhutan, India, Indonesia, Iran, Malaysia, Myanmar, Philippines, Singapore and Thailand. It is also the main species producing agarwood in Malaysia which also commonly known as karas (Nor Azah et al., 2008). According to (Zhang et al., 2012), high-quality agarwood has high resin content and high ethanol-soluble extract content. Therefore, the aim of this study was to determine the resin content distribution from inoculated and naturally formed.

2. Materials and Methods

2.1 Materials

A total of six agarwood samples were collected from *Aquilaria malaccensis* tree from different sources shown in Table 1. Three samples from inoculated agarwood were coded base on location as I1 for (inoculated grade A), I2 for (inoculated grade B) and I3 for (inoculated grade C) while another 3 samples from natural were coded as N1 for (natural grade A), N2 for (natural grade B) and N3 for (natural grade C).

Table 1. Agarwood collected from various sources and location

Code	Sources
I1	Inoculated grade A
I2	Inoculated grade B
I3	Inoculated grade C
N1	Natural grade A
N2	Natural grade B
N3	Natural grade C

2.2 Samples preparation

The agarwood samples obtained were chipped using machete. The samples were ground into small particles in powder form with seize smallest to 200 µm using Endecotts Test Sieves. The moisture content of the samples was 8% before test conducted. For resin content study, the samples were soaked in ethanol for each source.

2.3 Determination of resin content

This analysis followed closely the protocol developed by WHO (1998). Ground sample (4 g) was accurately weighed in a flask and 100 ml of 95% ethanol were added. The mixture was shaken and allowed to stand for 1 hour. It was then refluxed for 1 hour and filtered rapidly using filter paper. A 25 ml subsample of filtrate was then transferred to a ceramic evaporating dish and evaporated to dryness in a water bath. The evaporated product was dried at 105 °C for

6 hours and cooled in desiccators for 30 min before weighing. The resin content (Figure 1) of the extractable matter from each of the 6 agarwood samples was calculated in % (w/w).



Figure 1. Resin content determination by ethanol extract

Statistical Analysis System (SAS) was carried out to determine significance level for the effects of resin content percentages. The results were further analyzed using Least Significant Difference Test (LSD) to identify which factor(s) gives the most influence on the agarwood quality.

3. Results and Discussion

In this study, agarwood from inoculated agarwood has consistently in range amount of resin content percentages gain which the highest was 27.24% from inoculated (I2) source and the lowest was 25.67% from inoculated (I3) source. Meanwhile, natural was found varied depending to the grades on resin content percentage where natural (N1) has highest value (27.97%) and the lowest value was obtained from natural (N3) (19.61%). Figure 2 and 3 illustrates the distribution of resin content of natural and inoculated agarwood.

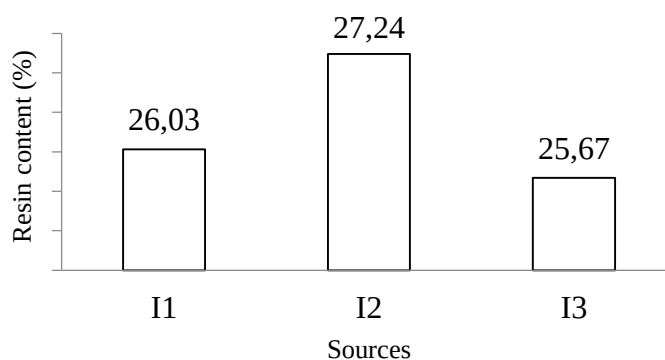


Figure 2. Resin content of inoculated agarwood.

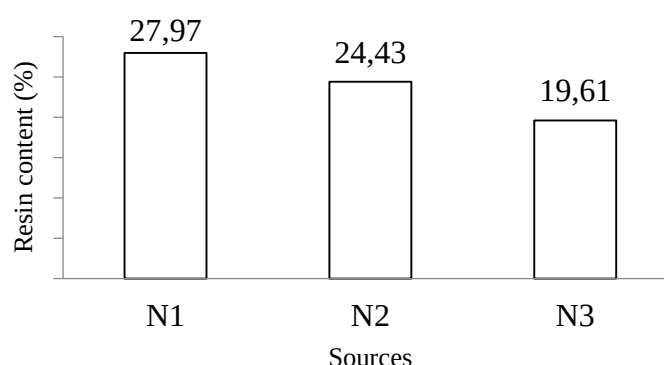


Figure 3. Resin content of natural agarwood.

Table 2 tabulates the summary of ANOVA for the effect of formation method and grade on the resin content. There were highly significant interactions between formation method and grade on the resin content of agarwood which were contributed by both factors.

Table 2. Summary of ANOVA for the effects of method and grade on the resin content

Source	DF	Pr > F	Significant
Formation method	1	0.0002	***
Grade	2	< 0.0001	***
Formation method*grade	2	< 0.0001	***

Note: *** significantly different at $p \leq 0.01$

For this project, three grades were used (grade A, B and C). All the grades represent each source from inoculated and natural agarwood. Grade A produced consistently high amount of resin content irrespective of formation method. The amount of resin content found in inoculated agarwood were observed consistently (25.67-27.24%) compare to naturally formed agarwood having more variability (19.61-27.97%) referred to (Table 3). One of the reasons for the consistency for this grade is because all inoculated samples were obtained from a plantation. The uniformity of inoculants and inoculation technique assure to the consistent of resin content. According to Persoon (2007), inoculation requires short period for agarwood formation, but produce a low agarwood yield. He also found that the resin produced in short period has inferior quality.

Table 3. Interaction effects between formation method and grade on the resin content

Grade	Formation method	
	Inoculated	Natural
A	26.03 ^a (0.53)	27.97 ^a (0.54)
B	27.24 ^a (0.89)	24.43 ^b (0.21)
C	25.67 ^b (0.31)	19.61 ^c (0.56)

Number in parenthesis are standard deviation (SD)

4. Conclusions

Inoculated agarwood show the consistency of resin content distribution despite coming from different sources. However, for natural formed agarwood shows the characteristic of agarwood depend on the maturity and period of infection to the tree that consequently affect the composition of the resin content. The distribution of resin content formation doesn't influence the grades of inoculated agarwood, but it almost approaching the natural agarwood resin content.

Acknowledgements

The authors gratefully acknowledge support from the Formulation Development Program, Natural Product Division, Forest Research Institute of Malaysia and Faculty of Forestry University Putra Malaysia (UPM) for all valuable guidance, comments, expertise, advice and suggestion on my project especially on statistical analysis part.

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Potential Development of Termite Control Systems for Land Productivity Improvement

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Abstract

Termites are naturally typical ecosystem engineers playing a major beneficial role through their support in essential ecological processes, although the insects are also known with their well-established role as pests. These roles are basically related to their living in a highly evolved social system of soldiers, workers, and reproductive classes obtaining most of their energy requirements from the digestion of cellulose. This characteristic gives an opportunity to develop termite control systems exploring their capability in breaking down specific, selected organic materials and producing biogenic materials. The current research is aimed at developing termite control systems being useful for land management, especially for the sustainability of land productivity. Newspaper wastes were prepared with and without the enrichment of nutrients and used as food sources in the form of bait stations. They were placed at Arboretum area of the Faculty of Forestry Tanjungpura University with three replications and allowed for 20 days. At the end of the period, the biogenic structures produced by termites were assessed for their physical and chemical properties. Soils around the termite stations were also sampled as control. Results showed that the bulk density, C-organic content, and C/N ratio of the produced biogenic materials were significantly better compared to the surrounding soils. The addition of enriched nutrient materials to the food source proved to increase the physical and chemical properties of biogenic products. The results underline that the biogenic structures produced by subterranean termites suggest the feasibility of using termite bait systems in maintaining or improving a land productivity.

Keywords: Biogenic structures, Land productivity, Soil structure, Subterranean termites, Termite bait systems.

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1. Introduction

Land productivity is a main factor in promising the sustainable production of agricultural and horticultural commodities. Unfortunately, the management practices of land owners in order to maintain their land production are mostly depending on the use of synthetic fertilizers. Therefore, it is undoubted that such kind of land practices can ecologically decrease their land productivity. The long term repetition of such a land management practice can cause the diminution of soil macro fauna which are expected to be naturally prevalent recyclers. In fact, it is well-known that existing macro- and micro-fauna in the soil ecosystem enable to reduce soil compaction, increase soil porosity, and provide nutrient-rich soil structure.

Termites provide the valuable service of recycling wood and other cellulose materials in the natural environment although they are also increasingly recognized as an economically significant deteriorating agent to wooden components of buildings. Termite controls for building protection, particularly in the form of bait systems, have been commercially available and generally accepted. The bait system employs slow action pesticide associated with an attractive food source to eliminate the attacking termite colony against termite attacks (Broadbent et al., 2006). The current study was aimed at manipulating or modifying the bait system by providing termites with a food source without the addition of toxic compounds. It was expected to attract termites and allow them to feed on paper wastes and result in biogenic products, improving soil physical and chemical properties.

2. Materials and Methods

2.1 Sample preparation

Two types of food sources for termites were prepared. They were the mixture of newspaper wastes and water as well as the mixture of newspaper wastes and soybean boiled water, each with the ratio of 1:10 (w/v). The soybean boiled water was obtained by boiling 400 g of soybean in 6000 ml of water for about one hour and supposed to be nutrient enrichment. The mixture was blended, dried, shaped to the size of 2 x 2 x 1 (cm) and then conditioned at 60°C for 48 hours. The conditioned shaped samples (approximately 100 g) were put into transparent plastic containers (H 20 cm, W 11 cm) with 3 mm-holes (6 holes at the bottom and 24 holes at around side). These plastic containers were considered as experimental units in the field test.

2.2 Field assay

Field assays were conducted at the Arboretum Sylva of Tanjungpura University (24-30°C; RH 77-93%). The test units were placed on the ground with the distance of 1 m each (Fig. 1.) and left for 20 days to allow the termite attacks. The attacked samples were then analysed for their structure and chemical properties. The soil sample from the surrounding test unit was also collected by using soil rings and used as control. Each experiment was conducted with three replicates. The physical properties of soil and produced biogenic structure were evaluated based on the procedures by Decaëns et al.,(2001). While, their chemical properties consisting

of C-organic content and C/N ratio were analysed in the laboratory using spectrophotometer (Rayleigh UV – 1800).

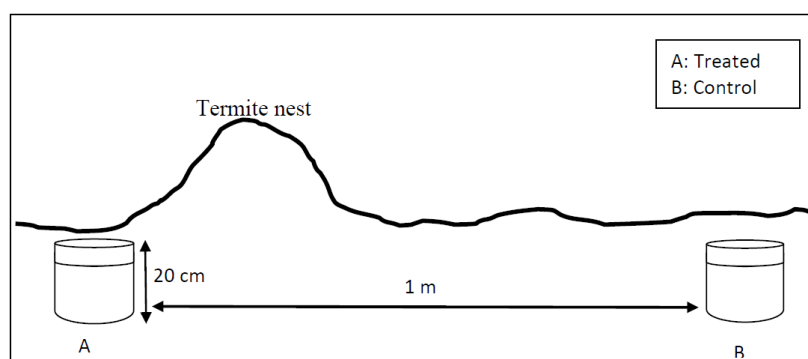


Figure 1. Placement of experimental units in the field assay

Termites found at all experimental units were collected and placed in small bottle jars containing 70% ethanol for further identification. The termite identification was based on their morphological characteristics using microscope and compared to references (Tho & Kirton, 1992; Nandika et al., 2003).

3. Results and Discussion

The biogenic structure produced in the field was found as a part of the biological activities of termite *Termes*, *Schedorhinotermes*, and *Discupiditermes*. The active termites attacking food sources depend on the types of baits. All the three termite genus were found at the bait stations with the enrichment of nutrient contents and only genus *Termes* and *Schedorhinotermes* were found at the bait stations without nutrient enrichment. This result indicated the important of adding nutrients to food sources made of paper wastes to attract more termite species. It is not only for the quality improvement of biogenic products, but also for the support of termite growth.

The bulk densities, C-organic contents, and C/N ratios of the surrounding soils and biogenic products are as shown in Fig. 2, 3, and 4. Generally, the results showed that the biological activity of termites in relation to the use of bait materials as food sources resulted in biogenic structures with lower density as well as higher C-organic content and C/N ratio compared to the surrounding soil. The lower density of biogenic structure (Fig. 2.) indicated the support of termite activities in increasing soil porosity. It is in line with the previous study conducted by Decaëns et al. (2001) showing that the density of biogenic product is lower than that of control soil. In addition, it was stated that the mixture of low density biogenic products and surrounding soil perform benefits to soil physical properties, particularly aeration and soil porosity. Mora et al., (2006) have observed the spatial distribution of biogenic structures produced by termites and other organisms, showing that the produced biogenic structures generally represent a large number of soil components having been modified by the soil organisms.

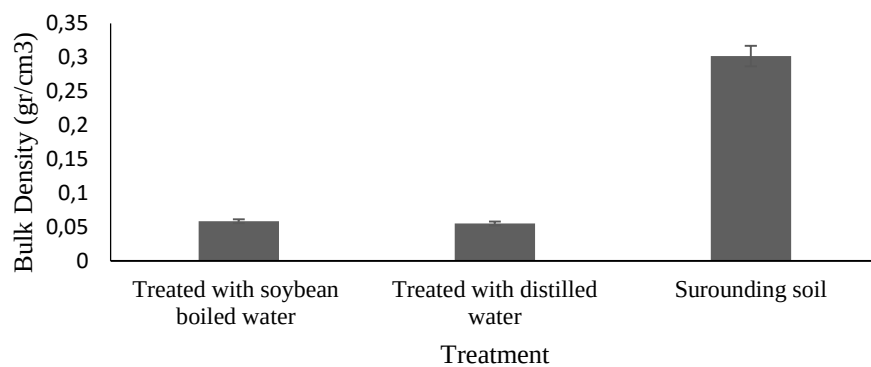


Figure 2. Bulk densities of biogenic structures and the surrounding soil.

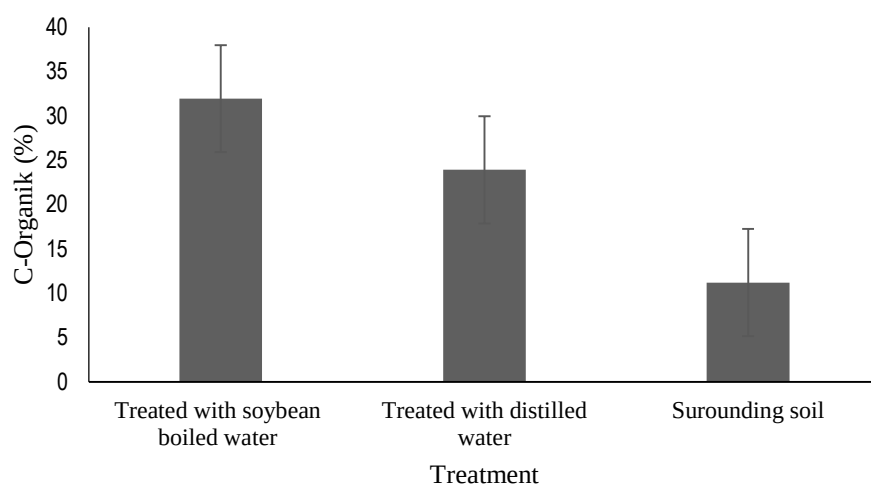


Figure 3. C-organic contents of biogenic structures and the surrounding soil.

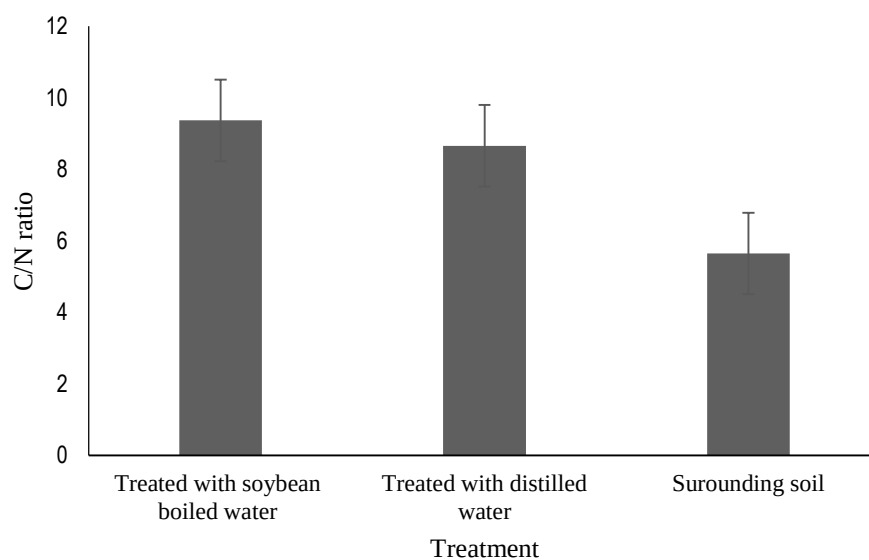


Figure 4. C/N ratios of biogenic structures and the surrounding soil.

Figs. 3 and 4 show that all biogenic products have significantly higher nutrient contents compared to the surrounding soil. Baits with the enrichment of nutrients are likely to have higher C-organic content and C/N ratio, although it was not significantly different with the baits without nutrient-enriched material. The results indicate the need of exploring the relationship between the nutrient content of bait materials and the termite growth.

4. Conclusions

Food sources made of paper wastes with the enrichment of its nutrient content with an appropriate composition are potential to be further developed and used as termite baits, especially for *Termes*, *Schedorhinotermes*, and *Discupiditermes*. Current resulted data indicates the attractiveness of paper waste-based formulation as food sources for the termites. The bioconversion of the food sources by the termites produced biogenic materials with lower density and higher organic content compared to the surrounding soil, potentially contributing to the improvement of land productivity.

Acknowledgements

The author gratefully acknowledges Directorate General of Higher Education of Indonesia for financial support in Fiscal Year 2015 under Program“International Research Collaboration and Scientific Publication”

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Identification of Metabolite Products from Biotransformation of PAHs Mixture by a pH-saline Tolerant Fungus, *Pestalotiopsis* sp. NG007

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Abstract

In this study, the ability of *Pestalotiopsis* sp. NG007 to degrade and transform PAHs was examined using four PAHs: acenaphthene (ACE), anthracene (ANT), chrysene (CHRY), and benzo[a]pyrene (BaP) in liquid medium. The experiments were conducted at different pH (3–12) and salinities (0–10%). The results showed that the biodegradation of PAHs mixture was dependent to pH and salinities. All the PAHs showed maximum degradation at range pH 3–5 and salinities 2–3.5%. The maximum degradation for ACE, ANT, CHRY, and BaP were 100%, 91%, 76%, and 68%, respectively. The biomass weight of strain NG007 increased from pH 3–11 (0.28–0.42 g/20 mL media), but dramatically decreased at pH 12 (0.20 g/20 mL media). In saline, strain NG007 grew higher than non-saline with optimum biomass was obtained at salinity of 2.5%. Analysis of metabolites using GC-MS showed that at least 11 compounds were detected. Strain NG007 degraded ACE via the formation of 1-acenaphthenol (I), acenaphthenon (II) and naphthalic anhydride (III). Anthraquinone (IV) detected in the culture can be identified as a metabolite from ANT degradation. In addition, the presence of 1-hydroxy-2-naphthoic acid (V) may indicate the metabolism of CHRY and BaP. Other compounds such as gentisic acid (VI), mandelic acid (VII), phthalic acid (VIII), catechol (IX), benzaldehyde (X), and benzoic acid (XI) indicated that the biodegradation of the major metabolites into small compounds was occurred. This study demonstrated that strain NG007 may have the potential for degradation of PAHs in contaminated environments.

Keywords: GCMS, ligninolytic enzymes, metabolites, PAHs, *Pestalotiopsis* sp.

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1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a class of important environmental pollutants which usually occur during the uncompleted combustion process. Their occurrences

have a major concern due to persistent, toxic, and carcinogenic properties (Bammarito et al., 2010). Microbial biodegradation is one of the most important natural processes which can influence the fate of pollutants in both terrestrial and aquatic environment. Little information is available of the biodegradation on PAHs by mangrove fungi. In this study, we investigate the biodegradation of PAHs mixture by *Pestalotiopsis* sp. NG007, a pH-saline tolerant fungus in liquid medium at different pH and salinities (Yanto et al., 2014).

2. Materials and methods

2.1. Chemicals

Four PAHs: acenaphthene (ACE), anthracene (ANT), chrysene (CHRY), benzo[a]pyrene (BaP) were used as substrates and pyrene (PYR) was used as an internal standard. 1-Acenaphthol (ACE-OH), 1-acenaphthene (ACE-ON), gentisic acid (GA), mandelic acid (MA), benzoic acid (BA), anthraquinone (ANTQ), 1,8-naphthalic anhydride (1,8-NA) were used as standard metabolites. All standards were purchased from Tokyo Chemical Industries, Ltd.

2.2. Microorganism

Pestalotiopsis sp. NG007 was previously isolated from mushroom associated with rotting wood. The strain was maintained in malt extract agar medium (MEA) containing malt extract 20 g L⁻¹, glucose 20 g L⁻¹, polypeptone 1 g L⁻¹, and agar 20 g L⁻¹ in disposable Petri dish under dark condition at 25 °C.

2.3. Experiment

Strain NG007 was pre-cultured in 20-mL ME liquid medium for 7 days. Mixture of PAHs contained 1 mg of ACE, ANT, CHRY, and BaP were mixed with 20 µL of Tween 80 and dilute with dimethylformamide (DMF) until 250 µL. All the mixtures were added to the pre-incubated culture and incubated for degradation in the dark at 25 °C.

2.4. Analysis of PAHs biodegradation

The PAHs mixture was extracted by solvent-solvent extraction using 100 ml ethyl acetate (EtOAc) three times. The dried extract was diluted with 2 µL of toluene and injected to GC Shimadzu 2014. In order to identify the molecular structure of metabolite products, the dried extracts were dissolved in 40 µL of toluene and 20 µL of N,O-bis-trimethylsilylacetamide (BSA) for trimethylsilylated (TMS) reaction at 70 °C for 20 min. The trimethylsilylated extracts were analyzed by GCMS (Shimadzu QP-2010) using a similar methods as previously reported (Yanto & Tachibana, 2013). Ligninolytic activities were assayed using a UV-Vis spectrophotometer (Shimadzu UV-1600) (Yanto & Tachibana, 2014).

3. Results and Discussion

Pestalotiopsis sp. has the ability to degrade all the PAHs mixture in the culture. The results showed that the biodegradation of PAHs mixture was dependent to pH and salinities. The biodegradation ability decreased with the increasing of initial pH medium. All the PAHs showed a maximum degradation at pH 3 and salinities 2–2.5%. The biodegradation of ACE, ANT, CHRY, and BaP at pH 3 were 77%, 60%, 60%, and 56%, respectively (Fig. 1).

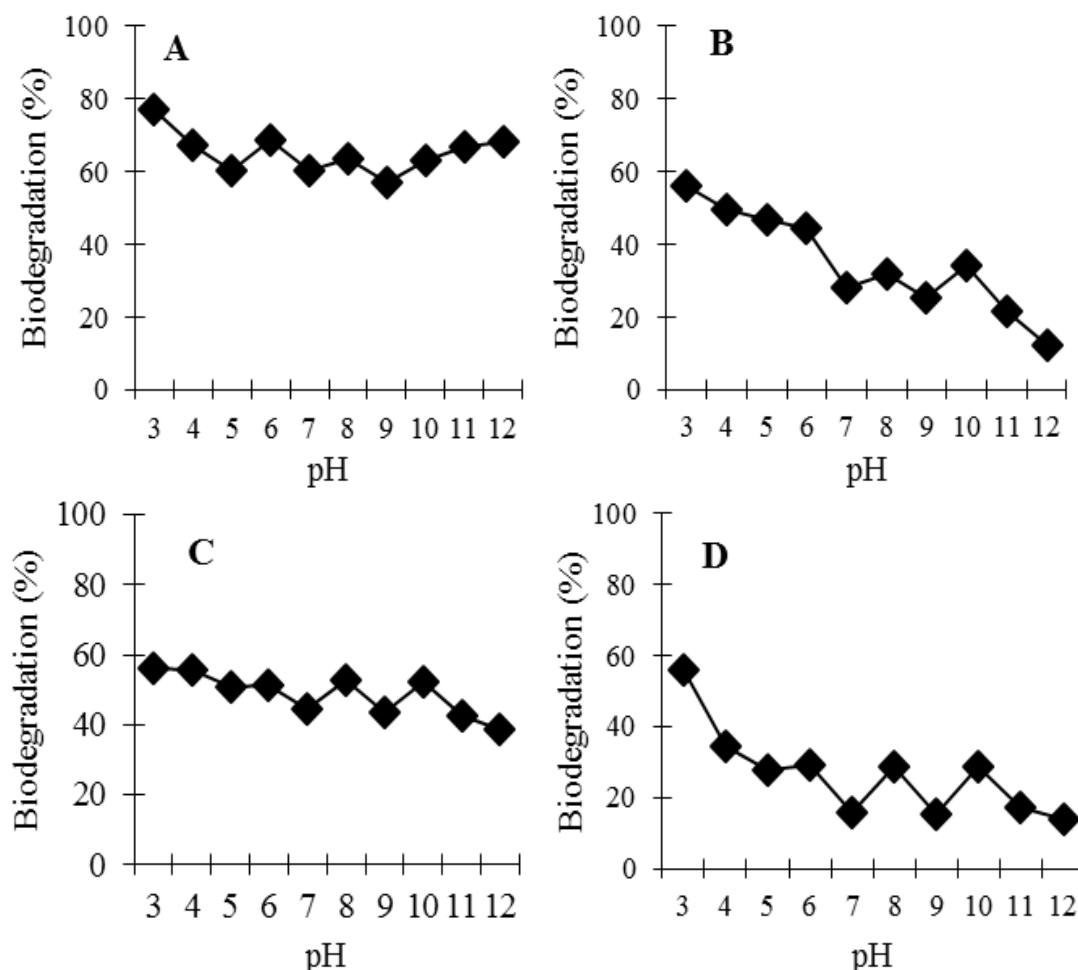


Figure1. Biodegradation of ACE(A), ANT(B), CHRY(C), and BaP (D) by *Pestalotiopsis* sp. at different pH

Under saline condition, the maximum degradation of ACE, ANT, CHRY, and BaP were 100%, 91%, 76%, and 68%, respectively at salinity 2.5% for ACE, CHRY, and BaP, and salinity 2% for ANT (Fig. 2).

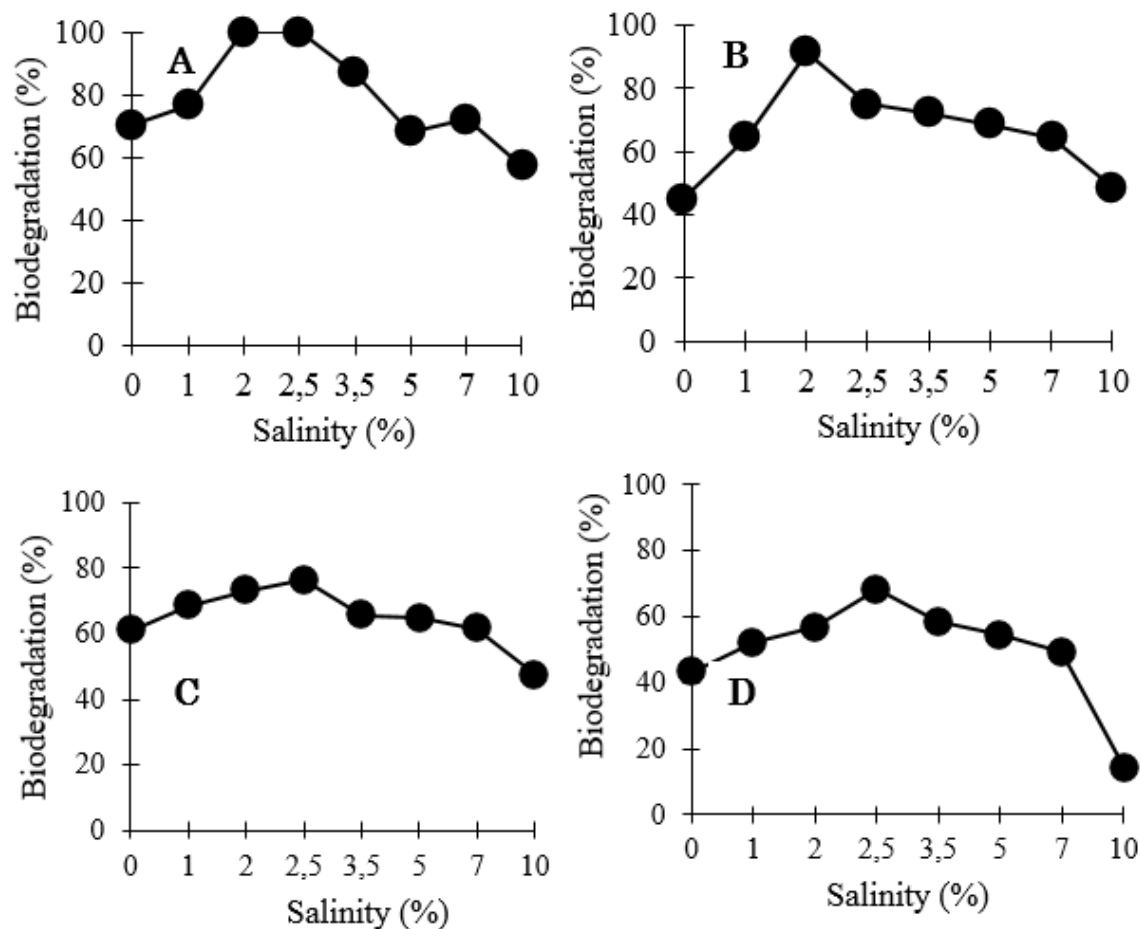


Figure 2. Degradation of ACE(A), ANT(B), CHRY(C), and BaP (D) by *Pestalotiopsis* sp. at different salinity

The fungal growth rates showed that strain NG007 can grow at different pH and salinities. In general, the biomass increased from pH 3 to pH 11, but dramatically decreased at pH 12. Under saline condition, the biomass reached its maximum at salinity 2.5% but dramatically decreased at salinity 10%. All these results indicated that strain NG007 is a pH-saline tolerant fungus. In addition, the biodegradation capacity decreased with the increasing of ring number in PAHs.

Analysis of metabolites using GC-MS showed at least 11 compounds were detected (Fig. 3). Strain NG007 degraded ACE via the formation of 1-acenaphthenol (I), acenaphthenone (II) and naphthalic anhydride (III). The presence of anthraquinone (IV) in the culture can be identified as a metabolite from ANT degradation. In addition, the presence of 1-hydroxy-2-naphthoic acid (V) may indicate the metabolism of CHRY and BaP. Other compounds such as gentisic acid (VI), mandelic acid (VII), phthalic acid (VIII), catechol (IX), benzaldehyde (X), and benzoic acid (XI) indicated that the biodegradation of the major metabolites into small compounds was occurred.

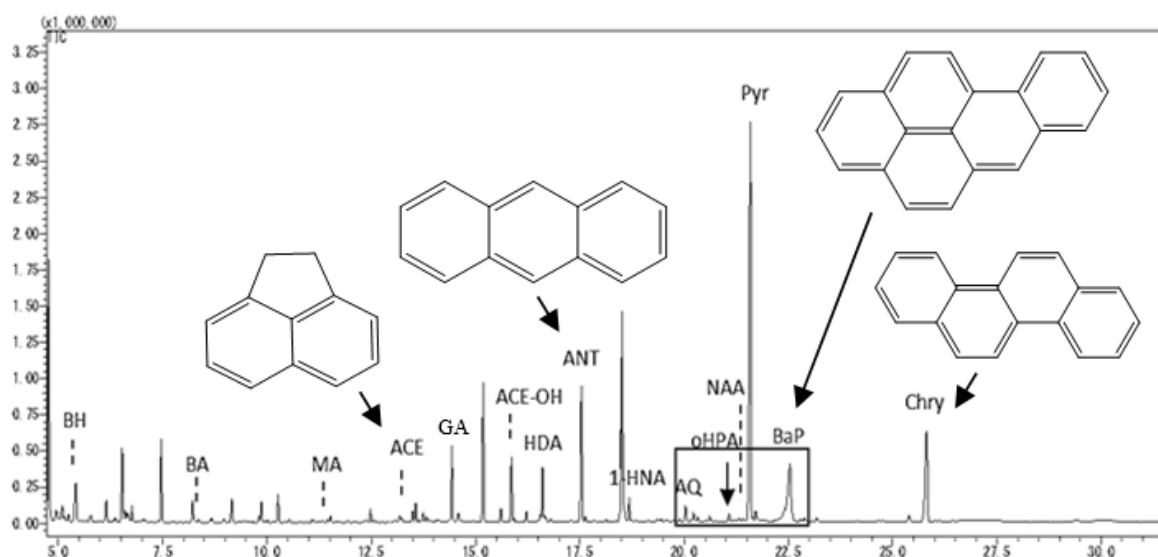


Figure 3. GC-MS profile for metabolite analysis of PAHs mixture using TMS derivatization

4. Conclusions

This study demonstrated that strain NG007 can degrade all the PAHs in the mixture at different pH and salinities. The strain may have the potential for degradation of PAHs in contaminated environments.

Acknowledgement

Part of this research was supported by KAKENHI-Japan (26450232).

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E. FOREST PRODUCT CHEMISTRY AND BIOREFINERY

Characterization of Liquid Product from the Result of Biomass Material Pyrolysis: Rice Hull and Bagasse

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Abstract

A liquid product can be obtained from result of the condensation of gaseous product of pyrolysis of biomass materials containing lignin, cellulose, hemicellulose, and other carbon component. The application of liquid product from the condensation of gaseous pyrolysed product can act as preservative, antibacterial, and antioxidant agent that inhibit the spoilage of food products. Bagasse and rice hull can be used as biomass raw material samples and both material is considered to have similar contents with wood. Chemical compounds in liquid products are influenced by several factors, such as temperature. Therefore, this study utilizes bagasse and rice hull for production of liquid product pyrolysis method with temperature variations between 330 up to 500 °C. The pyrolyzed products were characterized using Gas Chromatography Mass Spectrometry (GCMS) to identify the chemical component containing in the liquid condensation. The results showed that the liquid product contains acid, phenol and carbonyl compounds and the most important component for especially food preservation is phenol compounds. The highest percent yield which is 33.73 % was obtained for pyrolysis of bagasse material at temperature of 500 °C. The main component of liquid product is phenol, acidic compounds, oxygenate compounds, and aromatic compounds and 2-Furancarboxaldehyde was the main component. And for pyrolysis of rice hull, the highest yield was obtained as much as 39.34% at s 450 °C. The analyses of GCMS, the liquid products were containing various compounds: carbonyl, aldehyde, ketone and carboxylic acid, fenol and furan with derivatives.

Keywords: Bagasse, Rice Hull, Pyrolysis, Liquid product, Yield

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1. Introduction

Pyrolysis is irregular decomposition process form organic compounds or complex compounds into three shape compounds which is solid, liquid, and gas as a result of heating process without air contact and high temperature. The gaseous product is generated because of imperfect combustion, which is combustion without oxygen involving decomposition polymer reaction into organic compounds with lower mass because of heat effect. A liquid product from the condensation of gaseous products resulted from pyrolyzed process from materials

containing lignin, cellulose, hemicellulose, and other carbon. The condensed liquid contains various compounds of acid, phenol, and carbonyl which acts as a preservative, anti bacteria and antioxidants so as inhibit damage to food products (Swastawati et al., 2014). Criteria of a good quality liquid is determined by the chemical compounds it contains. Chemical compounds contained in the liquid condensed is dependent on several factors, including the operating conditions of the pyrolysis and the raw materials used (Haji, 2007).

Our country has a great number of biomass resources e.g. large waste plantation products as palm oil, coconut, and sugar cane, and waste forest products, waste from the production of food crops (agriculture). The waste products are basically material that do not yet have economic value, even they can pollute the environment and require a high cost processes. The utilization of waste is one of alternative to raise grades economic value and one of waste is an agricultural waste such as rice husk. If this waste as the raw material can be chemically convert to be liquid chemical, the sustainable chemical industry can be developed in the future because the huge supply of this waste and the economically added value.

Research on analysis content volatile compound in liquid product of numerous varieties of a rice husk on various temperature variations pyrolysis been carried out by Wen et al., (2007). The results show that variations temperature used affect components compounds that are produced. But the difference varieties a rice husk did not influence its content volatile compound main composed of a compound of phenol and furan. Research another is done by Swastawati et al., (2014) to know effect application liquid product and a rice husk to characteristic of the qualities of fish especially aspects of chemical, microbiology and sensory.

In addition, the side product generated is also coming from the activity of sugar industry which is the waste of bagasse. There's 68 sugar industries with sugar cane field area around 365 thousand hectare and sugar production around 28 million ton. Now, in Indonesia, there's sugar cane field around 429 thousand hectare with sugar production around 33 million ton. With sugar amount as much as that, will produce side product such as bagasse, filter mud and boiler ash 12.768; 1.588; and 0.12 million ton each. This side product especially bagasse can be used as liquid smoke raw material because it has biomass compounds that important in liquid smoke production. So, a research to get optimum condition of bagasse pyrolysis to get the best liquid product yields.

One of variable that influence liquid condensed quality is temperature. Temperature difference has a direct effect toward yield percentage, acidic level, and precipitated tar and also important compounds. There's plenty of research of temperature effect of oil palm shell and organic trash (Haji, 2007). Another raw material that have been used to produce liquid smoke is coconut fiber that has antioxidant like phenol.

In this process, there's some of equipment that used is pyrolyzator, heater, condensed pipeline, condensation column and distillate container. This research will produce the condensed liquid with different raw biomass material (bagasse and rice hull) and to know the effect of variables such as temperature to liquid product yield and chemical compounds, so we will get optimum condition of operation.

2. Materials and Methods

The raw materials of rice hull and bagasse were obtained in the area of Depok which are the results of the process of grinding rice and sugar cane. Before feeding to pyrolysed reactor, rice husk was washed and dried under sunlight for 3 days

2.1 Equipment unit of pyrolysis

The unit of pyrolysis is composed of several apparatus tools i.e, nitrogen gas cylinder, thermocouple, pyrolysis fixed-bed reactor, stainless steel tube line, condenser and liquid product glass bottle. The gas cylinder was connected to reactor pyrolysis by tube line. The upper part of reactor pyrolysis was connected to a tube pipe with a goose shaped neck which directly connected to condenser. Raw material (rice husk or bagasse) was fed into the fixed-bed reactor constructed by stainless steel material and externally heated and in atmospheric pressure. The length of reactor was 30 cm with 7 cm i.d. diameter. Figure 1 shows the scheme equipment pyrolysis.

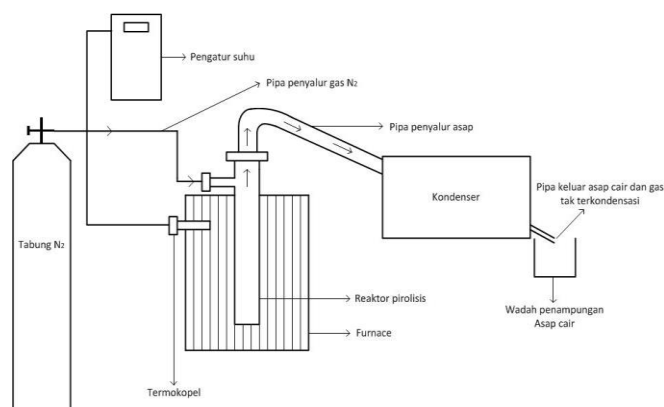


Figure 1. Schematic diagram set-up of pyrolysis unit

The purpose of this process is to produce liquid product from waste of rice and bagasse. Before pyrolysis reactor was operated, firstly the raw material waste was placed in the reactor as much as 12 g and prepared the cooling media using water ice for condenser and gas nitrogen (N_2). And before the pyrolysis process was then started by flowing the nitrogen gas into the reactor for minimum 15 minutes to purge the air in the reactor and pipeline. After the condition under flowing of nitrogen perfectly, the desirable temperature was set by turning on the furnace equipped with the control panel. The pyrolysis was maintained for an hour, in order to liquid product from the condenser was flowing out and accumulated into the bottle. After process was completed, the reactor was taken to measure the weight. Variation temperature were 330, 370, 400 and 450 °C.

2.2 The yield of liquid product

Weighed heavy bottles a net that will used as a container liquid smoke. Filled bottles clean with liquid smoke the results of the study. Weighed a bottle that it saves liquid smoke the results of the study. The percentage of yield calculated as follows,

$$\text{Yield of Liquid product (\%)} = \frac{\text{Weight of Condensed liquid product}}{\text{Weight of Raw material fed to pyrolyzed Reactor}} \times 100 \quad (1)$$

2.3 Analysis by GC-MS

An analysis of component chemical performed on liquid smoke commercial and liquid smoke a rice husk on all the variations of temperature used a gas chromatography mass spectrometry (GC-mass spectroscopy) with the model 6890, agilent technologies for gas chromatography connected to mass spectrometer (MS model 5973, agilent technologies). The type of capillary column used was HP-5MS with 0.25 mm x 60 m x 0.25 μ m, Model 19091s-36, agilent technologies. The carrier gas was helium with with purity 99.99% with flowing 1.0 mL/minute. The G.C instrument was operated at the mode of constant flow, the inlet pressure 15.92 psi and the maximum temperature was. Nominal pressure inlet with temperature maximum at 290 °C. The sample volume was injected with 1 μ L with the split ratio of 50:1. The initial oven temperature was 40 °C during 0.5 minutes, subsequently increased with the heating rate 2 °C/minute up to 290 °C and hold for 15 minutes. Total running time was analyzed 31.67 minutes for each sample. The peaks were appeared in the chromatogram were validated with the database WILLEY09TH.L.

3. Results and Discussion

3.1 Pyrolysis of bagasse

3.1.1 The yield of liquid product from bagasse Pyrolysis

Table 1. Liquid smoke product with pyrolysis temperature variation

No	Temperature (°C)	Condensate (%b/b)	Charcoal (%b/b)	Missing Weight (%)
1	350	6.56	64.63	28.80
2	400	10.89	54.32	34.79
3	450	30.72	32.61	36.67
4	500	33.73	32.40	33.86

As shown in table 1, the highest yield percent result obtained from this research similar to research by Haji (2007) that has yield percent between 32.87 until 37.83% but still less than research by Ramakhrisan (2002) that reached 59.6%. Liquid smoke with a combustion temperature of 350 °C has the lowest percent yield which is 6.56 %. Condensed liquid product produced at temperature 500 °C has the highest percent yield which is 33.73%. Charcoal percent left from reaction is also more and more decrease which is 32.40%. But, missing weight is also quite high until 32.40%. From Table 3 can be seen that main component of liquid smoke is phenol, acidic compounds, oxygenate compounds, and aromatic compounds. The biggest composition in pyrolysis liquid smoke is 2-Furancarboxaldehyde.

3.1.2 GC-MS characterization of liquid product from bagasse pyrolysis

As shown in Fig.1, the peak showing component type were contained in liquid product. The total component identified were 68 peak. But, the tabulate result just showing component with percent of quality more than 85% which means that peak has similarity more than 85% with database that used.

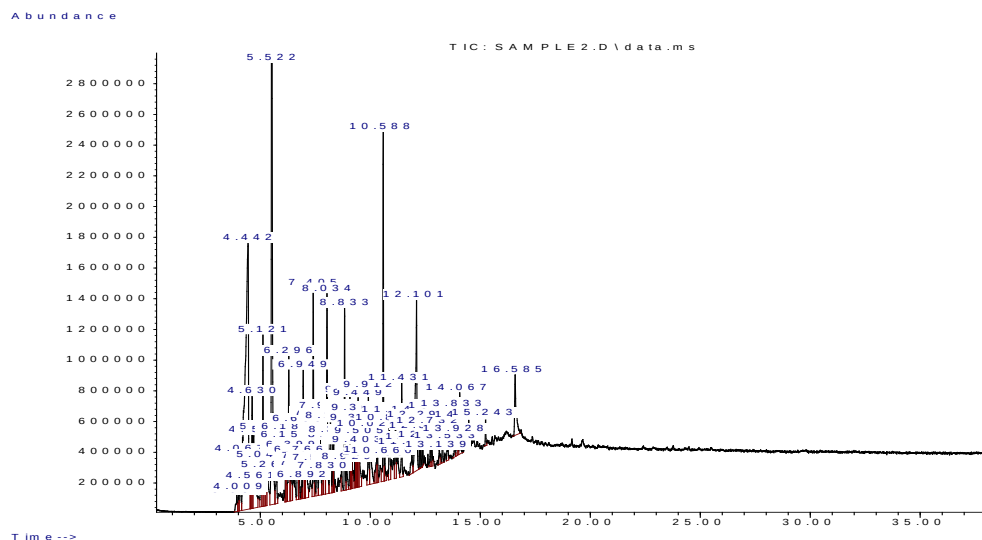


Figure 2. Chromatogram of bagasse pyrolysis liquid product analyzed by GC-MS

Table 2. GC-MS characterization of pyrolysis liquid smoke from bagasse

No	Component	Molecular Structure	% Area
1	2-Furancarboxaldehyde	$C_5H_4O_2$	17,76
2	2-Cyclopenten-1-one, 2-methyl-	C_6H_8O	0,84
3	1,2-Cyclopentanedione	$C_5H_6O_2$	1,08
4	Phenol	C_6H_6O	2,46
5	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	$C_6H_8O_2$	3,33
6	Phenol, 4-methyl-	C_7H_8O	1,92
7	Phenol, 2-methoxy-	$C_7H_8O_2$	4,79
8	2-Cyclopenten-1-one, 3-ethyl-2-hydroxy-	$C_7H_{10}O_2$	0,88
9	Phenol, 4-ethyl-	$C_8H_{10}O$	2,85
10	2-Methoxy-4-methylphenol	$C_8H_{10}O_2$	1,42
11	1,2-Benzenediol	$C_6H_6O_2$	1,12
12	2-Propenoic acid, 2-methyl-, ethyl ester	$C_6H_{10}O_2$	1,28
13	2-Furancarboxaldehyde, 5-(hydroxymethyl)-	$C_6H_6O_3$	1,76
14	Benzeneethanol, 2-methoxy-	$C_9H_{12}O_2$	1,78
15	Phenol, 2,6-dimethoxy-	$C_8H_{10}O_3$	5,08
16	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	1,43
17	Benzaldehyde, 3-hydroxy-4-methoxy-	$C_8H_8O_3$	1,28
18	Phenol, 2,6-dimethoxy-4-(2-propenyl)-	$C_{11}H_{14}O_3$	0,61
19	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	0,74
20	Ethanone, 1-(4-hydroxy-3,5-dimethoxyphenyl)-	$C_{10}H_{12}O_4$	0,71
21	Hexadecanoic acid	$C_{16}H_{32}O_2$	0,4
22	9-Octadecenoic acid	$C_{20}H_{40}$	2,37

From Table 2, it can be seen that main component of liquid smoke was phenol, acidic compounds, oxygenate compounds, and aromatic compounds. The biggest composition in pyrolysis liquid smoke is *2-Furancarboxaldehyde*.

3.2 Pyrolysis of rice hull

3.2.1 The yield of liquid product

Figure 3 showed that the liquid yield increased along with the the increase of pyrolysis temperature from 330 °C up to 450 °C. While the char wich is the solid residue after pyrolysis, the yield was decreased. The highest liquid product yield was attaines at 450 °C as much as 39,34%. This result is better than the result by Natarajan (2009) which is 27.19–30.11% at temperature pyrolysis 400-500 °C. But, the yield is lower comparing to the yield resulted by Swastawati (2014) which attained 55% at the same temperature. The liquid product resulted at pyrolysis temperature 330 °C showed the lowest yield e.g. 25.57%. Probabably, at this temperature, it is not enough to decompose the rice hull especially for lignin contain in the rice hull.

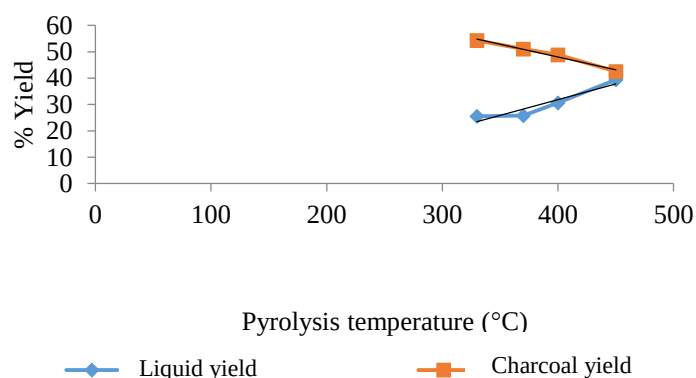


Figure 3. The yield of liquid product resulted from rice hull pyrolysis

3.2.2. GC-MS characterization of liquid product from rice hull pyrolysis

The types of liquid product was contain compounds such as carbonyl, aldehyde, the ketone, carboxylic acid and those a compound of phenol, furan and its derivatives. Those compounds specific contained in each liquid product percent peak different shown in Table 3. Those compounds of the most dominating liquid product a rice hull is belong to carbonyl namely carboxylic acid and a ketone by the number of different temperature depends pyrolysis used. This is in accordance with which has been stated by Haji (2007) that the chemical in those compounds in liquid smoke influenced by raw materials and temperature pyrolysis. Several compounds of the phenol clasification is present in the liquid product from rice hull in all temperature variations. This shows that pyrolysis lignin in a rice hull that produces compound phenol and its derivatives has been under temperature 330 °C. This result is suitable to the Wen et al., (2007) that degradation lignin a rice hull occured at temperatures ca. 200 °C. Liquid product from pyrolysis of rice hull at a temperature pyrolysis 450 °C produce the compounds of phenol, with the highest amount of total area peak of 9.64% and the number of smallest produced on temperature pyrolysis 330 °C as much as 5.86%. This may be due to lignin has not been perfectly decomposed at the temperature pyrolysis of 330 °C and the

decomposition increases in line with the increasing of pyrolysis temperature observed up to 450 °C.

Tabel 3. The chemical compounds characterized by GC-MS from sample of liquid product resulted from Rice Hull pyrolysis

Retention time	Compound	Molecular Formula	Area peak (%)				
			450	400	370	330	K
8.8448	Phenol	C ₆ H ₆ O	1.58	1.93	1.75	1.41	28.70
9.6617	2-Methylphenol	C ₇ H ₈ O					1.78
9.8835	4-Methylphenol	C ₇ H ₈ O	0.51	0.53			1.96
10.0739	2-Methoxyphenol	C ₇ H ₈ O ₂	2.37	3.09	3.48	2.16	4.61
10.8356	4-Ethylphenol	C ₈ H ₁₀ O	0.78	0.56	0.49	0.44	
11.1385	2-Methoxy-4-methylphenol	C ₈ H ₁₀ O ₂	2.33	2.26	1.64	1.49	1.22
12.6445	2,6-Dimethoxyphenol	C ₈ H ₁₀ O ₃	0.78	0.51	0.36	0.35	0.44
13.1899	4-hydroxy-3-methoxybenzaldehyde	C ₈ H ₈ O ₃	0.84	0.23			
13.484	2,6-Dimethoxy-4-methylphenol	C ₉ H ₁₂ O ₃	0.28	0.19			
	Total		9.46	9.30	7.72	5.86	38.70
5.3134	Acetic acid	C ₂ H ₄ O ₂	17.97	15.58	10.78	8.11	34.40
5.928	Propanoic acid	C ₃ H ₆ O ₂	4.28	5.01	2.52	2.28	4.37
6.6897	Butanoic acid	C ₄ H ₈ O ₂	3.24	3.20	2.62	2.56	1.83
	Total		25.49	23.79	15.92	12.95	40.60
5.7289	1-Hydroxy- 2-propanone	C ₃ H ₆ O ₂	8.08	8.45	12.30	8.26	3.88
6.5685	1-Hydroxy-2-butanone	C ₄ H ₈ O ₂	2.33	3.67	4.38	2.69	2.51
7.4859	2-Propanone, 1-(acetyloxy)-	C ₅ H ₈ O ₃	1.75	2.88	3.92	3.70	
8.0312	2-Methyl-2-cyclopenten-1-one	C ₆ H ₈ O	0.50	0.90	0.67	0.44	0.39
8.715	3-Methyl-2-cyclopenten-1-one	C ₆ H ₈ O	0.58	0.98	0.96	0.72	0.31
9.3902	2-Hydroxy-3-methyl- 2-cyclopenten-1-one	C ₆ H ₈ O ₂	2.43	2.12	2.30	1.89	
10.3855	3-Ethyl-2-hydroxy-2-cyclopenten-1-one	C ₇ H ₁₀ O ₂	1.32	1.10	1.12	0.51	
	Total		17.01	20.09	25.65	18.21	7.10
7.2003	2-Furancarboxaldehyde	C ₅ H ₄ O ₂	3.95	6.27	6.77	7.46	2.88
7.434	2-Furanmethanol	C ₅ H ₆ O ₂				3.24	
8.1351	Dihydro-2(3H)-furanone	C ₄ H ₆ O ₂		1.59	1.76	1.34	1.16
8.6544	5-Methyl-2-furancarboxaldehyde	C ₆ H ₆ O ₂	0.63	0.88	0.83	0.70	
	Total		4.58	8.75	9.36	12.74	4.04

4. Conclusions

Based on GC-MS analysis, component that has the biggest % area is furfural that has antimicrobial characteristic in liquid smoke. Liquid product contains acid, phenol and carbonyl compounds and the most important component for especially food preservation is phenol compounds. The highest percent yield which is 33.73% was obtained for pyrolysis of bagasse material at temperature of 500 °C. The main component of liquid product is phenol, acidic compounds, oxygenate compounds, and aromatic compounds and 2-Furancarboxaldehyde was the main component. And for pyrolysis of rice hull, the highest yield was obtained as much as 39.34% at 450 °C. The analyses of GC-MS, the liquid products were containing various compounds: carbonyl, aldehyde, ketone and carboxylic acid, phenol and furan with derivatives.

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F. GENERAL FORESTRY

Belowground Carbon Stored in Riam Berasap Peatland Forest of Ketapang, West Kalimantan: Natural Resources that Must Be Saved

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Abstract

Tropical peatland forests store a huge carbon pools since peatland forest sinks carbon both in the vegetation and its underlying peat. A large area of Indonesian peatlands, especially forested peatlands, are actively degrading. These forests recently experienced a lot of pressures from anthropogenic disturbances associated with timber harvesting and land conversion. Once the carbon allocation to the system is discontinued by deforestation, fires, or drainage, the surface peat oxidizes and emits carbon rapidly to the atmosphere. An assessment had been done to quantify below ground carbon stocks in Kabupaten Ketapang West Kalimantan. The assessment was distributed into 4 blocks of peatland landscapes: Riam Berasap, Manjau, Marsela, and Tulak peatland forest. To assess belowground carbon, we used 'fish-bone' survey method which was sistematically measured depths and sampled peat along the main transect across the indicated peat dome and developed several branches perpendicularly to the main transect. Peat samples were examined in soil laboratory to measure peat bulk density, LOI, and %C content. Peat depth area map was produce based on the depth result using GIS extrapolating method. Results show that the four peat blocks constitute different peat depth yet approximately similar peat characters, thus they store variably amount of carbon. Overall 14.560 ha peatland area estimated to store 56.5 million ton C. It is a huge amount of belowground carbon sink. When destructed, the stored carbon will turn into source and significantly caused substantial CO₂ emission and changes in global carbon cycle that could enhance global warming.

Keywords: belowground C pool, carbon sink, carbon source, peat depth, tropical peatland forest

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1. Introduction

Tropical peatland ecosystem represent a net long-term sink of atmospheric carbon dioxide (Roulet et al., 2007), however forest land cover change, forest degradation and

drainage establishment have huge impacts on their biogeochemical and ecosystem function (Waddington et al., 2010). Degraded peatland forest and highly extracted peatland or land cover changes become large and persistent source of CO₂ emission to the atmosphere (Petrone et al., 2003; Waddington et al., 2002).

Large areas of tropical peatland have been logged for wood products to supply regional and global demand (Curran et al., 1999) and developed for either small-scale farming (e.g., sago, corn, pineapple, and vegetables) or large-scale agricultural plantations (e.g., oil palm) involving extensive peatland drainage in Indonesia (Achten & Verchot, 2011; Carlson et al., 2012, 2013). These peatlands have also incurred synergistic exposure to drought and wildfires (Langner et al., 2007; Page et al., 2008; Langner & Siegert, 2009). Indonesian peatlands (approximately 19 million hectares) account for 35 % of global tropical peatlands area. Many Indonesian peatlands, especially forested peatlands, are actively accumulating peat at the present time while others are in a steady state or are degrading. Once the carbon allocation to the system is discontinued (e.g. by deforestation, fires or drainage), the surface peat oxidizes and emits carbon rapidly to the atmosphere, mostly in the form of carbon dioxide (CO₂), a greenhouse active gas. This process also results in progressive loss of peat from the surface, which leads to surface subsidence and an increased potential for flooding during the wet season.

Land use change and fire, associated with human settlement, and plantation developments that involve deforestation and drainage, destroy the natural resource functions of tropical peatlands. Legal and illegal logging activities result in degradation of natural peat swamp forests. The land use changes and peatlands conversion would cause substantial change in global carbon cycle. The conversion, of tropical peatland for agriculture, settlement and plantations involves drainage and land clearing, which besides causing loss of biodiversity, inevitably produce changes in the physical, chemical, and biological properties of the peat soils. However, the remaining forests and peat lands are potentially contribute to the reduction of net CO₂ emissions by fixing carbon in wood, leaves and soil (Astiani, 2014).

Most of peatland landscape in Riam Berasap was in PT Kayong Agro Lestari (KAL) concession, which was one of growing oilpalm concession in Kabupaten Ketapang West Kalimantan. More than half of the area concession is covered by peatland forests, which hold large amount of carbon held both in above and especially below ground area. Better policy or planning should be suggested to maintain and manage carbon stocks within the peat area. Therefore, the valuable data on carbon stocks sequestered in this area need to be performed. Thus, our study objective was to estimate below ground carbon stocks at Riam Berasap peatland landscape areas in Kabupaten Ketapang West Kalimantan. We aim to quantify below ground carbon stocks measures (t C/ha) of peatlands landscape in this area.

2. Materials and Methods

2.1. Study Sites

The areas of carbon assessment located within Riam Berasap landscape distributed between $110^{\circ} 6' 0''$ E to $110^{\circ} 18' 0''$ E and $1^{\circ} 21' 0''$ S to $1^{\circ} 31' 0''$ S in Kabupaten Ketapang, West Kalimantan. This carbon assessment surveyed within 4 blocks of forested peatland landscape which included in : Riam Berasap (RB), Manjau (MJ), Marsela (MS), and Tulak (TL) Peatland Forests.

These areas were chosen based on the indication of peatland area detected from satellite image interpretation and soil map. Below ground carbon assessment was measured along some transect survey plan in 4 blocks of the peatland area, that was done simultaneously with above ground carbon stocks (be published separately at Astiani, 2016, in progress). The survey sites are presented in sketch map marked with black dots below (Figure 1).

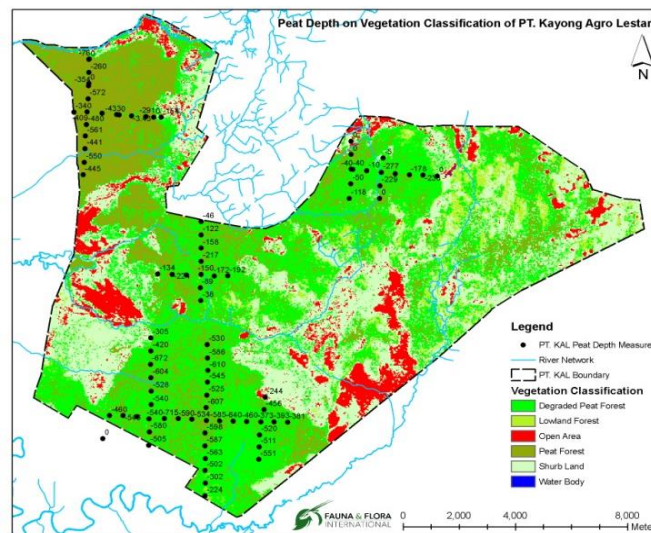


Figure 1. Study area with four blocks of peatland forest

2.2. Below ground carbon assessment

Peat area indication is derived from overlaying PT KAL area using soil and vegetation maps provided by FFI representative (Land Sat Image 5 (2009) and SRTM 90 m Resolution). Systematic transects and point samplings were applied to estimate peat biomass based on peat area indication. East-west or North-South orientation transects were built within each peat group (dome) across the middle of the dome with 'Fish-bone' transect approach within 2-3 km distance. Within each transect, peat depths were measured in a distance of 500m. Peat soil core samples were taken systematically on each 2 km distance, using by Russian Borer samples. Each peat core samples, the peat depth was measured until reaching the mineral soil below the peat layers.

Peat core samples were collected from each 20 cm depth layer until the soil borer reach the mineral soil (Figure 2). Each peat layer sample was placed into plastic sample bag, labeled and kept for further analysis. Since base on our experiences before, one set of soil core sample did not fulfill laboratory material for examination, two set of cores of each soil samples were taken.

For further chemical and physical analysis in laboratory, we sent the peat samples immediately for analysis of bulk density, water and ash contents, and organic carbon analysis in laboratory. The peat samples were expedited to IPB Laboratory at Bogor (Jawa Barat) and UNTAN Lab at Pontianak (West Kalimantan). Other concentrations of chemical analysis were done by CHNS analyzer after samples had been filtered. Soil Bulk Densities were analyzed using *Thermo gravity* metrical Desiccation at 105⁰C. The Laboratory works took about 2-3 months to finish.



Figure 2. Peat carbon sampling and assessment

3. Results and Discussion

3.1 Peatlands Condition and Peat Depth Ranges within Landscape

This study confirmed that there were four blocks of peatland found in Riam Berasap landscape with various depth and extends. Results indicated that those peat lands vary with depth from 0 to 7.15 m. The peatlands were distributed into several group of peat domes. The peat depth distributions on each peatland block were presented in Table 1.

Table 1. Peatland Blocks and Depth Ranges within Riam Berasap Landscape

No	Peat Block	Peat Depth Range (cm)
1	Riam Berasap (RB)	76 - 572
2	Manjau (MJ)	38 - 224
3	Marsela (MS)	0 - 235
4	Tulak (TL)	224 - 715

Along with this study, above ground biomass was also estimated, yet will be published separately. To describe the forests above ground of the peatland landscape, they were stratified into high and low degraded one. Most of deep peatlands (>3m) were still covered

by forest except the patches that has been given a plantation license and changed into oilpalm area. However extensive drainage ditches had been established for the plantation and thus, they will affect the present forest dynamics and carbon fluxes (Astiani et al 2014). The forest condition at the assessment time were present in Figure 3.



Figure 3. Forest on above ground of peatland blocks in general: (a) Low degraded; (b) high degraded; peatland forests

3.2. Peatlands Characteristics and Development

Peat depth distribution can also be viewed from their cross section across the estimated peat dome in the landscape. Sketches of below ground-peatland cross section are presented in Figure 5. The peat depth tend to deepen toward peat dome. Interestingly, peat domes were found more than one in each peatland block. Totally, 83 peat depth profiles were measured in the area with peat depth range from 0 cm to 715 cm. Those depths are categorized as shallow to very deep peat.

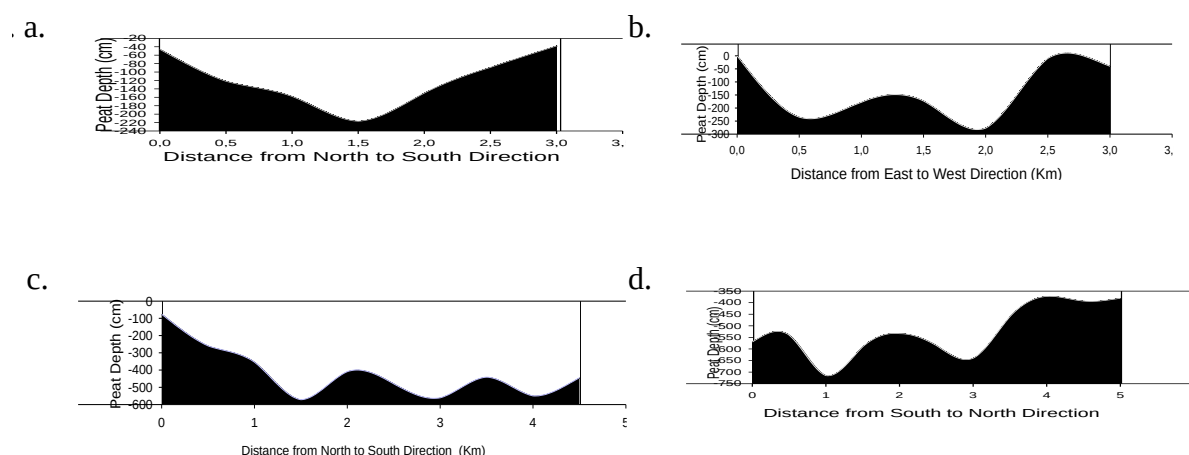


Figure 5. Peat land cross section at 4 peat block area a) MJ b) MS c) RB, and d) TL

Physical and chemical peat analyses of 18 cores were taken along the transects. The proportion of peat that Lost on Ignition (LOI) were high and abruptly changed at end of peat layers that mixed with mineral soil. The LOI were range between 85-99 % while in the bottom layers were range between 10 -70%. The peat C:N ratio, %t LOI, Bulk Density, and practical ‘Palm Pressure Test’ in the field support the fact that peat in the landscapes were

mostly in mid to advance level development of their decomposition and categorized as *Hemic* and *Sapric* peat. Moreover, mineral soil under peat profile at RB and TL were over an sandy alluvial deposit, while at MJ and MS, mineral soils was sandy Yellow Red Podsollic. Peat bulk density of each peatland landscape and their overall mean are presented in Figure 6 a, b, c, d and e.

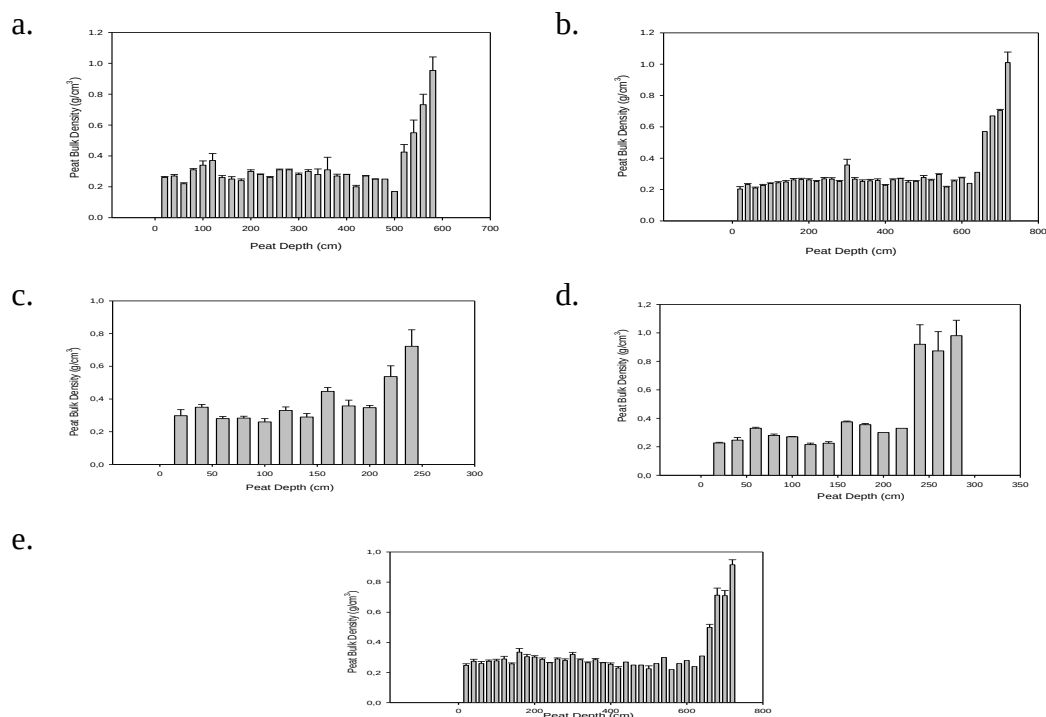


Figure 6. Bulk Density Distribution (Mean and SE) along the peat depths of the 4 blocks (a) (RB) (b) (TL) (c) (MJ), (d) (MS), and (e) Overall peatland.

Results indicated that Spatial vertical distribution of peat bulk density of each peat block at Riam Berasap landscapes slightly vary accross 20 cm ranges (0.17-3.7 g/cm³). The mean bulk density of each block area also varied and, in the average, was higher if compared to peat bulk density at S Matan peatland which was 0.11 g/cm³ (Astiani, 2010), except the last 60-80 cm at the peat bottom, where peat material mixed with gley humus and mineral soil. The mean bulk density and their standard deviation are 0.27 ± 0.04 , 0.26 ± 0.03 , 0.32 ± 0.05 , 0.29 ± 0.05 for RB, TL, MJ, and MS consecutively. The mean bulk density of peat at this area is 0.27 g/cm³ and the average of last 60 cm peat layers at peat bottom is 0.72 g/cm³.

3.3. Belowground carbon stocks

Based on peat depth, bulk density, LOI, and C content, mean peat carbon allocation within each peat depth range (20 cm) were resulted. Mean of C stocks per 20 cm depth was 281.6 ± 7.3 ton/ha with the lowest and the highest mean value of 171.2 and 391.3 ton/ha per 20 cm depth. The C stock per hectare and total values within all Riam Berasap peatland were presented in Fig. 7, Fig 8, and Annex 1.

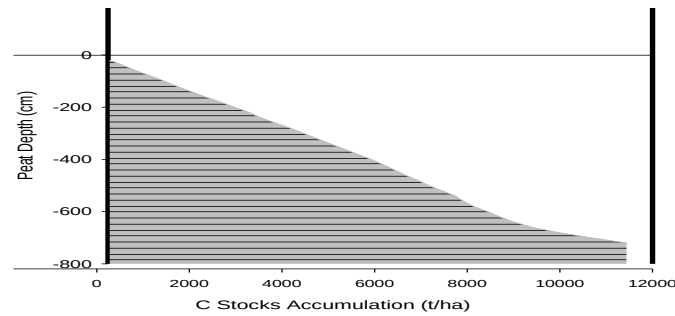


Figure 7. Mean carbon stock (ton/ha) along the peat depth

Riam Berasap peatland landscape mostly still covered by peatland forest. When compared to above ground biomass of forested peatland, each 20cm of peat soil depths potentially stored 2 times amount of above ground stocks (mean ~130 ton/ha). However, peatland is a dynamics ecosystem. Land cover changes of peatland forest and especially with drainage establishment around the landscape, not only will cause a large amount of carbon losses on above ground biomass but also alter the carbon balance of this landscape through peat soil C emission, forest C stocks changes, growth, and mortality (Astiani, 2014). It was also agreed by Fargione (2008); Carlson et al. (2012 and 2013) that forest degradation, landcover changes, and altered drainage, combined with changes in temperature and precipitation, are transforming peatland forests into major carbon sources rather than stores/sinks.

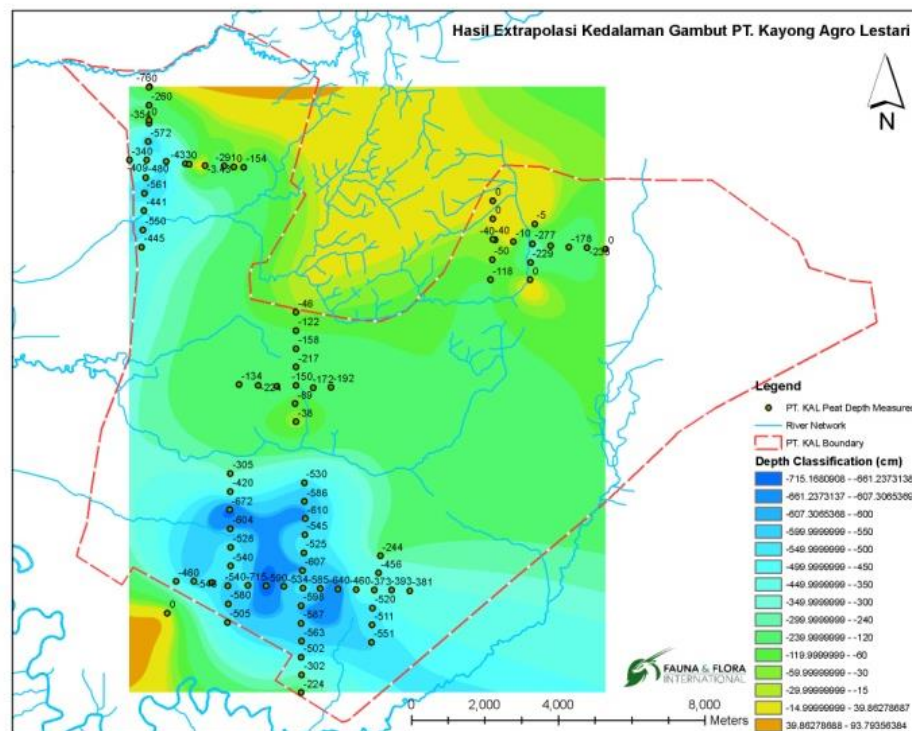


Figure 8. Peat depth distribution and area covered

Since Riam Berasap peatland landscape had been given a lisenche for oilpalm plantation, it is urgent to show that, based on this study results, this peatland forest blocks sink a huge

amount of carbon especially below ground carbon. Thus, clearing those area to other land uses surely will cause huge carbon feedback to the atmosphere, the stored carbon will turn into source and significantly caused substantial CO₂ emission and changes in global carbon cycle that could enhance global warming. Therefore, the peatland forest should be conserved.

4. Conclusions

A large amount of carbon stored below ground in peatland landscape of Riam Berasap. Peat carbon held in peatland area per 20cm depth were ranged from 171,2 to 391,3ton/ha per 20cm depth (mean $281,6 \pm 7.3$ ton/ha). Overall, 56,5 M ton C were allocated within underlying peatland of Riam Berasap. The variation of carbon allocated within peat landscape was dictated by peat bulk density, C content, and peat depth. These peatland landscape mean bulk densities ranged from 0,26 to 0,32 g cm⁻³ that the peat soil in this landscape were categorized into hemist and/or saprist. It is urgent to save this peatland landscape to hindered from huge carbon feedback into atmosphere

Acknowledgements

We gratefully acknowledge supports from Fauna and Flora International under short term collaboration. Thank you to people of Riam Berasap which support us in many ways included in field assessment assistance. Thanks to every one, that we can not mention them in person, who involve in this study for works, ideas, and supports.

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ANNEX 1:

Below ground C stocks Maintained at Riam Berasap Peatland Forest Ketapang

Peat Depths	Peat Carbon t/ha /20cm depth	SE	Peat C (tha ⁻¹ depth ⁻¹)	Area (ha)	Accumulated Peat C (t x10 ³)
0-20	278,88	2,74	278,88	259,26	72,30
20-40	287,42	1,99	566,3	223,63	126,64
40-60	280,8	2,33	847,1	327,31	277,26
60-80	304,7	2,02	1151,8	472,44	544,16
80-100	303,34	1,51	1455,14	585,56	852,07
100-120	268,75	1,77	1723,89	797,83	1375,37
120-140	304,26	2,51	2028,15	1.890,76	3834,74
140-160	306,25	4,38	2334,4	959,22	2239,20
160-180	329,02	2,37	2663,42	1.028,98	2740,61
180-200	305,55	2,04	2968,97	795,59	2362,08
200-220	313,15	1,83	3282,12	653,32	2144,27
220-240	247,61	5,04	3529,73	531,18	1874,92
240-260	316,35	2,75	3846,08	426,21	1639,24
260-280	323,73	2,85	4169,81	388,54	1620,14
280-300	291,14	0,07	4460,95	382,28	1705,33

300-320	283,79	0,59	4744,74	393,19	1865,58
320-340	289,4	1,9	5034,14	334,56	1684,22
340-360	299,99	3,9	5334,13	301,84	1610,05
360-380	294,73	0,81	5628,86	281,5	1584,52
380-400	292,9	1,91	5921,76	281,03	1664,19
400-420	255,83	2,12	6177,59	245,91	1519,13
420-440	240,16	4,43	6417,75	233,29	1497,20
440-460	238,59	2,52	6656,34	231,65	1541,94
460-480	273,32	0,85	6929,66	226,28	1568,04
480-500	234,13	3,17	7163,79	240,37	1721,96
500-520	285,85	2,31	7449,64	301,14	2243,38
520-540	286,81	2,34	7736,45	307,04	2375,40
540-560	171,18	1,45	7907,63	353,61	2796,22
560-580	227,64	5,66	8135,27	330,16	2685,94
580-600	300,04	2,3	8435,31	301,63	2544,34
600-620	261,17	3,33	8696,48	288,09	2505,37
620-640	309,59	4,21	9006,07	103,49	932,04
640-660	391,25	3,20	9397,32	43,21	406,06
660-680	365,01	2,18	9762,33	24,68	240,93
680-700	202	6,98	9964,33	10,15	101,14
700-720	173,48	6,45	10137,81	4,01	40,65
				14.558,94	56.536,67

Variability of Mercury Contents in Plants among Age of Tailings of Ex-Gold Mining Area

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Abstract

Community gold mining in Menjalin West Kalimantan has been done more than 10 year ago. It is indicated that mercury is accumulated in the tailings area where local communities are doing their small agricultural farms for their subsistence. The content of mercury in the tailings of ex gold mining is becoming one of the problems for plant growth as well as people health, since the community plant not only woody but also horticultural plants. The purpose of this study was to measure the ability of some plants to absorb mercury in the tailings area of ex gold mining at the different level of ages. We conducted a study to measure the mercury in plants in the tailing areas of ex-gold mining. We separated the tailings into three age groups, <5th, 5-10th and >10th. The sampling of tailings and plants were done purposively throughout the tailing areas, and the samples were analyzed for their mercury contents using Atomic Absorption Spectrophotometer (AAS). Results indicate that plants response with different abilities in absorbing mercury. Several species of horticultural crops namely chili (*Capsicum frutescens* L.), eggplant (*Solanum melongena*), cassava (*Manihot utilissima*), and sugar cane (*Saccharum officinarum* L.) and woody plants namely agarwood (*Aquilaria malaccensis*), rubber (*Hevea brasiliensis*) and white jabon (*Anthocephalus cadamba*) have a high tendency to absorb mercury to exceed the threshold. The older tailing ages the lower mercury content in the tailings but not in plant tissues. Woody plants have the ability to accumulate higher mercury three times higher than horticultural crops. Woody plants prospects are very good for phytoremediation heavy metals, including mercury.

Keywords: Ex-gold mining, Horticultural crops, Mercury, Tailing ages

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1. Introduction

Community Gold mining were done illegally began to bloom in West Kalimantan over 10 years ago. Illegal gold mining activities have occurred almost equally in all districts in West Kalimantan, including in Landak district especially in Menjalin subdistrict. As a result of this activity is the landscape be changed, previously vegetated areas (wooded) turned into the tailing areas that barren and arid. Caused by the use of mercury in one of the gold mining process, namely the amalgamation process, the tailing areas are indicated also contain

mercury. Mercury is one of the hazardous heavy metal and can be toxic (Palar, 2004; Wang, 2004), so its presence in the environment is harmful to flora and fauna, including humans. Mercury in the environment are mobile (Bash et al., 2007), may evaporate due to the heat or move to follow the flow of water. Furthermore, mobilization of mercury by the flow of water occurs in two directions, first into the ground to follow the movement of ground water (water capillary and bound in soil particles) and the second in surface soil through erosion or leached elsewhere.

The tailing areas of the ex-gold mining in Menjalin subdistrict were used by the local community for cultivation, both horticultural crops and plantation crops (woody). Horticultural crops, not only for their own consumption but also sold in the local market. This crop planting activities carried out by local people, and carried out immediately after the areas are abandoned by gold miners. The content of mercury in the tailings ex-gold mining is one of the constraints to the plants growth. However, a few species of cultivated plants can grow well and can be harvested. This is because the response of each species for mercury is different. Some plant species are susceptible to mercury and others are tolerant. The plant species that can grow in areas that contain mercury are mercury-tolerant species. Some plant that are tolerant to mercury will accumulate mercury in the plant tissues, so that when this part of the plant for human consumption it will be harmful to humans. This information was not known by the community around the tailing areas of ex-gold mining.

On the other hand, over time, the mercury in the tailings will be reduced because evaporated, absorbed by the plant and transported by water flow (as previously described). These conditions will provide a better place for plant growth. However, there is no clear and definite information about the safe time limits for the former gold mining area safe from mercury. However, there is no clear and definite information about the time that is safe in the tailing areas of ex-gold mining for the plants cultivation, especially agricultural crops. Therefore, in-depth research is needed on this subject, so that it can provide useful information, especially for the community around the gold mining.

The purpose of this study was to measure the ability of some plants (horticultural crops and woody plants) to absorb mercury in the tailing areas of ex gold mining at the different level of ages.

2. Materials and Methods

Materials used in this study are samples of crops that have been planted by local communities in the tailing areas of ex-gold mining, that separated by: (1) horticultural crops consisting of chili (*Capsicum frutescens* L.), sweet potato (*Ipomoea batatas* L.), cassava (*Manihot utilissima*), eggplant (*Solanum melongena*), papaya (*Carica papaya*), sugar cane (*Saccharum officinarum* L.), bananas (*Musa acuminata balbisiana*) and pineapple (*Ananas comosus*) (2) plantation crops (woody plants) consisting of: agarwood (*Aquilaria malaccensis*), rubber (*Hevea brasiliensis*) and white jabon (*Antocephalus cadamba*). The method that used in this research was survey method. Sampling sites are located in Menjalin

sub district of West Kalimantan (Fig. 1). We conducted a study to measure the mercury in plants in the tailing areas of ex-gold mining. We separated the tailings into three age groups, <5 years, 5-10 years and >10 years. The sampling of tailings and plants were done purposively throughout the tailing areas, and the samples were analyzed for their mercury contents using Atomic Absorption Spectrophotometer (AAS). Horticultural plant samples, taken at the plant consumed (fruit, leaves or stems), while woody plants samples taken both the shoot and roots. Mercury analyzes were conducted in the laboratory of Research and Standardization Industry (BARISTAND) Pontianak, West Kalimantan, using standard SNI06-6992.22004.

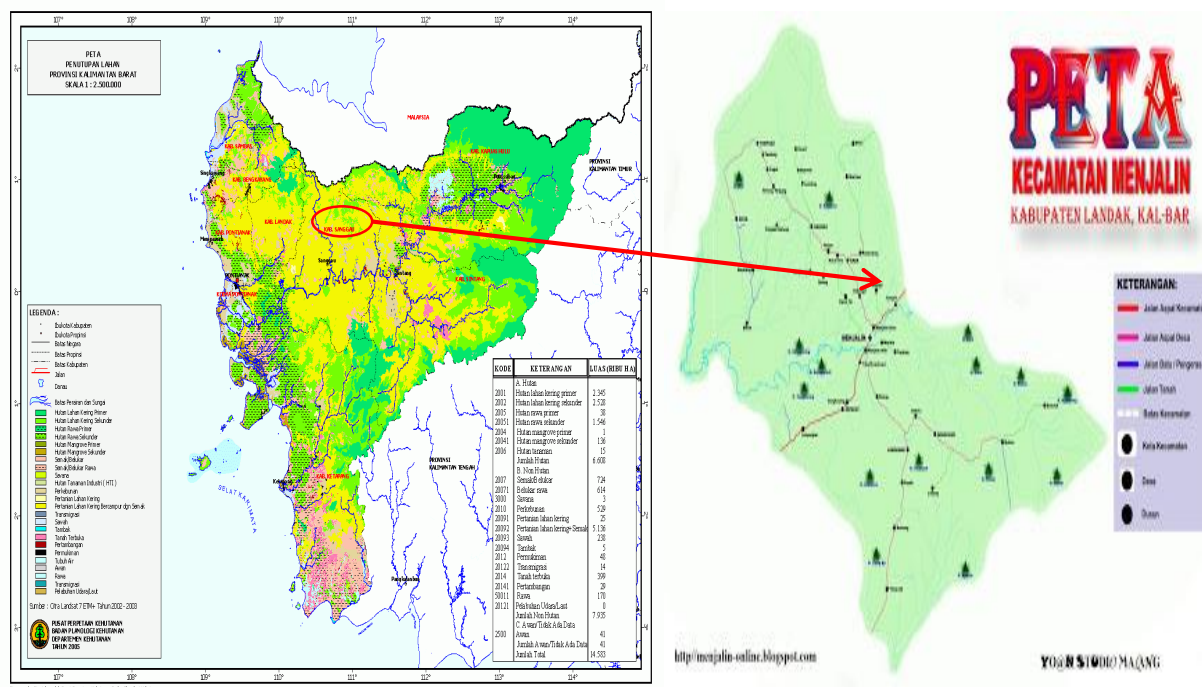


Figure 1. Map of Menjalin subdistrict

Furthermore, we will compare the results of mercury contents between plants species in the different tailing ages. This we do to classify the plants into groups of mercury accumulator or not, as well as to determine the effect of different tailings ages on mercury content in the plant tissues.

3. Result and Discussion

3.1. The Effect of tailings ages to the variability of mercury contents in the plant tissues

The tailing areas of ex-gold mining that used for plant cultivation by local community are separated into three age groups, namely <5 years, 5-10 years and >10 years. To determine the effect of tailing ages for the differences of mercury up take in plants, then the data from the analysis of mercury each plant species are separated into the each of tailing ages (Fig. 2). The results showed that the older of tailings, the lower mercury content, from 0.5 ppm

to <0,020 ppm after more than 5 years that areas were abandoned by gold miners. However, this condition is not followed by decreasing of mercury content in the plant tissue.

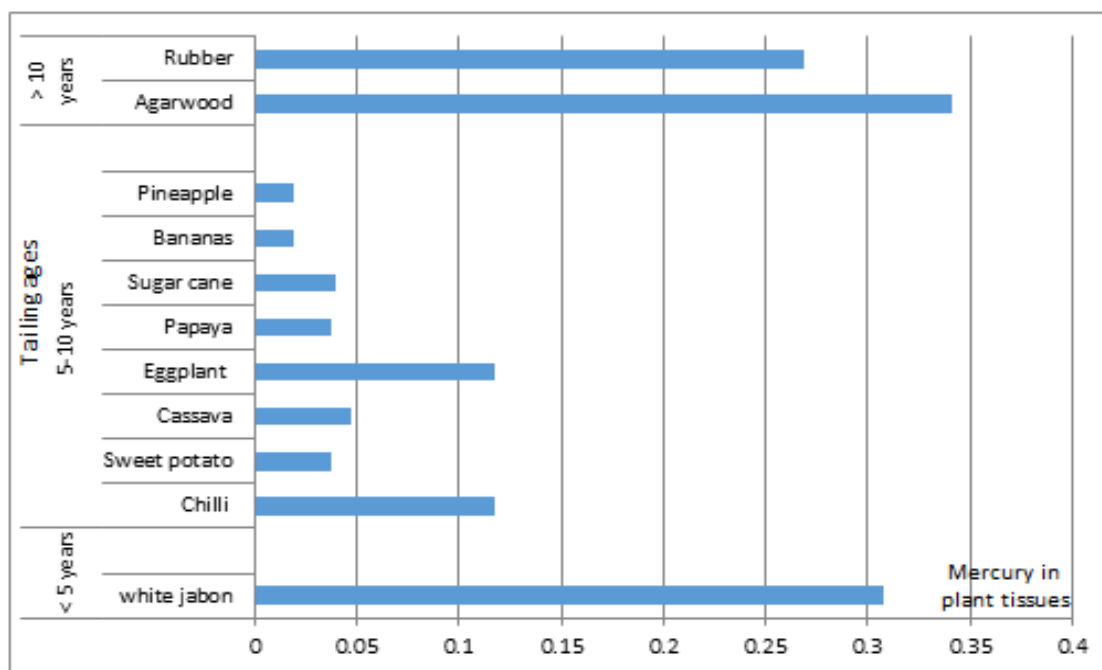


Figure 2. Level of mercury content in plant tissues at different tailing ages

This condition is caused by the uneven spread of the plant at all levels of the tailings ages. At the tailings aged <5 years and > 10 years only species of woody plants planted. In the other hand, at the tailings aged 5-10 years found only horticultural crops. The life cycle of these two groups of plants are different, that are annual and perennial then they have a different phenomena. Rubber and agarwood have 4 and 3 years old and planted in tailings aged >10 years, while the 1-year-old of white jabon grown in tailings aged <5 years. Total mercury content found in plant tissues of woody plants are almost the same, namely 0.269 ppm-0.341 ppm. The facts show that even though the mercury content in the tailings has come down over time (>10 years), but the content of mercury in the plant tissues of woody plants remains high. This trend shows that woody plants have a long period of time in storing mercury in the plant tissues. According Pulford & Watson (2003) and Ekyastuti (2013) the species of woody plants has the potential to be used as phytoremediator heavy metals, including mercury.

Horticultural crops are only found in the tailings aged 5 to 10 years, and not found in other tailings age. Therefore, the relationship between the ability of plants to absorb mercury species with different tailing ages can't be explained. Actually we found that different plant species have the ability to absorb mercury differently. Therefore, the furthermore discussion will be presented the results of a deeper investigation on this.

3.2. Mercury content of some plant species were planted in the tailings ex-gold mining

Based on the analysis of mercury in plant tissue, it is known that all species of woody plants in the study site are absorbing mercury, while for horticultural crops have a varying abilities (Table 1). All the species of plants that can be grown in the tailing areas containing mercury are mercury-tolerant species. The mechanism of plants tolerance to mercury in the soil can be divided into 3 different ways: (1) exclusion, in this mechanism the transport of metals are restricted and constant metal concentrations are maintained in the shoot over a wide range of soil levels, (2) inclusion, in this mechanism the metal concentrations in shoot reflect those in the soil solution in a linear relationship, and (3) bioaccumulation, in this mechanism the metals are accumulated in the roots and shoot at both high and low soil concentrations (Baker, 1981 in Jadia & Fulekar, 2009). The statement answered the question of why the results of the mercury analysis in plants cultivated by Menjalin community vary.

Table 1. Mercury contents in plant tissues

Plant species	Mercury content (ppm)		
	Root	Shoot	Latex
(1) Woody plants			
Agarwood	0.322	< 0.020	
Rubber	0.250	< 0.020	< 0.020
White Jabon	0.289	< 0.020	
(2) Horticultural crops			
	Fruit/tuber	Leaf	Stem
Chilli	0.098	< 0.020	
Sweet potato	< 0.020	< 0.020	
Cassava	0.028	< 0.020	
Eggplant	< 0.020	0.098	
Papaya	< 0.020	< 0.020	
Sugar cane		< 0.020	0.021
Bananas		< 0.020	
Pineapple		< 0.020	

These results also explain that the woody plants tend to be more capable as an accumulator of mercury compared with horticultural crops. This is evident from the range of the mercury content in the plant tissue of woody plants (<0.020 ppm - 0.322 ppm) were much higher than horticultural crops (<0.020 ppm - 0.098 ppm). Furthermore, it can be explained that the mercury in the woody plants is stored in the roots and not in the leaf or shoots. This indicates that the species of these plants are using phytostabilization mechanism to address mercury in the soil (Wang, 2004; Prabha, 2007; Tangahu et al., 2011). Phytostabilization is the mechanism of the plant in overcoming soil contaminants by means immobilize or reduce these contaminants in the roots of plants (Tangahu et al., 2011). In this way the mercury absorbed in the root surface or deposited and accumulated in the root zone, so that migration to vital parts in the plant tissue can be prevented (Sumarsih, 2015). Caused by mercury is not found (or found in small amounts) in the leaf, then the process of photosynthesis is not disturbed so that the plant growth is normal, although less than the maximum.

Meanwhile on horticultural crops, the plant responses to mercury in soils are varied. From the eight species of horticultural crops that grown by the local community, two species among them (chili and eggplant) is an accumulator of mercury. This is because both species are storing mercury in fruits and leaves as much as 0.098 ppm by far exceeds the safety threshold established by the government (SNI 7387-2009) is 0.03 ppm. Two other crops (cassava and sugar cane) storing mercury in the tubers and stems of the plant as much as 0.028 ppm and 0.021 ppm close to the safety threshold. Meanwhile, the four other species (sweet potato, papaya, banana and pineapple) have a mercury content which still well below safety threshold in all plant tissues (<0,020 ppm). This is a concern to be informed to the local community, especially the species of plants that have the potential to absorb mercury (mercury accumulator) above the threshold of safety that was not chosen to be cultivated again. The differences in plant responses to the mercury because every plant is specific in absorbing heavy metals (Sarma, 2011; Tangahu et al., 2011). This means that mercury accumulator may not necessarily lead accumulator as well, and vice versa. Until recently, it was reported by Sarma (2011) has found more than 500 species of plants from 101 families of plants used for phytoremediation of heavy metals.

4. Conclusion

Results indicate that plants response with different abilities in absorbing mercury. Several species of horticultural crops namely chili (*Capsicum frutescens* L.), eggplant (*Solanum melongena*), cassava (*Manihot utilissima*), and sugar cane (*Saccharum officinarum* L.) and woody plants namely agarwood (*Aquilaria malaccensis*), rubber (*Hevea brasiliensis*) and white jabon (*Anthocephalus cadamba*) have a high tendency to absorb mercury to exceed the threshold. Tailing's age show different mercury content in tailings but not in plant tissues. It is demonstrated that the older tailing age the lower mercury content in the tailings but not in plant tissues. Woody plants have the ability to accumulate higher mercury three times higher than horticultural crops, using phytostabilization mechanism. Woody plants prospects are very good for phytoremediation heavy metals, including mercury.

Acknowledgements

Our thanks goes to the Directorate General of Higher Education (DIKTI) on the funding for this research through research scheme MP3EI.

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Potential Utilization on Patent Wood Product to Fulfill the Needs from Renewable Resources

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Abstract

Wood industry in perspective of sustainable development faced with a number of issues such as shortages of raw materials, inefficiency, overcapacity, competitiveness of products and low added value. Development of new product based on needs of customer, becomes one of new models for continuing diversification product. Capturing from harvesting result on R & D seem become more sophisticated especially utilization source natural wealth from wood. This kind of knowledge bring more value in order to complete customer satisfaction, moreover no bordering limitation of kind product that used by end users. This paper discuss how user can know competition among the same product through utilization of patent database that registered on WIPO fields. Methodologies that apply in paper using software Matheo Patent Xe To see more information related utilization wood technology such as potential useful through strategy, research and development, patent analysis and patent collaboration among users. The result that can be obtain from patent analysis in wood product, is to find out how the development of technology and products that have been produced as well as how commercial processes connecting with technology users, especially in renewable resources. Summary report from utilization of R & D on wood patent database can be apply incase opportunity in dissemination with industrial and stakeholder that needs impact on newest implementation of technology and level competitiveness in appropriate designation to commercialization form renewable resources.

Keywords: patent, renewable, resources, utilization, wood

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1. Introduction

Indonesia's forests have enormous potential, breadth reaching 99.6 million hectares or 52.3% of the total area of Indonesia. Large forest area which is currently still can be found in Papua, Kalimantan, Sulawesi and Sumatera. Indonesian forest has various types of wood. There are at least 4,000 species of wood that 267 species of which is a timber that has a high economic value. In general, the types of wood and its distribution is as follows. Wood keruing, meranti, agathis produced mainly in Papua, Sulawesi, and Kalimantan. Teakwood are produced in Central Java. Rattan are produced in Kalimantan, North Sumatra and West

Sumatra. Sandal wood are produced in the East. Wood Rasamala and acacia are produced in West Java (Kemenhut, 2011).

Based on the potential for above, Indonesia should become a major player in the wood-based industry plants, because of the diversity of types of wood supported, climate and strategic location between a number of countries in the world. "Indonesia has a climate that is very conducive to the trees grow very rapidly, and its location in the state of potential. Natural factors make many kinds of trees grow abundantly in parts of Indonesia which has a tropical climate. Trees grown dominated by tropical rain forest plants (<http://industri.bisnis.com>)

Trees are plants that consists of three main parts, namely the roots, stems and leaves as well as a network of vascular and contains cellulose, hemicellulose and lignin. The tree is timber. Wood can be processed further into wood-based products. Processed wood products is a product made of wood. The products are made from wood, among others: Plywood / Plywood Wood, sawn / sawntimber Wood Flakes / Chip Wood, Notching / Moulding, Veneer, Blockboard, Furniture, Paper, Pulp component of building / construction timber, Particle Board / Particle Board, Board, Fiber Cement Board. The development of increasingly sophisticated technology provides the opportunity to produce wood-based products are more varied. First product is usually made of particle board with a thickness between 8-12 mm. However, today with increasingly sophisticated technology, particle board products can be made with a thickness of 2-3 mm. Lately many wood products industry company that shortages of raw materials ([http //: industribisnis.com](http://:industribisnis.com)).

Processed wood products in Indonesia are mainly exported to Asian countries such as Japan, Singapore, Taiwan, Hong Kong, China and South Korea. It is also exported to European countries and the United States. In 2002, the biggest sawn timber exported to Taiwan with volume reaching 286 279 m³, or 73% of the total export volume of sawn timber. Products plywood (plywood), the largest exported to Japan at 1.29 million m³, equivalent to 26% of the total export volume of plywood. Based on data from the Ministry of Forestry period from January to December 2013, which is processed from Timber Legality Information System, the export value of A group of Indonesian forestry products reached \$ 5.75 billion. This figure is up 11.21% compared to 2012. The forest products group A includes wood paneling, wood (wood working), pulp (pulp), paper, and prefabricated wood buildings. Of the five categories, the highest export value contained in the wood panel and pulp products. (<http://ilmuhutan.com/produk-kayu-olahan-di-indonesia>).

Production of forest products are successfully exported mainly in the form of processed wood products such as sawn timber, plywood and other processed wood. For example, in 2002, volume and foreign exchange earnings from processed wood products are successfully exported to various countries are presented in Table 1 as follows:

Based on Figure 1-4, the export of processed wood products from Indonesia exported to many countries, especially Asian countries such as Japan, Singapore, Taiwan, Hong Kong, China and Korea. Partly to European countries and the United States. In 2002, the biggest sawn timber exported to Taiwan with volume reaching 286 279 m³, or 73% of the total export

volume of sawn timber. Products plywood (plywood), the largest exported to Japan at 1.29 million m³, equivalent to 26% of the total export volume of plywood. (http://www.kppbumn.depkeu.go.id/Industrial_Profile/PK4/Hutan).

Table 1. Volume Export of Processed Wood Products 2002

Export of Processed Wood Products	Volume (m ³)	Value Million US \$	Destination
Plywood	4.983.025	440,91	Japan (26%)
Raw Wood	392.588	1,91	Taiwan (73%)
Woodworking	6.676.796	222,83	Singapore (40%) & Japan (22%)
Blockboard	464.218	31,61	Hong Kong (57%)
Pulp	232.710	54,05	China (98%)
Paper	282.470	166,91	Asia (89%)
Veneer	132	0,06	Singapore (100%)
Chipwood	59.138	5,19	Japan (48%) & Korea (26%)

Source : BPS, 2006

Referring to the latest data, wood and forest products industry in Indonesia has declined. According to BPS data, wood products and forest products in the last three years continued to experience negative growth. In 2004, the industry recorded negative growth of 2.1%, 2005 growth of minus 1.3%, and they grew in the first quarter of 2006 to minus 5.8%. Based on data from the Indonesian Wood Panel Association (Apkindo), the production of wood panels Indonesia ever reaches about 7 million cubic meters in the period 1999-2000 has plunged to 3.5 million cubic meters in 2005. In fact, Malaysia is estimated to produce wood panels of up to 4 million cubic meter. Of 120 plywood factories in Indonesia, the factory which is currently recorded are still producing and exporting their products 52 mill. However, these factories with an average production capacity utilization of less than 50% of normal capacity (BPS, 2006).

Ironically, the timber industry and forest products have been growing rapidly in competitor countries such as China, Malaysia and Vietnam that do not have their own raw material. Indonesia's furniture exports recorded at 1.79 billion US dollars, growing an average of US \$ 0.088 billion per year in the last 8 years. In the same period, furniture exports from China grew by an average of 1.1 billion US dollars. China prohibits logging in furniture exporting country amounted to 14 billion US dollars in 2005 (BPS, 2006).

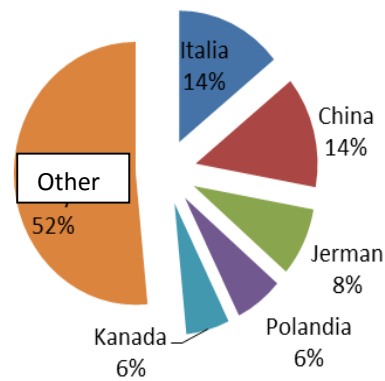


Figure 1. The biggest furniture exporting country in the world year of 2004 (Source: BPS, 2006)

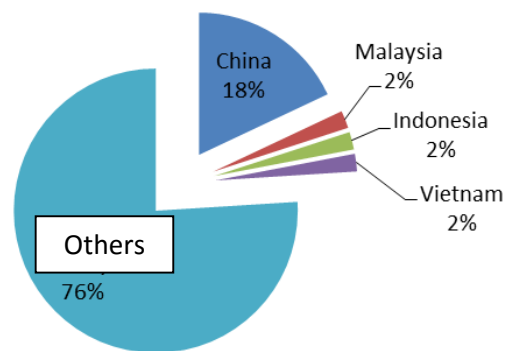


Figure 2. Furniture exporting country in Asia year of 2006 (Source: BPS, 2006)

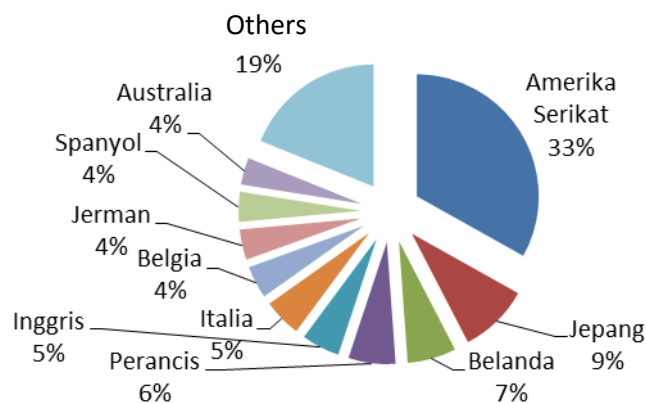


Figure 3. The main destination country of Indonesian furniture export year of 2005 (Source: BPS, 2006)

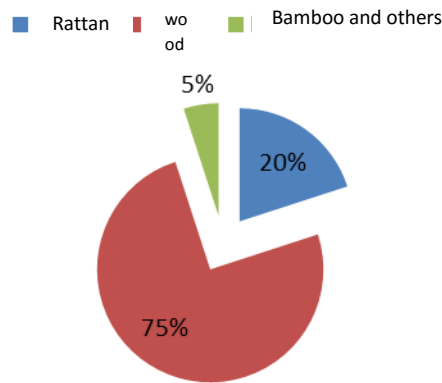


Figure 4. Indonesian furniture export based material export furniture Indonesia year of 2006 (Source: BPS, 2006)

Wood processing technology, in principle, can be divided into several sections including cutting technology normally associated with tools and methods of cutting, gluing techniques related to the type of wood and the formulation of adhesives, structural modification techniques wood, wood preservation techniques and others. Some of these technologies are owned by the need to be able and developed by the furniture industry in the undertakings continue to produce processed wood products quality and competitiveness. Competition products and technologies in the furniture sector is sufficiently high that without mastery of wood processing technology, the furniture industry will be less able to compete with the industry and furniture products from abroad.

Development of the forestry industry (wood-based industry) in Indonesia is driven by efforts to achieve economic development goals increase foreign exchange earnings through exports, increase employment, and achieve added value. Forestry industry has always been considered as the main economic sectors that have a comparative advantage because of the abundance of raw materials and cheap labor. Comparative advantage due to the perception that it is noticeable tendency Indonesian forestry industry continues to grow and develop. Industry capacity installed over the years has grown substantially. The rapid development of the timber industry is not accompanied by conservation and reforestation optimal causing forest destruction and lack of raw materials. Therefore, the importance of a balance between the use of timber forest products with the conservation so that development can be sustainable timber industry and sustainable (Sumitro, 2005).

Information technology in the processing of wood and its derivatives can be obtained through the data on patent documents both patents domestically and abroad. Patent document is a document that is full and rich in information technology that is publicly accessible and easily understood by the public. In addition to information technology, patent documents contain data about the data inventors, applicants, patent application date, destination countries patent applications, and much more. Through information and data, can be obtained benefit them if patents are not registered in Indonesia, then we can use or adapt these technologies freely (free-to-operate) because according to the rules prevailing in the

patent that the patent is protected only where the patent is registered. In addition, through the data date of registration or certificate granting patents it is known that certain patents are still in a period of protection or expired protection. If an expired patent protection, the technology in the patent information has become public domain.

Another benefit of patent documents is able to know the trend of technology developed at this time, knowing the player technology and even competitors who master certain technologies. And analysis proper understanding of the information in patent documents can seize opportunities or adapt the technology gap and utilize these technologies can even develop into a better direction over existing technologies. This intelligent of competitive activity, potential for new inventions on the development of existing technologies is also quite large.

Many software and international patent databases that provide information such patent Matheo patent documents, WIPO, Espenecet, USPTO, Google Patents, patent offices in each country such as Indonesia through dgip.go.id, Japan through the Japan Patent Office, and others. This study aims at presenting the technology mapping and the use of timber and derived products through patent information obtained through a search by Matheo Patent software and WIPO website.

2. Material and Methods

The study used a qualitative research methodology to approach the study of literature through a search of patent information, patent documents database analysis to collect data and information related to the topic by focusing on finding answers to problems, especially studies on the utilization and development of wood technology and derivative products. Extracting data and information is done by two approaches:

2.1 Literature Browse

Literature Browse information related to the topics and problems of various written sources, such as books, journals, articles or writings of other experts;

2.2 Analysis database

Analysis database of patent documents on the use of technology through the development of herbal medicine Matheo Patent XE software and WIPO patent databases. This study is implementable / applicative, where the results are expected to be utilized by the user. More specifically, this study is the process of modification and reengineering / reverse engineering of a technology that is sourced from patent information.

3. Results and Discussion

Based on studies that have been done on the utilization of wood and its derivatives technology through patent information obtained the following results. Referring to Fig. 5 can be understood that for the field of wood technology Chinese, English and American master and lead the technology. This is demonstrated through a number of international patent applications the country. While Indonesia with the potential of wood and other dairy

products that are not yet able to compete on the technology aspects indicated by the patent applications in the field of wood technology is still very low even according to the data does not exist yet of Indonesian patent applications in the field of wood processing technologies. Indonesian patents in the field of wood processing technology is merely a domestic patent applications.

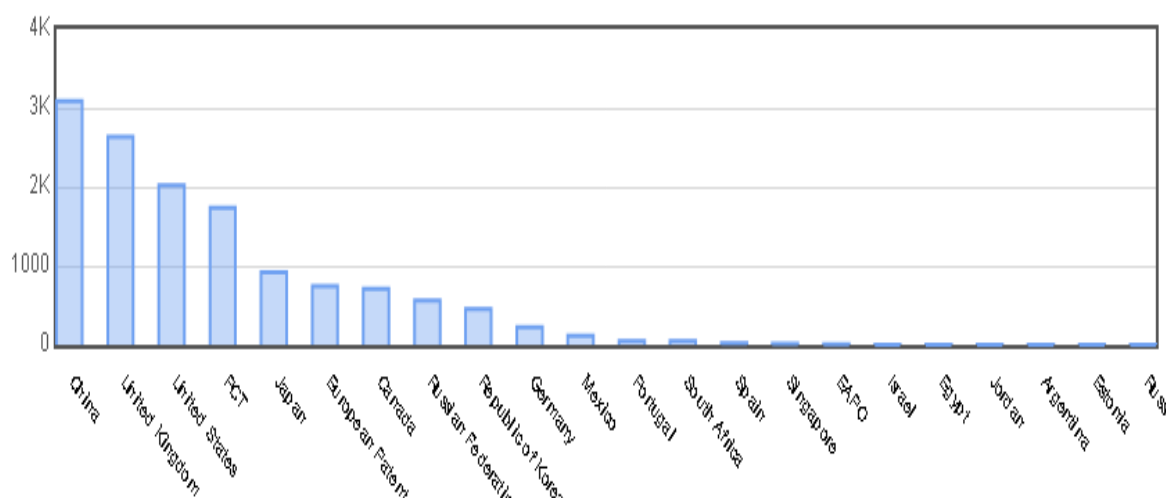


Figure 5. The applicant country of International Patent in Wood Technology

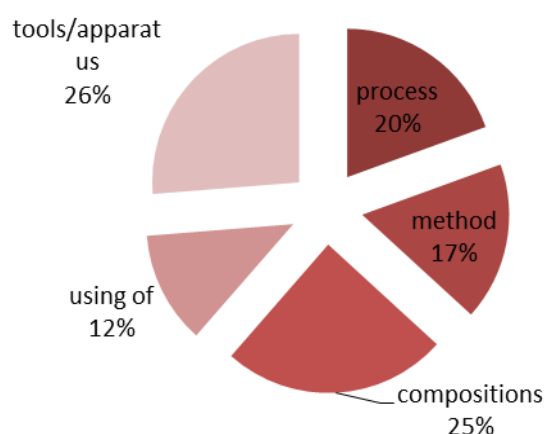


Figure 6. The field of Technology in Wood Patent Application (Source : Matheo Patent XE)

The field of wood technology based on Figure 6 shows the equalization wood technology in the field of processes, methods, compositions, use or apparatus despite technological tools for wood processing slightly dominate in the range of 26% followed by the composition of 25%, the 20%, the method and the use of each - each 17 and 12%. Such data indicates that the development of wood technology had been developed over the years and has the tendency of technology tools and products in the form of the composition of the material that is constantly increasing in addition to other technologies also increased. This can be seen in international patent publication number continues to increase every year as shown in Fig. 7.

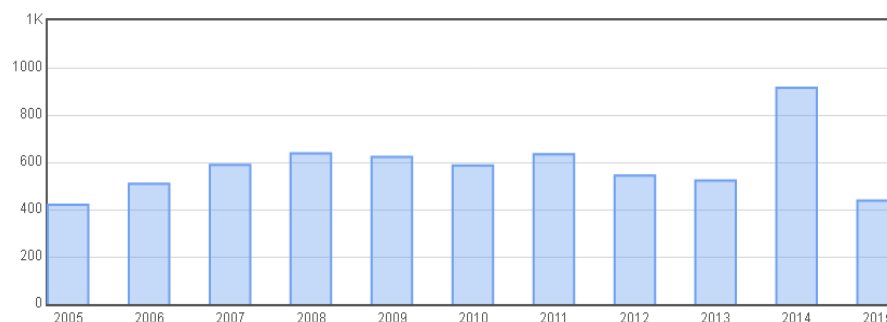


Figure 7. The Number of Patent Publication in Wood Technology

Through this information, obtained many benefits and opportunities, especially the state of Indonesia which have great potential in the field of wood to see the trend in the field of wood technology and take advantage of these technologies to process wood into competitive products. Obviously, with this patent information, research and development in Indonesia as well as national timber industry does not have to do research from the beginning to find a tool or process in the field of wood processing. However, the presence of information technology in the patent application of existing technologies can be utilized as a source of technology into initial referral us before doing research and further development even these technologies can directly adaptation and use to support national timber industry course with the provisions applicable in the patent.

The importance of information technology in the patent is a patent technology has a tendency of new technologies and has a high industrial applicable so that by utilizing these technologies the opportunity to produce, process and tools that have commercial prospects and competitiveness in support of the timber industry is also high. In terms of making diversified wood products would need good technology as well. Source of relevant technology support is of patent information. Mastery of technology will support the sustainability of the national timber industry in the undertakings produce wood products that are innovative, high quality and competitiveness. Developed countries such as China, the United States can dominate the world furniture market as they master the technology in the field of wood processing shown in the country's patent application data in Fig. 5.

Therefore, if Indonesia wants to improve competitiveness in the furniture industry, the first thing that must be done is to apply technology in the field of wood processing. Through intelligent competitive and the principle of freedom to operate and the provisions of the patent, will accelerate the process of technology transfer and dissemination of technology in the field of wood processing. Through these activities, the possibility of resulting inventions and innovations are also quite open. With the completion of the new innovations that will be followed by an increase in the competitiveness of Indonesian timber products.

4. Conclusion

Patent information in the field of wood processing technology can be utilized as a source of information technology in an effort to accelerate process of technology transfer and dissemination of technology in the field of wood processing. Mastery of technology will support sustainability of national timber industry in the undertakings produce wood products that are innovative, high quality and competitiveness. Through intelligent competitive and principle of freedom to operate and provisions of the patent, opportunities / possibilities it generates new invention and innovation are also quite open.

Acknowledgements

The author would like to thank The Chief of IPR Management Center for Innovation LIPI, speakers and informants who have provided information and discussions during data collection.

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Mercury Accumulation and Arbuscular Mycorrhizal Colonization in Several Pioneer Plants on Ex-Gold Mining Area

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Abstract

Pioneer plants and arbuscular mycorrhizal (AM) fungi have important role in succession of degraded land and mercury-(Hg)-contaminated as a result of gold mining. They have the potency to be developed as biological agents for degraded land rehabilitation and Hg-contaminated soil remediation. An experimental study to evaluate Hg accumulation and AM colonization in pioneer plants had been conducted. Hg concentration in plant tissues and diagnostic structures of AM infection within the root of pioneer plants grown on riparian and terrestrial ex-gold mining areas were analyzed. *Cyperus halpan* and *Lipocarphachinensis* tend to accumulate Hg 0.10 mg/kg and 0.05 mg/kg in roots, whereas *C. cephalotes* and *Dillenia excelsa* accumulated Hg 0.30 mg/kg and 0.15 mg/kg in aerial part (stems and leaves). On the other hand, some pioneer plants accumulate Hg both in roots and in aerial part, namely *Eugenia spicata* (Hg 0.46 mg/kg and 0.10 mg/kg), *Eleocharis atro purpurea* (Hg 0.10 mg/kg and 0.07 mg/kg) and jagu (Hg 0.50 mg/kg and 0.50 mg/kg). AM colonization was found in the roots of some pioneer plants species, which grown on riparian and terrestrial, except *C. halpan*, *C. cephalotes*, and *L. chinensis*. Although the relationship between AM colonization and Hg content in roots was not clear, AM-pioneer plants symbiosis could be expected to affect Hg accumulation in plants tissues. This result needs further investigation to evaluate the ability of Hg accumulation by AM pioneer plants.

Keywords: Degraded land, Land rehabilitation, Remediation, Riparian, Terrestrial

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1. Introduction

Mercury (Hg) is the one of toxic heavy metal which has no known biological role and detrimental to living organisms as resulting in inhibition of enzyme activity and cell damage of living organisms (Landis & Yu, 2003). Bio-accumulation of organic forms like methylmercury in biological tissues, facilitating the magnification of this toxin along trophic

food chains resulting in long-term health hazards, is of major concern (Balshaw et al. 2007). Sources of Hg contamination in the environment are natural (volcanic action and erosion of Hg-containing sediments) and anthropogenic source. Anthropogenic source include mining and transporting Hg ores and processing; dumping industrial wastes into rivers and lakes; combustion of fossil fuels (e.g., Hg content of coal is about 1 ppm), pulp and paper; use of Hg compounds as seed dressings in agriculture; and exhaust from metal smelters, etc. (Landis & Yu, 2003). Gold mining activity not only caused the physical, chemical and biological soil damage, but also caused Hg contamination in the soil and the environment.

In early succession, pioneer plants invading the area have the ability to grow in degraded soil and survive in Hg-contaminated soil. It indicated that the pioneer plants might be resistant or tolerant to Hg. All plants appear to concentrate traces of Hg in varying degrees, depend on the deposits in substrates in which they are rooted, plant species, and locality (Landis & Yu, 2003). Kabata-Pendias and Pendias (1989) stated that the element of Hg is more easily bio-accumulated than other elements. Baker (1981) proposed two basic strategies by which higher plants can tolerate the presence of large amounts of metals in the environment, i.e. (1) exclusion, whereby transport of metals is restricted, and low, relatively constant metal concentration are maintained in the shoot over a wide range of soil concentration; and (2) accumulation, whereby metals are accumulated in nontoxic form in the upper plant parts at both high and low concentration. He suggested that accumulator can be characterized by a leaf:root metal concentration ratio of <1 because of the tendency to translocate metals from root to shoot, whereas in excluder the ratio is >1 . The uptake and accumulation of heavy metals by plants may be the most important aspect of pollution dynamics (Mohapatra, 1989).

Soils of mining area generally low in nutrients and organic matter, and the problem of how the pioneer plants might deal with the heavy metals present also needs to be addressed. Astiani and Ekamawanti (2002) found arbuscular mycorrhizal (AM) fungi in the rhizosphere of several pioneer plants grown on ex-gold mining area in Mandor, West Kalimantan. AM fungi play important roles to promote plant growth in marginal soil due to their unique position at the soil/root interface and their recognized role in element transport and immobilization (Smith & Read, 2008). AM fungi, as mycosymbiont, have enormous potential to be used in synergy with the plants, as phytosymbiont, in soil remediation of heavy metal-contaminated soil (Gaur & Adholeya, 2004). The potential and the prospects of AM fungi in heavy metal tolerance of plant and its utilization for enhancing phytoremediation have been reviewed (Regvar and Vogel-Mikuš, 2008; Upadhyaya et al. 2010) and proposed as one of the mechanisms of plant heavy metals-tolerance (Hall, 2002; Hildebrandt et al. 2007), including Hg-tolerance (Ekamawanti et al. 2013; Ekamawanti et al. 2014). Since ex-gold mining area would have been rehabilitated, it is worth to make useful AM-plant symbiosis as an alternative to land rehabilitation success. Therefore, the Hg accumulation and AM colonization should be revealed. The objective of research was to evaluate Hg accumulation and AM colonization in pioneer plants grown on riparian and terrestrial of ex-gold mining area.

2. Materials and Methods

2.1 Plants and soils sampling

We collected three (3) individuals of each pioneer plant species from riparian, such as *Pityrogramma calomelanos* (paku-pakuan sp.1), *Scirpus lateriflorus* (rumpun sp.A), *Cyperus halpan* (rambang), *Melastoma affine* (cengkodok), *Nephrolepis exaltata* (paku-pakuan sp.2), *Eleocharis ochrostachys* (purun), *Eleocharis atropurpurea* (rumpun ijuk), *Fimbristylis acuminata* (rumpun kumis), *Cyperus cephalotes* (rumpun air), *Dillenia excelsa* (simpur), and from terrestrial namely *M. affine*, *D. excelsa*, *Eugenia spicata* (ubah ube), *Gleichenia linearis* (paku resam), *E. atropurpurea*, *Lipocarpa chineensis* (rumpun sp.B), and jagu (unknown Latin name). We divided plant samples into two parts, root and aerial part (shoot), then cleaned the plants with water and dried all parts under the sun. On each rhizosphere of pioneer plants, we took 500 g soil sample for total Hg concentration determination. Disturbed and undisturbed soil samples were collected and composited from 10 sub samples then analysed for determination of soil chemical and physical properties. All plant and soil samples were collected from riparian and terrestrial of ex-gold mining area, Mandor district, West Kalimantan (00°18' - 00°22' N and 109°18' - 109°20' E).

2.2 Total Hg concentration analyses

About 0.5 g of sample was taken for acid digestion using HNO₃ 2 mL, HClO₄ 2 mL, H₂SO₄ 5 mL and aquadest 1 mL and heated in acid room at 250°C for 20 min. Then, total Hg concentration of samples were analysed with Atomic Absorption Spectrophotometer.

2.3 AM colonization determination

AM colonization was detected by modified technique of Koske and Gemma (1989). Root samples were cleared and bleached with KOH 10% and mixture of H₂O₂ 5% and NaOCl 5.25%, then stained with trypan blue in lactoglycerol. Vesicle, arbuscular and internal hyphae were used as diagnostic structures of mycorrhizal infection in root. Root colonization by AM fungi was counted by slide methods of Brundrett et al. (1996). AM infection level was classified based on The Institute of Mycorrhizal Research and Development, USDA Forest Service, Athens, Georgia (Sieverding, 1991) as: class 1 with AM infection 0% - 5%; class 2 with 6% - 25%; class 3 with 26% - 50%; class 4 with 51% - 75%; and class 5 with 76% - 100%.

3. Results and Discussion

The results obtained in this study reveal that several pioneer plants could be potential as Hg accumulator, which were indicated by the ratio of Hg concentration in the aerial parts and in the root >1 and as Hg excluder which were showed by the ratio of Hg concentration in the aerial parts and in the root <1 (Table 1). It was observed that amount of Hg accumulated in the roots was comparatively less than the aerial parts in *C.cephalotes*, *G.linearis*, *D. excelsa*, *E.spicata*, *E.Atropurpurea* and jagu. It indicated that these pioneer plants may be potential candidates for mercury phytoextraction. On the other hand, not only *C.Halpan* and *L.Chinensis* but also *E.spicata*, *E.Atropurpurea* and jagu showed higher

accumulation levels in the roots. Muddarisna & Krisnayanti (2015) also found that *Cyperus kyllingia* showed high tolerance and potentially effective mercury accumulation in roots and shoots. This may be partly due to plant variability and their ability to absorb and accumulate heavy metals (such as Hg) in their tissues (Ferguson, 1991).

The accumulation levels were not uniform among the pioneer plant species. Molina et al. (2006) and Temmerman et al. (2009) point out that heavy metals bioaccumulation depends on the absorption mechanism of each plant species. This would explain why in some cases the absorption rate is constant and independent of Hg concentration in the soil; that there is no relationship between Hg content in the soil and in the plant; or that the bioaccumulation of Hg in the plant does not increase even if Hg concentration in the environment increases. It may be caused by many factors like the fluctuating environment (such as temperature, soil pH, soil aeration, soil moisture), the root system, availability of element in the soil, plant energy supply to all parts, etc. which influence the uptake and accumulation of the metal (Ferguson, 1991).

Table 1. Total Hg concentration (mg/kg) of pioneer plants tissue and rhizosphere samples collected from riparian and terrestrial of ex-gold mining area

Plant Species	Total Hg concentration (mg/kg)			[Hg] of aerial part:[Hg] of root ratio
	Aerial part	Root	Soil	
Riparian:				
<i>Scirpus lateriflorus</i>	< 0.001	< 0.001	< 0.001	1
<i>Pityrogramma calomelanos</i>	< 0.001	< 0.001	< 0.001	1
<i>Cyperus halpan</i>	< 0.001	0.100	< 0.001	0.01
<i>Melastoma affine</i>	< 0.001	< 0.001	< 0.001	1
<i>Nephrolepis exaltata</i>	< 0.001	< 0.001	< 0.001	1
<i>Eleocharis ochrostachys</i>	< 0.001	< 0.001	< 0.001	1
<i>Fimbristylis acuminata</i>	< 0.001	< 0.001	< 0.001	1
<i>Eleocharis atropurpurea</i>	< 0.001	< 0.001	< 0.001	1
<i>Cyperus cephalotes</i>	0.298	< 0.001	< 0.001	298
<i>Dillenia excelsa</i>	0.150	< 0.001	< 0.001	150
Terrestrial:				
<i>M. affine</i>	< 0.001	< 0.001	< 0.001	1
<i>E. atropurpurea</i>	0.099	0.066	0.033	1.50
<i>Gleichenia linearis</i>	< 0.001	< 0.001	< 0.001	1
<i>Lipocarpa chineensis</i>	< 0.001	0.051	< 0.001	0.02
<i>D. excelsa</i>	0.033	< 0.001	0.695	33
<i>Eugenia spicata</i>	0.463	0.100	< 0.001	4.63
Jagu	0.500	0.500	0.398	1

Except *C. halpan*, *C. cephalotes* and *L. chinensis*, AM colonization were found in several pioneer plant species, both of which grow on riparian and terrestrial, with the percentage of AM colonization ranges from 2.7% - 16.3% (Table 2). Although percentage of AM colonization were low (class 1 and 2), they have become indicator that several pioneer plants species found in the area of ex-gold mining were host plants of AMF. This was basic information for development opportunities of mycorrhizal plants that can accumulate

mercury in tissue plants, both in the roots and the aerial parts. According to Gaur & Adholeya (2004), AMF play an important role for plants in the accumulation and tolerance to heavy metals. Upadhyaya et al. (2010) stated that the AMF present on the roots of plants growing on (heavy) metal-contaminated soils play an important role in (heavy) metal tolerance and accumulation. The occurrence of AM fungi in plants growing on HM-contaminated sites (Shetty et al. 1995; Weissenhorn & Leyval, 1995; Pawlowska et al. 1996; Chaudhry et al. 1998; Chaudhry et al. 1999) may indicate that these fungi have evolved a HM-tolerance and play a role in the phytoremediation of the site (Salt et al. 1995).

The results of this study showed that there was no clear relationship between the percentage of AM colonization and Hg content accumulated in pioneer plants. However, since AM fungi can compensate for inefficient plant nutrient and HM uptake, they should be integrated into the design of future soil clean-up strategies with pioneer plants (Upadhyaya et al. 2010). AM fungi are not only an aid to ecosystem remediation but also be considered as a key indicator for soil pollution or soil quality because AM fungi are ubiquitous microorganisms, many plants are highly dependent on mycorrhizal for their growth, they provide a direct link between soil and roots and are involved in the transfer of elements including pollutants from soil to plants (Mathur et al. 2007). Therefore, further research on the ability of Hg accumulation in mycorrhizal pioneer plants needs to be conducted.

Table 2. AM colonization in pioneer plants roots samples collected from riparian and terrestrial of ex-gold mining area

Plant Species	AM collonisation (%)	Class of AM colonization
Riparian:		
<i>S. lateriflorus</i>	12.5	2
<i>P. calomelanos</i>	3.8	1
<i>C. halpan</i>	0.0	0
<i>M. affine</i>	12.8	2
<i>N. excaltata</i>	4.0	1
<i>E. ochrostachys</i>	15.0	2
<i>F. acuminata</i>	16.3	2
<i>E. atropurpurea</i>	8.2	2
<i>C. cephalotes</i>	0.0	0
<i>D. excelsa</i>	8.0	2
Terrestrial:		
<i>M. affine</i>	8.7	2
<i>E. atropurpurea</i>	6.2	2
<i>G. linearis</i>	6.7	2
<i>L. chineensis</i>	0.0	0
<i>D. excelsa</i>	13.5	2
<i>E. spicata</i>	2.7	1
Jagu	11.5	2

4. Conclusions

C. halpan and *L. Chinensis* were Hg excluder (non-accumulator) which tended to accumulate Hg only in plant roots. In contrast, *C. cephalotes*, *G. linearis*, and *D. excelsa* were Hg accumulator that accumulated Hg only in aerial part of plants. Several pioneer plants did not only accumulate Hg in roots but also in aerial part of plants, namely *E. spicata*, *E. Atropurpurea* and jagu. Several pioneer plants species which grew in riparian and terrestrial, except *C. halpan*, *C. cephalotes*, and *L. chinensis*, were colonized by AM fungi. Even though the relationship between AM colonization and Hg content in pioneer plant tissue was not clear, AM-pioneer plants symbiosis could be expected to affect Hg accumulation in plants tissues.

Acknowledgements

The authors gratefully acknowledge support from Research Insentive Program of Mathematics and Natural Sciences, the Ministry of Research and Technology.

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Design of Performance Measurement for Company in Forestry Sector based on MBNQA Criteria

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Abstract

Total Quality Management (TQM) is one of quality management concept that has been adopted widely by many companies to maintain and increase their customer satisfaction. Many studies have proved the benefits of TQM implementation in vary sectors. The implementations of TQM were introduced in various forms, including TQM form of model quality management awards, such as the Malcolm Baldrige National Quality Award (MBNQA). MBNQA is one of the most popular TQM concepts which used widely throughout the world. One of the criteria contained in MBNQA is result criteria. This criteria can be used in measuring the performance of the company. However, number of research that discuss the design of performance measurement for forestry company still rare. This research aims to develop a performance measurement framework for forestry company based on MBNQA. In designing of the performance measurement tool, this study also considered various indicators of performance which are generally used by forestry company. The method used in this study was the Analytical Hierarchy Process (AHP) by involving respondents who are experts in the field of forestry and MBNQA criteria. The output of this research is a performance measurement framework that can be used by forestry companies.

Keyword : MBNQA, Performance measurement framework

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1. Introduction

Quality has been emerging as important management function in recent years. In high competition level among firms, it's important for them to develop their own quality management system (Lau et al. 2004). The relationship between the implementation of quality management system and organizational performance has been mentioned in (Jang & Lin, 2008; Feng et al. 2008; Martinez-Costa, 2008;Chow-Chua, 2003).

MBNQA (Malcom Baldrige National Quality Award) is one of various form of quality management system used widely throughout the world. MBNQA, awarded to a firm which success in implementing quality management requirement of the award. According to Evans (2005), The awarding system implemented in USA for the first time on August20, 1987 by signed into Public Law 100 – 107. Evans (2005) also explained the purpose of the award are to help stimulate American companies to improve quality and productivity in various sectors

such business, industrial, governmental, and other enterprises. Since then, many researchers being interested in studying MBNQA (Lau et al., 2004); D'Souza & Sequeira, 2011a; D'Souza & Sequeira, 2011b; Sawaluddin, 2013; Puay et al., 1998; Miguel, 2001). However, research paper which designed to find unique performance measurement for certain sectors like forestry, agriculture, and the other is scarce.

Lau et al. (2004) investigate the implementation level of quality management in China with MBNQA criteria. Lau et al. (2004) compared firms in three different stage of the development of a quality system: firms that focus on inspection, statistical quality control and total quality management in the context firms in China. Similar research in smaller scope have been done by D'Souza & Sequeira (2011a) in the context of health care in India. In the other research, D'Souza & Sequeira (2011b) also investigate the relationship between service quality management dimensions and the impact on performance in the context of healthcare organizations. Sawaluddin (2013) research the relationship of MBNQA quality management practices, they are the effect of leadership, workforce focus, strategic planning, and customer focus to operation focus, measurement, and analysis and knowledge transfer and organization performance. Puay et al. (1998); and Miguel (2001) did a comparative study between major national quality award throughout the world.

In the other side, forestry sector is one of lowest value contribution in PDB (Masyhud, 2011). Thus, designing of performance measurement as an effort to improve the performance of forestry sector is needed.

2. Materials and Methods

This research performed quantitative research methodology. This research consist of three steps, they are interpreting step, weighing criteria step, and analyzed step. The first step is interpreting step, used to define the MBNQA document from company of forestry sector's view. The second step is weighting. In this step, the expert chosen in this research is asked about the importance of the each clause of the first step using Analytical Hierarchy Process (AHP) as has been done by Barzekar (2011). There were four experts in quality management system and industry of forestry sector. Then, the last step is analyzing the weight score in second step in order to formulating the new performance measurement of company of forestry sector.

3. Results and Discussion

3.1 Interpretation of MBNQA

In this step, we interpreting the criteria from a company in forestry sector view. Generally, there are seven main criteria in MBNQA, they are 1) Leadership, 2) Strategic Planning, 3) Customer Focus, 4) Measurement, analysis, and knowledge management, 5) workforce focus, 6) Operation Focus, and 7) Result. They are explained as follows :

1) Leadership

This clause is divided into two sub clause, sub clause of senior leadership and sub clause of Governance and Social responsibilities. Subclause of Senior Leadership notices how do the leaders of the forestry company lead. It notices how the company of forestry set and

implement their vision and values; how the senior demonstrate their commitment according to ethical behavior in business of forestry sector, how the leader doing communication and focus on action to achieve the organization objective. Sub clause of governance and social responsibilities notice how the company of forestry sector review and achieve their key aspect (accountability, fiscal accountability, transparency in action, independence and effectiveness if internal and external audits, protection of stakeholder and stockholder interest appropriately, and succession planning for senior leader); how the company of forestry evaluate their performance of senior leader. This sub clause also assessing legal and ethical behave of forestry company.

2) Strategic planning

This clause consisted of sub clause strategy development and strategy implementation. Strategy development notices how the company of forestry sector conduct their strategic planning, innovation, strategy consideration and how well their work systems designed, how they determine future core competences. The sub clause also assessing the aspect about strategic objective considerations. Sub clause of strategy implementation assessing two main aspect, firstly the aspect of action plan development and deployment; secondly the aspect of performance projection.

3) Customer focus

This category assess how the company of forestry engages its customers for marketplace success, including how they reach their voice of the customer, builds customer confidence, and utilization of information which informed by their customer. The criteria consist of sub clause voice of customer and customer engagement. Sub clause voice of customer notice how the company of forestry listing to their current customers and potential customer. The sub clause also considering the determination of customer satisfaction and engagement aspect. The sub clause of customer engagement notices how the company of forestry offer their product, support their customer and segmenting their customers. The sub clause also assess how the company build its relationship with their customers.

4) Measurement, analysis and knowledge management

This category assess how the company of forestry sector selects, collects, analyzes, manages and improve its data. This category also assess their how the company uses the information of findings to improve the performance of the company. The category consist of two sub clause, they are sub clause of measurement, analysis, and improvement of organizational performance and sub clause knowledge management, information, and information technology. The first sub clause notices the aspect of performance measurement, performance analysis and review, performance improvement and the second sub clause notices organizational knowledge aspect and data, information, and information technology aspect.

5) Workforce focus

This category notices how the company of forestry sector assesses workforce capability and capacity needs and conducts conducive workforce environment to high performance. This clause consist of two sub clause, workforce environment and workforce engagement. The first sub clausul assess the aspect of work force capability, capacity and the workforce

climate; the second clause assess the aspect of workforce performance, assessment of workforce engagement and workforce and leader development.

6) Operation focus

This criteria assess how the company of forestry sector designs, manages and improves its products and work process and improves operational effectiveness to deliver customer value and achieve organizational success and sustainability.

7) Result of focus

In MBNQA model, result criteria assess the relationship of six criteria above with the organizational performance. This clause watch 1) product of forestry company product performance and its process effectiveness results 2) customer focussed results 3) workforce – focused results, 3) senior leadership and governments results, 4) financial and market results.

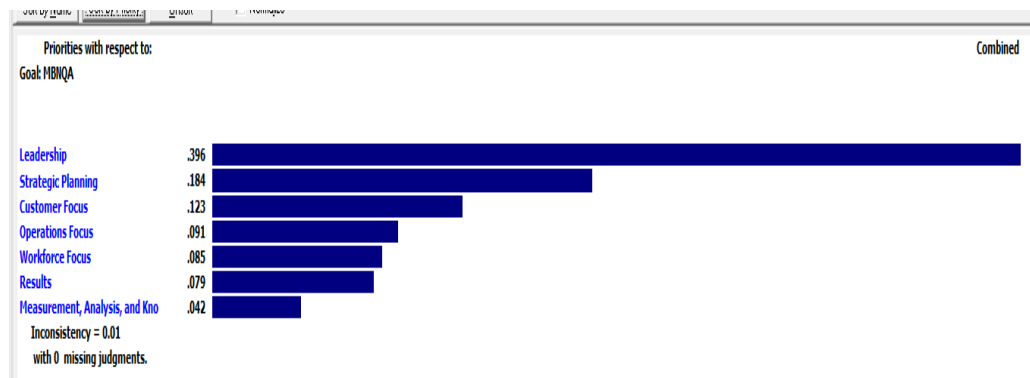
3.2 Weighing The Clause

In weighting the clause, this research used expert choice version 11 software. The software helped in determining the importance of the each clause compare to the another. The experts was asked to gave a score around 1–9 for the importance level and then the score was compiled. The result of the compilation was shown in Figure 1.

Compare the relative importance with respect to: Goal: MBNQA							
	Leadership	Strategic P	Customer f	Measur	Workforce	Operations	Results
Leadership		2.21336	3.93598	6.1793	4.42673	4.55901	5.8259
Strategic Planning			1.68179	4.11953	2.63215	2.0	1.94801
Customer Focus				3.36359	1.41421	1.31607	1.91089
Measurement, Analysis, and Knowledge Management					2.21336	2.63215	2.05977
Workforce Focus						1.0	1.03395
Operations Focus							1.07457
Results							
Incon: 0.01							

Figure 1. Compilation of the expert's answer

According to Barzekar (2011), the inconsistency level of the table must not higher than 0.1. the compilation process in table 1 is fulfill the requirement (0.01). Then the score put in series from the highest score in to lowest score. The most important clause to the less important clause according to the experts are: Leadership, strategic planning, customer focus, operation focus, workforce focus, result focus, and measurement, analysis, and knowledge Management.



ce of the clause

3.2 Analysis

Table 1 shows the difference between current MBNQA and the MBNQA of company in forestry sector version.

Table 1. Comparison of current MBNQA and MBNQA of company in forestry sector

Clause	MBNQA of company		Difference
	Current MBNQA	in forestry sector	
Leadership	0.12	0.396	-0.276
Strategic Planning	0.085	0.18	-0.095
Customer Focus	0.085	0.123	-0.038
Measurement analysis and Knowledge Management	0.09	0.042	0.048
Workforce Focus	0.085	0.085	0
Operation Focus	0.085	0.091	-0.006
Result Focus	0.45	0.079	0.371

In Table 1, there are two clause in the new MBNQA version that significantly different with the current MBNQA. They are leadership clause and Result Focus. According to the experts, this could be caused by the characteristics of companies in forestry sectors. Generally, companies of forestry sectors, especially in plantation types, based on long term process. This characteristics, lead the companies in to the high risk business. But not only the long term process can make this business became risky. Plate of rules, especially on environmental issue also could increase the risk.

Leadership aspect is needed to overcome the major problem. Without the strong capability of the leadership, the company will be crushed. The implication of this score is : a company should chose a strong leader firstly, whoever could drive the vision and values of the forestry company into entire level organizations; well done in promoting legal and ethical behave, excellent in communicating to entire workforce and key customer.

The other clause that significantly has different score is result focus. While the current MBNQA put it in high score, the expert didn't. According to the experts, this clause couldn't put as importance as in current MBNQA because of the long term characteristics of the forest company. The long term characteristic makes the clause couldn't be consider as first clause to watched. Since this clause is only a cause of the other enabler, this clause also became less important as clause of measurement, analysis and knowledge management. The last clause, was only considered by the expert as supporting clause, not the major clause.

3.3 Research limitations and future research

Through this research, the MBNQA criteria has adopted into MBNQA version based on company in forestry sector. However, this is still too general. This research didn't distinguish the manufacturer company and plantation company of forestry sector because of the limitation number of experts. In the future, it can be done.

4. Conclusions

From the description above we can conclude that design of performance measurement is can be done. MBNQA version based on company in forestry sector has different score of its each clause with general MBNQA, consist of leadership (0.396), Strategic and Planning (0.18), customer focus (0.123), Measurement, analysis and knowledge management (0.042), workforce focus (0.085), operation focus (0.091), and result focus (0.079). This score shows that the most important clause that influence the company in forestry sector is leadership aspect.

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The Comparison of Demographic Parameters Population of Long-tailed Macaque in West Java and Yogyakarta Province

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Abstract

Long-tailed macaque (*Macaca fascicularis*) is most widely spread throughout the world. Pangandaran Nature Reserves/ Recreation Park in West Java and Paliyan Nature Reserve and Kaliurang Forest Tourism in Yogyakarta are one of its natural habitat distribution in Indonesia. Various studies of long-tailed macaque have been carried out, but the research on demographic parameters has not been done continuously. The main reason of this research was to estimate the demographic parameters of the long-tailed macaque in Pangandaran Nature Reserve/ Nature Park in West Java and Paliyan Wildlife Reserve and Kaliurang nature recreation forest area in Yogyakarta and compared both of them. This research was conducted in April-May 2014. The data collection was performed on demographic parameters of 8 group long-tailed macaques using a concentration count method and the analysis divide in 3 classification, the life opportunity of infant and juvenile to sub-adult age classes (p_x IjSa), the life opportunity of sub-adult to adults age classes (p_x SaA), and the ratio of infants and juvenile to reproductive females (r). The results showed that p_x IjSa for West Java group has a value range of 0.303-0.945, p_x SaA with a range value of 0.545-0.764, and r the has a value range of 0.344-0.813. Yogyakarta group, p_x IjSa have a value range of 0.302-0.933, p_x SaA with a range value of 0.688-0.952, and r has a value range of 0.231-1.559. Sex ratio of males to females of reproductive age in the range of the same value for the entire group was observed at 1:1 to 1: 2.

Keywords: Demographic parameter, Habitats, Long-tailed macaque, Population.

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1. Introduction

Long-tailed macaque (*Macaca fascicularis*) is one of 19 species of primate genus *Macaca* (Fooden, 1982) and its most widely spread all over the world (Berkovitch & Huffman, 1999) were distributed in the south, southeast and east Asia as well as in northern Africa (Matsumura, 2001). Regional distribution of long-tailed macaque that Indochina, Thailand, Burma (Myanmar), Malaysia, Philippines, and Indonesia (Hendratmoko,

2009). Long-tailed macaque in Indonesia spread in many regions in Indonesia which are Borneo, Sumatra, Java, Bali, Lombok, Sumba and Flores (Supriatna & Wahyono, 2000).

Distribution of long-tailed macaque is due to extensive long-tailed macaque ability to adapt to the environment when compared with other types of non-human primates (Lindburg, 1991; Berkovitch & Huffman, 1999) and supported also by its ability to survive in habitats disturbed (Cowlshaw & Dunbar, 2000), long-tailed macaque is capable of living in the trees and on the ground, its also has a high variation of feed, a high reproductive rate and are not afraid of human presence. One of the natural habitat distribution of long-tailed macaque in Indonesia, in West Java province is represented by Pangandaran Nature Reserves/ Nature Park which has two forms of conservation management. As for DI Yogyakarta represented by Paliyan Wildlife Reserve and Kaliurang nature recreation forest area. Long-tailed macaque most often found in this region, although for a group of long-tailed macaque in the nature reserve area is more difficult to find when compared with the group that was in the area of nature park. Various research related to long-tail macaque group have been done a lot, but the research related to the demographic parameters to see the condition of its population has not been done in a sustainable research, so that the time-series data of the population could not be found in time-series.

Validated scientific study of population demographics parameters can basically determine the conservation strategy of long-tailed macaque (Santosa, 2010). The development of demographic parameters from time to time is necessary for the analysis of the species sustainability in the future (Santosa et al., 2012). The objectives of this research is to estimate the demographics parameters of the long-tailed macaque population that are life opportunity, the ratio of infants and juvenile to the reproductive female and sex ratio from reproductive ages in the Pananjung Pangandaran Nature Reserve/ Nature Park and Paliyan Wildlife Reserve and Kaliurang Nature Recreation Forest area and to compare the demographic parameters of the population of long-tailed macaque in those two locations.

2. Materials and Methods

This research was conducted at Pananjung Pangandaran Nature Reserve/Nature Park and Paliyan Wildlife Reserve and Kaliurang nature recreation forest area in April and May 2014. The data collection of demographic parameters of 8 group of long-tailed macaque are 2 groups in Pangandaran nature reserve, 2 groups in Pangandaran Nature Park, 2 groups in Paliyan wildlife Reserve, and 2 groups in Kaliurang nature recreation forest area and were performed using concentration count method. Observations were made three times that are in the morning (6:00 a.m. to 08:00), noon (11:00 to 13:00) and afternoon (4:00 p.m. to 6:00 p.m.) by using binoculars, hand counter and a digital camera. The data recorded during the observation are the number of individuals of each group, the number of individuals by sex and by age class.

2.1 Data analysis

2.1.1 The ratio of infants and juvenile to reproductive females (r)

The equation used to calculate these ratios are as follows:

$$r = \frac{\sum X_i}{\sum B_i} \quad (1)$$

r = the ratio of infants and juvenile to reproductive females
 X_i = the number of infants and juvenile group- i
 B_i = the number of reproductive females group- i

2.1.2 Life opportunity

The equation used to calculate the life opportunity areas follows:

$$p_x = \frac{L_{x+1}}{L_x} \quad (2)$$

L_{x+1} = the number of individuals that live in the age classes $x+1$
 L_x = the number of individuals that live in the age classes x

2.1.3 Sex Ratio

Sex ratio used in reproductive sex ratio that is the ratio of the number of males in a particular reproductive class age to the number of females in a particular class age. The assumption is the sub-adult and adult age classes considered in are reproductive age class. The equation used to calculate the sex ratio is:

$$S_r = \frac{\sum \text{males}}{\sum \text{females}} \quad (3)$$

3. Results and Discussion

3.1 Group size

Long-tailed macaque groups that were observed throughout the observation sites were 8 groups. The individual numbers of each group in West Java can be seen in Table 1 and observation group for Yogyakarta province can be seen in Table 2. Group of long-tailed macaque that has high number of individuals in the Pangandaran nature reserve/nature park is Rengganis cave's group with 59 individuals. It is the largest population of long-tailed macaque around the observation location. Rengganis Cave group is a group that has been habituated to the presence of visitors both from the field workers and visitors.

As for the size of the smallest group is Southern white sand that has 24 individuals. Southern white sand group is thought to be a fraction of the group from Northern white sand. Conflict could be happened all the time when the two groups meet. The territory overlaps is an indication that these two groups was initially a large group that is splitted. Conflicts between these two group of long-tailed macaque could occur due to internal conflicts within

the group or because of external conflict outside groups such as the seizure of the feed in the territory and so forth.

Table 1. Characteristics of long-tailed macaque's group in West Java Province

No	Group	Infants+ Juvenile	sub-adult		Adult		Total
			Male	Female	Male	Female	
Pangandaran Nature Reserve							
1	Rengganis cave	29	5	6	5	14	59
2	Kalenhaur	13	4	2	3	6	28
Pangandaran Nature Park							
3	Northern white sand	11	11	2	3	14	41
4	Southtern white sand	7	4	2	3	8	24

Table 2. Characteristic of long-tailed macaque's group in Yogyakarta Province

No.	Group	Infants+juvenile	sub-adult		Adult		Total
			Male	Female	Male	Female	
Paliyan Wildlife Reserve							
1	Plot 141	6	5	2	5	11	29
2	Plot 139s	53	7	13	9	4	106
Kaliurang nature recreation forest area							
3	Nirmolo	17	3	5	7	10	42
4	Tlogo Muncar	17	9	3	6	18	53

The observation of the population of long-tailed macaque in Yogyakarta, shows that population with the greatest number of individuals is Plots South 139 is equal to 106 individuals in the Paliyan Wildlife Reserve. This number is thought to be a fusion between several groups of long-tailed macaque in the surrounding area of Paliyan Wildlife Reserve, as a result of expulsion by farmers so that some small groups of long-tailed macaque subsequently merged into one large group.

According to Henzi et al. (1997), fusion is the inverse of the meaning of fission in the group of wildlife which is the merger of several small groups of animals into one large group due to a common interest that benefit if they become one big group.

Fusion group mechanisms is often occur at the foraging time (King et al. 2008; Grove 2012). This fusion phenomenon may occur in a short time/ temporary (Kappeler and van Schaik, 2002), or may occur in the long term/ permanent depending on how the environmental habitat of these animals (Sueur et al. 2010). The larger size of the group will also make the long-tailed macaque group needed more time to find food for all members of the group (Majolo et al. 2008).

Long-tailed macaque population in Kaliurang nature recreation forest area is a group that has been survived and they are still developing well after Merapi eruption in the 2010 ago. Natural disasters that occurred in 2010 is become a major mortality factor that makes the largest population of long-tailed macaque reduced. Natural disasters can destroy a

population. Naturally, this is a natural mechanism in the selection process to control the number of population numbers in the wild.

3.2 Life opportunity, the ratio of infants and juvenile to reproductive females, sex ratio

Calculation results for life opportunity, the ratio of infants and juvenile to the reproductive female and sex ratio for each group of long-tailed macaque in West Java can be seen in Table 3 and for Yogyakarta group can be seen in Table 4.

Table 3. Life opportunity, the ratio of infants and juvenile to the reproductive females and sex ratio of each group MEP in West Java

No	Group	px IjSa	px SaA	r	S _r
1	Rengganis cave	0.303	0.720	0.813	1 : 2
2	Kalenhaur	0.369	0.625	0.725	1 : 1
3	Northern white sand	0.945	0.545	0.344	1 : 1
4	Southern white sand	0.686	0.764	0.350	1 : 1

Table 4. Life opportunity, the ratio of infants and juvenile to the reproductive females and sex ratio of each group MEP in Yogyakarta

No	Kelp	px IjSa	px SaA	r	S _r
1	P141	0.933	0.952	0.231	1 : 1
2	P139s	0.302	0.688	1.559	1 : 1
3	Nirmolo	0.376	0.885	0.567	1 : 2
4	Tlogo Muncar	0.565	0.833	0.405	1 : 1

Based on the observation results for West Java group, the highest value for life opportunity of infants and juvenile age classes to the sub-adult age classes is owned by Northern white sand that is 0.945 but its also has the lowest value for life opportunity of sub-adults age classes to adults age classes, that is 0.545. Environmental conditions in the habitat of Northern white sand group is known has the availability of natural feed plants. It is important for the survival of infants and juvenile age classes. Leca et al. (2007) states that a high level of life opportunity is very likely to occur when environmental of wildlife habitats supports the population growth. While the lower value of life opportunity made possible because of the conflicts that may occur either within the group or in the form of a conflict with other groups.

Conflict between these groups are able to make a decrease in the number of individuals in the group because of the fight often makes injuries, that commonly causing death for the long-tailed macaque that being attacked. The lowest value of life opportunity of infants and juvenile age classes to sub-adults age classes owned by Rengganis cave group that is 0.303 but its also has the higher value of life opportunity of sub-adults age classes to adults age classes, that is 0.720. It is describe that the habitat of wildlife give influence to survival rate of long-tailed macaque.

The calculation toward the ratio of infants and juvenile to reproductive female for the West Java group showed a value that varies. Rengganis cave group has the highest value for the ratio of infants and juvenile to reproductive females. The high value of the ratio of infants and juvenile to the reproductive female is comparable to the number of the group. While, the lowest value of the ratio of infants and juvenile to reproductive female given by North White Sands group. The value for sex ratio for all groups have the same relative ratio it is 1:1, but only the Rengganis cave group has sex ratio 1:2. Allegedly, the long-tailed macaque that has been habituated to human presence makes this group does not only depend on natural food, but also on additional feed that given by visitors.

The highest value of life opportunity of infants and juvenile age classes to sub-adults age classes, and sub-adults to adults age classes for long-tailed macaque in Yogyakarta is Plot 141 group. Its value shown the value that close to 1. This means that the incidence of death in age classes transition (infants and juvenile to sub-adults and sub-adults to adults) rarely occur, so that it has a good population growth. Maestriperi (2007) states that the life opportunity of long-tailed macaque in their natural habitat is indeed likely to be high which may be due to high levels of long-tailed macaque adaptability to environmental conditions habitat by any changes that occur.

It is also seen at the time of observation, in which groups of long-tailed macaque in Kaliurang nature recreation forest area the tourist area have grown accustomed to human presence even been adapted to processed food given by visitors. This makes long-tailed macaque does not only depend on their natural food and it is one of the negative impacts from tourism activities undertaken by visitors (Fuentes et al., 2006; Martin & Reale, 2008; Cunha, 2010).

The results of the ratio of infants and juvenile to reproductive female in Yogyakarta showed values varying. It shown that the ratio depend on the number of female reproductive in each group. The highest value of the ratio of infants and juvenile to reproductive female is comparable to the number of the group. The largest group size of long-tailed macaque in Yogyakarta owned by Plot 139s, Paliyan Wildlife Reserve. The long-tailed macaque in this place have the highest number of infants and juvenile as same as the reproductive females. For the sex ratio, only Nirmolo group has sex ratio 1:2, while for the other three groups 1:1.

Based on the measured value of the parameter demographic shows that the long-tailed macaque were observed for either West Java group and Yogyakarta group is a species that has a high level of adaptability to their habitats so that they can survive and thrive in every kind of habitat.

4. Conclusions

Long-tailed macaque groups of West Java Province has a highest value to life opportunity of infants and juvenile age classes to the sub-adults age classes. While long-tailed

macaque groups of Yogyakarta Province has a highest value to life opportunity of sub-adults age classes to adults age classes, life opportunity of sub-adults age classes to adults age classes and the ratio of infants and juvenile to reproductive females. For the sex ratio of males to females of reproductive age are in the same range of values for the whole group that has been observed that are 1:1 to 1: 2.

Acknowledgements

The authors gratefully acknowledge support from the Beasiswa Unggulan Programme 2012 from Directorate General of Higher Education, Ministry of Research and Penelitan Unggulan Perguruan Tinggi Programme 2014 from Directorate General of Higher Education, Ministry of Research.

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Pangolins Zoo-culture (*Manis javanica* Desmarest 1822) in Orang Rimba Bukit 12 Jambi Province

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Abstract

Pangolins utilization have already known by many ethnic groups in the world, also allegedly found in Orang Rimba Jambi Province. This tribe is known have traditional wisdom in the use of natural resources. However, as a culture, traditional wisdom also dynamically so it change wildlife utilization paradigm and value over time and complexity interaction. This phenomenon was referred as zoo-culture. The main goal was to identified and analyzed the zoo-culture phenomenon in Orang Rimba include: 1) Orang Rimba's knowledge and wisdom in pangolin utilization, 2) perspective changes of Orang Rimba in pangolin utilization, 3) local actor on Orang Rimba who making decision for changing perspective. Data and information collected by open and closed interview with key person that represented "Adat and Spiritual" of Orang Rimba. The result show that pangolins have no social and culture value for Orang Rimba, so their cultural attitudes and behavior easily changed with forest changing where they live and increasing economic value of pangolins. Dominant local actors who influence the economic utilization of pangolins not found yet but institutional of Orang Rimba assumed capable being a good middleman like head of groups (Tumenggung) and his members can access and met person outside forest more often than others of Orang Rimba.

Keywords: local actors, Orang Rimba, Pangolin, utilization, wildlife perspective, zoo-culture

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1. Introduction

The utilization is one type of interaction between human and resources, it is begin from traditional ethnic to modern or develops people. One of them is utilization of pangolin which has been known in a long time ago as a source of animal protein, a healing diseases, and ritual sculture by various communities in the world. The African and Asian people (China, Singapore, Taiwan, Hong Kong), many use it as medicine (Soewu & Ayodele, 2009; Soewu & Adekanola, 2011). Pangolin scales useful as an esthetics, while the flesh believed to be efficacious cure poisoning, inflammation, scabies, and rheumatism (Cunningham & Zondi, 1991; Brautigam et al., 1994; Nowak, 1999). Besides as a medicine, pangolins are

considered to contain mystic also widely used as an animal ritual formerly by some communities in Africa and India (Douglas, 1957; Brautigametal., 1994). In Indonesia, pangolin in meat and scale sused by people of Central Java as the healer (Kartikasari et al., 2008).

One of the traditional ethnic in Indonesia which also suspected of utilizing pangolin apart communities in Central Java is the Orang Rimba. Orang Rimba or also known as Kubu tribe are indigenous in Jambi Province which living in and outside Bukit Duabelas National Park (TNBD). Direct utilization of natural resources by hunting, gathering, to farming became basic assumption that the community also has knowledge and wisdom in using and managed of pangolin. This assumption is based by any indigenous communities have local knowledge as their collective knowledge in touch with nature (Keraf, 2002; Sahlan, 2012).

Knowledge and wisdom are dynamic and may change over time. This is because it continues to evolve and adapt to the local culture and environment (Hansen & VanFleet, 2003). Based on that understanding, wildlife which exploited by communities not only meet its own needs (subsistence) but has started to be developed into an economic commodity commercially traded both nationally and internationally. It means there has been a change views and its cultural behavior of the community towards the existence of wildlife, the value of the benefit and the pattern the utilization of wildlife.

Development of pangolin utilization as an international economic commodities in recent years also assumed have an impact on cultural change the Orang Rimba. These assumption previously obtained because of the preliminary study, pangolin scales only used as a lightning rod and rain by the Orang Rimba. The question is whether this phenomenon actually happens and how the change occurred as well as local actors who play an important role in influencing those changes.

The third question encourages study of Orang Rimba's zoo-culture in pangolin utilization, includes their wisdom and traditional knowledge, processes and causes of perspective change, and decision maker actors in attitudes and perspective change of pangolin utilization. Zoo-culture is part of ethnology understanding which see ethno-zoology as a dynamic phenomenon due to socio-cultural interaction. Various studies on ethno-zoology and wildlife utilization has not touched to wisdom and traditional knowledge developments. Using zoo-culture concept to reveal problem be very required because human interaction with pangolin evoke traditional wisdom. Li (1999) said that it can not be separated. Therefore wildlife utilization can be assessed whether flourish, survive, or can compete with the high pressure from the outside, who was carrier the change in community and its causes. Besides wildlife utilization in Indonesia's ethnic community's life and culture particularly belief towards pangolin benefits is an interesting case to be proven considering the alleged of wild population continues to decline. Based on this background, this research objectives is to identified pangolin zoo-culture in Orang Rimba include 1) traditional wisdom and knowledge of pangolin utilization, 2) analyzed the perspective changes in utilization and pangolin conservation and 3) analyzed the key actors whose roles as Orang Rimba's decision.

2. Material and Methods

Data collected by purposive (Neuman, 1999) through open and closed interviews. Orang Rimba who become informants target is they which living in Makekal Forest, Kejasung, Air Hitam and the Terap Forest.

Next, the partially data collected to be triangulated by researchers triangulation (researchers set different sciences such as researchers and facilitators Unit Rimba Indonesian Conservation Community (KKI) Warsi). Detailed information data collection is presented in Table1.

Table 1. Material information data and data collection methods

Sub-topics	Data	Informants	Data collection technique
Tradition and wisdom in pangolin utilization	- Parts of the body used, - The allotment, - Efficacy (if a drug), - Using and storage techniques, - The intensity of taking in the wild, - The time and location of the hunt, - Hunting technology, and - Other rules on hunting of pangolin	TheAdat leadersand/or spiritual leaders(eg: Tumenggung of Orang Rimbaand staffs)	Open interviews
Perspective changes	- current comprehension on pangolin - the inheritance of traditions and wisdom on pangolin utilization	Youth and the children of Orang Rimba	Open interviews
Local actor decision maker and bearer of changes on pangolin utilization	- Decision-makers in a group of Orang Rimba on wildlife utilization, including pangolins - How familiesand/ or individuals access to resources and information from outside	The Orang Rimba within the group, pangolin hunters	Observation and closed interviews (Irianto and Bungin 2006)

Data analysis refers to Neuman (1999). Data obtained classified or categorized based on the answers of similar/adjacent (reduced). Results classification used for temporary inference that by defining common symptoms that occur on the historical behavior of the utilization of traditional an teater. Then the data is presented in a narrative descriptive according to the theme or topic that has been reduced.

3. Result and Discussion

3.1 Wisdom of Pangolin utilization

Wildlife is an integral part of Orang Rimba's life, so that each group or family hunting regularly. Species in most commonly hunted are mammals which daily useful as a source of protein and medicine. In many ethnic, mammals indeed included the most commonly hunted species, one of which on community Arunachal Pradesh, India (Chutia, 2010).

Orang Rimba have been also hunt pangolin but not used in social life as food or as medicine like other mammals. *Tumenggung*, *Mangku*, and old people whose be regarded understand the Orang Rimba's custom in forest utilizing resources also said that pangolin not used as a cultural and ritual animal or a protected animals such as tigers. In contrast to Coggins's discovery (2003), both pangolin and tigers in the other ethnic classified as relics of the past (ancient), are two important species in the ecosystem, and species of high treatment efficacious. At Busukuma Tanzania, pangolin considered contains mystery and powerful magic than as foodstuffs so that the community gave three names to the species of pangolin are "something that they ate", "something amazing for eye to see" and "destroyer cherry trees" (Wright, 1954).

When preliminary studies results confirmed, the past collective knowledge does not much inherent in individuals of Orang Rimba. Just a bit of Orang Rimba stating there is a possibility of their ancestors have used pangolin scales as a lightning rod and rain. Now Orang Rimba already not using that knowledge. If the possibility of pangolin's scales utilization in Orang Rimba means the use of pangolin have been done a long ago such other traditional community. Pangolin's scales also used by traditional communities in Tanzania but not as a lightning rod, but as a protector of attacks/bites snakes or wild beasts with drape it on the neck or leg (Wright, 1954).

Pangolin value differences on Orang Rimba and other ethnic groups in the world can encourage lack of attention towards pangolin populations. For example, on Orang Rimba community there were no prohibitions or restrictions on pangolin hunting. Specific ethnic assessment on wildlife benefits also affect to animals quantity hunted and lack of hunting regulation so it will be impact on population management. In some ethnic groups who not find about pangolin value for their community, sum of pangolins hunted more than large mammals like in three ethnic groups in Arunachal Pradesh, India (Chutia, 2010). Nevertheless, in fact Orang Rimba helped to maintain existing pangolin populations in the forest because hunting usually done on local community agroforest land (The Hamlet/Malay and community Transmigration). Orang Rimba known often looking for a pangolin in rubber plantation aged 20-30 years old, in old shrub, dead timber, or logged forest. Sodeinde and Adedipe (1994) also said that besides in natural forests, evidently pangolin can also survive and breed in cultivation areas such as forest plantations and rubber plantations. According to Akpona et al. (2008) *tricuspid* species of pangolin also prefer the old teak plantations than closed natural forests. Meijaard et al. (2006) said that the secondary forest (logged) really has a high conservation value than oil palm or acacia.

Furthermore, although this time hunting location has become so far due to very difficult to find pangolin, the hunt has never been done in Bukit Duabelas National Park (TNBD) although according to them there is pangolin in Rimba's Zone of TNBD. Forest conditions which more density than plantation will make Orang Rimba difficult to find pangolin so they are unwilling to find it out. Dense forests also close to Orang Rimba's tomb location in the core zone of the national park that is forbidden to be accessed.

Wisdom towards wildlife is formed from the values given for the benefit of wildlife and society is reflected in every cultural attitudes and actions (zoo-culture). The goal is to protect and conserve resources. If certain species assessed as an important part of his life to meet their subsistence needs, the attitudes and behavior of society would seek for wildlife conservation. Additionally, Gadgil (1993) said it will to be called as a wisdom, if a knowledge in resource utilization passed down from generation to generation. In context of pangolins utilization, Orang Rimba can be said not to have any collectively knowledge. Pangolins are also not rated as animals required in their daily lives. Local knowledge in using scales as a lightning rod as found in a preliminary study was also not much known in Orang Rimba community. Therefore we can said that Orang Rimba have not the wisdom of pangolin, neither customary rules or cultural attitudes and behaviors that support the pangolin conservation.

3.2 Changes thought in pangolin utilization

Results of interviews concluded that there has been a perspective change about pangolins and utilization. The perspective change the look of the "unknown" to "economically valuable". Orang Rimba who previously did not look at the anteater as a useful resource socially and culturally in the community become economically beneficial due to the high resale value so that those involved in the trade Rimba pangolin today.

Orang Rimba's unfamiliarity with the pangolin trade began after the opening of forests Hill 12 where they lived by the Malay community and migrants around. The opening of the forest means open access from the outside into the forest dwelling Orang Rimba and shorten the distance to the settlement of other communities so as to facilitate the transfer of information. The opening of access and Orang Rimba's unfamiliarity with the money so the land trade that fueled internal conflicts and external Orang Rimba be driving the exploitation of various types of resources. Thus, changes perspective Orang Rimba to easily Pangolin also occur even though you were on Natural Resources Conservation Center (2004) record pangolin is a God for Orang Rimba same as Elephant God and Gods Tigers they believe. This difference suggests that the collective knowledge and cultural Orang Rimba defeated by the intervention of outsiders.

As a culture, knowledge and wisdom that can be changed, but the extent to which these dynamics capable filtered (filter), to survive, even competing with the high pressure from the outside. That is, the culture of utilization of wildlife evolved with the times by taking into account local cultural values (traditional) and preservation of wildlife. Shifting or reduction of traditional knowledge that can be caused by several factors, such as interaction with many parties in the social life (Li, 1999) and the opening of the isolation in certain areas (Pattiselanno & Mentansan, 2010). As culture, Orang Rimba not take advantage of pangolin. Nevertheless, their interaction with the environment Hill 12 since first forming properties that are wise in managing anteater by ignoring and not killed in vain. In its development, open access and dynamic culture that encourages Orang Rimba arrest and sale of pangolin. Pangolin high value economically perspective and guiding changes in cultural behavior Orang Rimba to anteaters. In the absence of regulation of sex pangolins are caught, then the

size of a small anteater was still arrested for sale. Based on this, in the context of zoo-culture Orang Rimba are not able to filter and defend their actions in advance just ignore anteater. Cultural Orang Rimba to pangolins have changed including cultural behavior due to the increase in the economic value of pangolin.

Not only the use of pangolins in Orang Rimba, some tribes in Indonesia also have experienced discoloration traditional values in the utilization of natural resources. Bajo for example, the high benefits offered middleman fade values of their traditional utilization of fish resources (Baharudin, 2011).

3.3 Local actors carrier and influencers Orang Rimba's perspective change

Changes in utilization of pangolin primarily related community perspective is influenced by local actors. Sztompka (1993) say that the social changes that occur in the community does not escape from the key actors that influence. Local actors that is the intermediary to bring information from the outside and give effect to the inside or the key person who directly make changes. On the other hand, the emergence of local actors influenced by the social interest of outside parties seekers pangolin and gatherers. Social interest include direct proximity with there sources and ability to maintain the confidentiality of trade information.

Compared to other communities, Orang Rimba is a group of people who are very close to the resource. Rimba people are able to access all the resources in the forest. The identification results show that the dominant local actors in the Orang Rimba in the utilization of pangolin was not found. From this means everyone in the group can access the Orang Rimba pangolins according to his ability. Each person is also likely to be intermediate changes in mindset and cultural behavior in the group.

The dominance of roles that can influence cultural attitudes and behavior towards the use of value can be seen from the number of pangolin pangolin catcher. Rimba people rarely catch pangolin alone. They form a group of as many as 2-4 people in it and all members get the division of tasks. If pangolins are found in trees during the day, the number of climbers which usually takes 1-2 people. The rest waited below and charge capture pangolin pangolin when rolled over and fell to the ground. Proceeds from sales of pangolins are also shared equally among the members. Based on this information becomes pangolin trade secret or confidential utilization rate of pangolin with economic objectives at the Orang Rimba very low (low secure).

That is, information about the name of the Jungle People hunts are not covered. Just like any other resource that partly traded by the Orang Rimba like jernang, pig, latex rubber, and so on, the use of pangolins are also greatly influenced by external demand (the market). People jungle obtain any information regarding Pangolin from outsiders who need anteater. In addition to visits from the number of catchers and the division of roles in the hunt, local actors can be identified from the ability to access information. The dominant local actors who can master the information from the market allegedly is the Jungle People who frequently access the market or have frequent encounters with other people.

Under these conditions, although not found the dominant local actors, Tumenggung (head group) and his staff likely to be information intermediaries in the utilization of pangolin. Positions held by Orang Rimba in the group enables communication occurs more easily than the other Jungle People. This is due to Jungle People who have positions more often traveling to represent the community in activities and activities outside the jungle. With the intensity of the meetings and interaction with the community in the surrounding villages or towns that quite often the knowledge transfer disclosure of information becomes easier. In addition to knowledge transfer easier, the transfer of culture as a lifestyle outside parties are also easily happen and can be a factor in the loss of resources and differences perspective. Hidayat (2012) says that the influence of money or fascinated with luxury objects such as mobile phones, motors and so make leadership Orang Rimba easily exploited by outsiders that such collective customary land ownership can be easily removed. The same condition is also found in the Dayak Kenyah in East Kalimantan. Community interaction Dayak Kenyah traveling with the community in the city is also a cause of the development of technology and traditional knowledge that they have toward animals (Hastiti, 2011).

4. Conclusion

Wisdom and knowledge of the use of pangolins in Orang Rimba barely held even though they state there is a possibility of pangolin was once used by his predecessor to the ritual culture. Under these conditions, perspective of Orang Rimba to pangolin definitely changed, especially after the change in the forest where they live and the inclusion of information that states the high economic value of pangolin. Meanwhile local actors who dominate the dissemination of information and encourage changes in the value of the use of the pangolin was not found but the institutional and leadership Orang Rimba can be a mediator.

Acknowledgment

I thanked to the NGO Indonesian Conservation Community (KKI) Warsi along with Unit Rimba researchers and/or facilitator who have helped in the ease of communicating with Orang Rimba sake data acquisition, cross-check the data, and data presentation support.

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Inventory of Non-commercial Plants in Peat Swamp Land in West Kalimantan – Its Potency as Sustainable Bioenergy Raw Materials

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Abstract

Raw materials is the main problem of non achieving production targets and the sustainability of bioenergy industry, therefore its necessary to find another alternative bioenergy raw materials, especially from plants so the continuity of production can be maintained. This research aim is to know the non commercial plants which not yet utilized that grows in peat land area in West Kalimantan province, the dominance index and its potential as bioenergy raw material. Plant inventory was carried out on vegetation of Kuala Mandor B district of Kubu Raya Regency and Putussibau Utara district of Kapuas Hulu Regency by using purposive sampling in selected sample plots with quadrat sampling technique. The result shown that there were 42 species of plants that found in Putussibau Utara district while there were 18 species of plants that found in Kuala Mandor B district. Based on Importance Value Index (IVI) of non commercial plants in Putussibau Utara district, the most dominan species in tree level is *Cotylelobium burckii* (F. Heim) with IVI = 30.923; the IVI in poles level is *Tarennia costata* (Miq.) Merr. with IVI= 68.934; the sapling level is *Lithocarpus elegans* (Blume) Hatus. Ex Soepadmo. With IVI =29.747; and the seedling level is *Alocasia macrorrhiza* (L.) G. Don. With IVI= 27.143. In Kuala Mandor B area, the non commercial plants that found is already known by the community but not yet utilized. The potensial plants that will be used to further analysis especially for the bioenergy raw material is *C. burckii* (F. Heim), *T. costata* (Miq.) Merr., *L. elegans* (Blume) Hatus. Ex Soepadmo. *A. macrorrhiza*. (L.) G. Don and *Memecylon garcinioides* Blume.

Keywords: Bioenergy, Inventory, Non -commercial plants, Peat land

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1. Introduction

At this time, energy is one of expensive commodities and become scarce. In every day occurs almost in every gas and oil station there are long queues, blackouts electricity experiencing. This happens because the main energy source is derived from petroleum whose continued to diminish while the level of demand rapidly increase as a result of the increasing of population and people's lives. To overcome the problem of energy supplies it necessary to find an alternative energy that can substitute or replace the role of petroleum energy.

From year 2006, accordance with the instructions of the President No. 1 of year 2006 and Government Regulation No. 5 of year 2006, the concept of bioenergy continued to be encouraged. Bioenergy production began to intensively conduct, but the production capacity is still very far to meet the energy needs. As example for bioethanol, currently only able to supply 0.4% of existing energy needs (Bustaman, 2008).

This time, low production of bioenergy due to the constrains of raw materials. Foodstuffs such as corn starch, palm, corn, palm oil, cassava, sweet potato, taro, sorghum, banana, seaweed, canna, noni fruit and palm juice is the main raw materials for bioenergy production (Gozan et al. 2007; Lestari et al., 2007; Bustaman, 2008; Putri et al., 2008; Widyastuti, 2009; Retno et al. 2009; Utami, 2010; Wiratmaja et al. 2011; Sarunggalo, 2011; Sukandar et al. 2011) and this affects to the competition of these plants as bioenergy raw material and as feedstock for food consumption. Therefore, it necessary to find the alternative bioenergy raw material other than feedstock crops so that continuity of the production can be maintained, the increasing of production capacity, reduction of productin cost and the competition with food businesses can be avoided. To find the bioenergy raw materials which can fullfill those criteria, its necessary to conduct the inventory of plant species which have not been utilized and have no sale value (non-commercial) but has great potency as bioenergy raw materials.

West Kalimantan province covering an area of 1.73 million ha of swamp peat land forest (Wahyudi et al. 2012) and has a very large of plant species diversity which have not known and utilized, therefore its has a big potential as sustanaible bioenergy raw material supplier. This study was aims to determine the non- commercial plant species and not yet utilized that grow in peat swamp area in West Kalimantan, to know the Importance Value Index (IVI), dominance index, diversity index, species richness index, species abundance index, species evenness index and to determine the plant species that has potency as bioenergy raw materials.

2. Materials and Methods

This research was conducted in two site in Kuala Mandor B district of Kubu Raya Regency and Putussibau Utara district of Kapuas Hulu Regency. The apparatus that used are geophraphical positioning system (GPS), phiband, rope, digital camera. The inventory were conducted by using purposive sampling in quadrat sampling technique. There were 30 sampling plot with size 20 m x 20 m and total area is 1.2 Ha. In general, the plant level plot categorized in four vegetation level which are 2x2 m for seedling and shrub (those plants with no stem achieving a length of at <1.5 m); 5x5 m for sapling (those plants with at least one stem achieving a length of at least > 1.5 m with diameter < 10 cm); 10x10 m for poles (young tree with diameter 10-20 cm) and 20x20 m for tree (tree with diameter at breast height >20cm). The information that was recorded from each sample plot includes: diameter at breast height (dbh), tree, poles, sapling and seedling species names, regerants frequency, GPS reading, Field observation result than analysed to determine the Importance Value Index (IVI), species dominance index, species diversity index, species richness index, species abundance index, species evenness species index.

3. Results and Discussion

3.1 Non commercial plants species that grow in peatland area

Based on the inventory result, there were 42 species of non commercial plant that belong in 18 family which found in Pala Pulau area of Putussibau Utara district of Kapuas Hulu Regency, 27 species among of it already identified while 15 species of them not yet identified. Most species are on Rubiaceae and Cluciaceae family with 3 species of each of them, and followed by Melastomataceae, Anacardiaceae and Euphorbiaceae with 2 species of each of them and other family consist 1 species (Fig. 1).

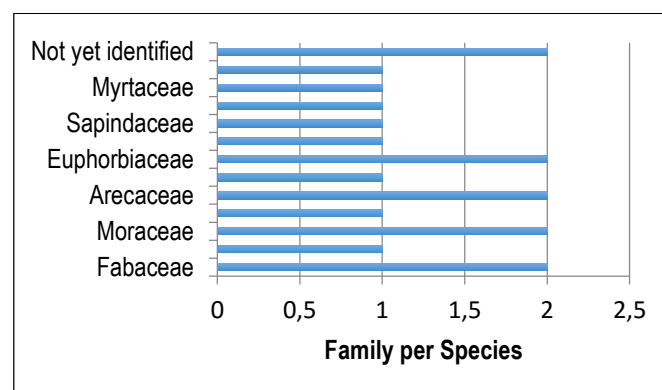


Figure 1. Non commercial plants family in Putussibau Utara district

In Kuala Mandor B district of Kubu Raya Regency area, there were 18 plants species were found that include in 12 family. 16 species among of it were identified and only 2 species are not yet identified. Most species are include in Arecaceae, Euphorbiaceae, Moraceae and Fabaceae with 2 plant species each of it. While the rest of it consist 1 species (Fig. 2).

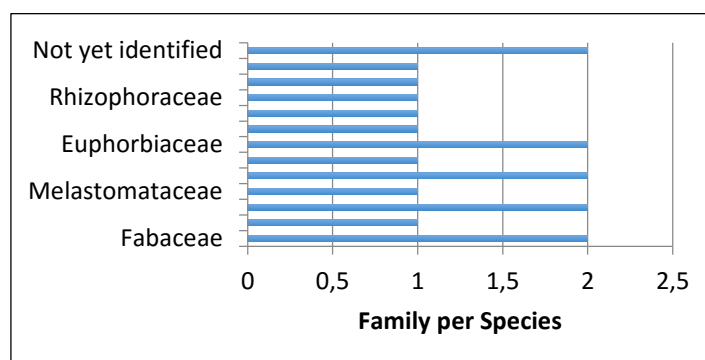


Figure 2. Non commercial plants family in Kuala Mandor district

The highest number of plant in all vegetation level (tree, poles, sapling and seedling) were found in Pala Pulau area of Putussibau Utara district of Kapuas Hulu Regency with 273 individual and seedling level had the highest percentage (38.462%) (Table 1). While in Kuala Mandor B, there were 113 individual plants and the seedling level also had the highest percentage (47.88%) compare than others (Table 2).

Table 1. Recapitulation of species number, individual number and percentage in all vegetation level of non commercial plant in Pala Pulau area of Putussibau Utara district Kapuas Hulu Regency

No	Vegetation Level	Number of Species	Number of Individual	Percentage %
1	Tree	11	66	24.176
2	Poles	10	48	17.582
3	Sapling	19	54	19.780
4	Seedling	18	105	38.462
Total			273	100.00 %

Table 2. Recapitulation of species number, individual number and percentage in all vegetation level of non commercial plant in Kuala Mandor B district of Kubu Raya Regency

No	Vegetation Level	Number of Species	Number of Individual	Percentage %
1	Tree	8	25	22.124
2	Poles	6	16	14.159
3	Sapling	8	18	15.929
4	Seedling	8	54	47.788
Total			113	100.0

3.2 Importance value index (IVI)

Importance value index provide a knowledge on important species of plant community. At Pala Pulau area, *Cotylelobium burckii* (F. Heim) is a non-commercial plant who dominate IVI in tree level, followed by *Gluta wallichii* (Hook.f) and *Nephelium sp.* In poles level, *Tarenna costata* (Miq.) Merr was dominate then followed by *Lithocarpus elegans* (Blume) Hatus. Ex Soepadmo and *Medinilla sp.* In sapling level, *L. elegans* (Blume) Hatus. Ex Soepadmo was dominate and followed by *Nephelium sp.*, *C. burckii* (F.Heim) and *G. wallichii* (Hook.f) while in seedling level *Alocasia macrorrhiza* (L.) G.Don was dominate and then followed by *Medinilla sp.*, *Memecylon garcinioides* Blume and *Nephelium sp* (Fig. 3).

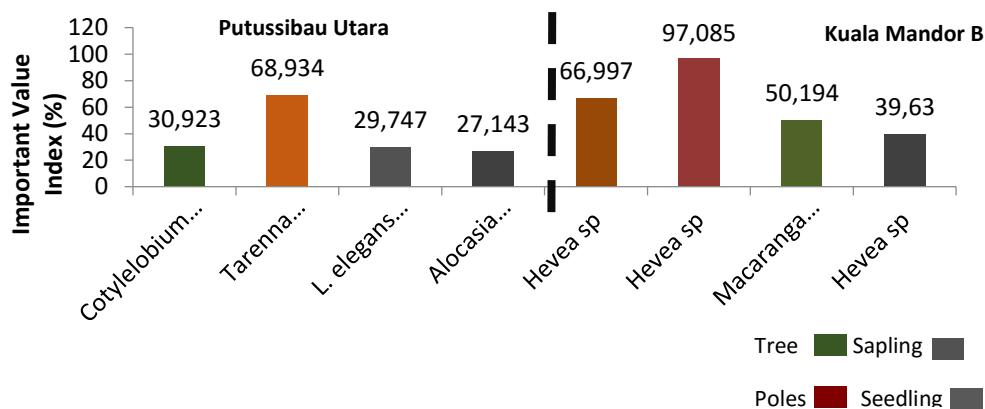


Figure 3. The highest importance value index in each vegetation level for Putussibau Utara district and Kuala Mandor district

While at Kuala Mandor B area, *Hevea sp* was dominante as non commercial plant, followed by *Vitex pinnata* L, *Archidendron pauciflorum* (Benth.) I.C Nielsen, and *Ficus lepicarpa* Blume, Bijdr. In poles level, *Hevea sp* was dominate and followed by *V. pinnata* L; *Bellucia pentamera* Naudin, Ann. Sci. Nat; *Crystostachys lakka* Becc. While for *Macaranga gigantea* (Reinchb.f & Zoll.) Mull.Arg. was dominate in sapling level then followed by *B. pentamera* Naudin, Ann. Sci. Nat; *Dillenia suffruticosa* (Griff ex. Hook.f & Thomson) Martelli and *Hevea sp*. In seedling level, *Hevea sp* was dominate then followed by *D. suffruticosa* (Griff ex. Hook.f & Thomson) Martelli; *A. macrorhiza* (L.) G. Don and *B. pentamera* Naudin, Ann. Sci. Nat. (Fig. 3) .

Accordance to Soerianegara & Indrawan (1982), plant species those who have big role in the forest is characterized by high value of IVI, since its sum of relative density (RD), relative frequency (RF) and relative dominance (RD). High value of IVI of a species due to high domination role in those plant community. A species has a role play if it has IVI more than 10% for seedling and sapling and 15% of IVI for poles and tree level (Sutisna, 1981). Besides that, the high IVI also can describe that a species can compete in a particular area, have a high tolerance and fits in the habitat compared to other species. Indrayanto (2006) states that in the forest communities there is a competition among individuals of a species or different species, because they have the same needs for example in terms of obtaining nutrients, minerals, water, sunlight and grow space. This competition causes certain species will be more dominant than others.

3.3 Dominance Index (C), Species Diversity Index (H'), Richness Index (d), Abundance Index(e) and Eveness Index (E).

Non- commercial plants species diversity that grown on peat lands can be determined by using the species diversity index (H'). Richness index (d) is used to determine the amount of diversity in a community based on its index value. Abundance index (e) and Eveness index (E) can determine the equitable distribution individual among species in a habitat. Whereas to determine the concentration of a species in a habitat is can calculated by Dominance index (C) which is the opposite of the Diversity Index (H').

The dominance index (C) value in Putussibau Utara district which is highest on the seedling level. The highest value of species diversity index (H') on tree level, while in species richness index (d) the highest value derived from seedling level. Both of species abundance index (e) and evenness index (E), the highest value derived from tree level. In Kuala Mandor district, the highest value of dominance index and species richness index derived from sampling level, while in tree level obtain the high value in species diversity index, species abundance index and evenness index.

Dominance index is used to determine centralization and dissemination pattern of a species which the dominance centered. The smaller of dominance index value, thus the dominance pattern will spreading in various dominant species. In Putussibau Utara district, the highest dominance index value in tree level derived from *C. burckii* (F. Heim) while the lowest is *Santrilia grifitii* (Hook.f). Engl. In poles level, *Tarenna costata* (Miq.) Merr. had the highest value, while *C. burckii* (F. Heim) had the lowest value. In sapling level, *L. elegans* (Blume) Hatus. Ex Soepadmo. had the highest value of dominance index and *Baccaurea bracteata* Mull. Arg. had the lowest value. *Memecylon garcinioides* Blume. had the highest value in seedling level while *Gluta sp.* had the lowest value.

Table 3. Recapitulation of dominance index (C), species diversity recapitulation (H'), species richness index (d), species abundance index (e), species evenness index (E) in each vegetation level of non commercial plant in two area.

Area	Vegetation Level	Number of Species	Number of Individual	C	H'	D	e	E
Putussibau Utara District	Tree	19	66	0.065	1.230	9.892	0.962	0.418
	Poles	10	48	0.162	0.869	9.405	0.869	0.378
	Sapling	19	54	0.064	0.419	10.390	0.961	0.417
	Seedling	18	105	0.079	1.175	34.360	0.936	0.406
Kecamatan Kuala Mandor B	Tree	8	24	0.139	0.881	5.007	0.975	0.424
	Poles	6	16	0.198	0.744	4.251	0.956	0.415
	Sapling	8	18	0.206	0.796	5.576	0.882	0.383
	Seedling	8	54	0.169	0.836	4.041	0.925	0.402

In Kuala Mandor B district, *Hevea sp* had the highest value of dominance index in tree and poles level while *Nephelium lappaceum* L. and *L. eliptica* Blume. had the lowest value in tree and poles level. For sapling and seedling level, the highest value of dominance index respectively is *M. gigantea* (Reinchb.f & Zoll); *D. suffruticosa* (Griff ex. Hook.f & Thomson) Martelli. , while the lowest value respectively is *B. pentamera* Naudin, Ann. Sci. Nat and *Archidendron pauciflorum* (Benth.) I.C. Nielsen.

Overall, the dominance index value of all species lower than value 1.00 (highest dominance index value), its shows that the dominance pattern does not spreading just in one species. Where the community not only controlled by one species but there were several

species also dominate these communities as well shows the plant communities in dynamics condition within continues to the point where a species can dominate the habitat in long term. Accordance to Ewusie (1990), sometimes tree that dominance can produce micro- climate that resulted seed sprouts of themselves can not live in it, and thus there is an opportunity to use that habitat by other species which the sprout seeds of it can survive in new condition and then may displace species in those habitat in long term.

Species diversity index (H') can be determined by using Shannon-Wiener formula. This index can describe the high level of diversity that is present in the observation area. Species diversity index affected by the number of individuals plant of a species. The higher the index value, the more number of species that live in the area. Shannon –Wiener index value can be classified in three ranges, from 1-3. H' index value that less than 1 ($H' < 1$) indicates a low of species diversity; the H' value that range between $1 \leq H' \leq 3$ indicates medium of species diversity and H' value that more than 3 ($H' > 3$) indicates high condition of species diversity. In Putussibau Utara district, the species diversity index range from low (poles and sapling) to medium (tree and seedling). While in Kuala Mandor B district, the species diversity for all vegetation level included in low category. Tree and seedling level has higher species diversity, its cause by changes in vegetation and succession process that occur constantly in the forest area its suitable with the opinion of Soerianegara & Indrawan (1982) that during the succession process underway to achieve a dynamic balance condition in environment thus alterations vegetation community that occurs called with climax vegetation. In stable community changes also can occur. According to Ewusie (1990), the high level of biodiversity in tropical regions due to the availability of resources and a high level productivity in the region, thus resulting higher of forest function that can be managed by the community to maintain the stability and sustainable ecosystem.

Species richness index (d) influenced by the number of species and number of individuals for all species where the more species are found, the greater of species richness index and vice versa (Odum, 1993). In Putussibau Utara district, the highest value of species richness index is resulted from seedling level, while in Kuala Mandor B district the highest value resulted from sapling level. Its indicate that the number of structure species have higher number than other observation plots. Its means that beside it have high of species number but also supported by a great of diversity value. This is due to habitat condition that suitable that will affect to the growth of the species.

Species abundance index (e) is influenced by the value of diversity index of particular species and all species, its means that the higher value of abundance index, the spread pattern of a stand increasingly prevalent in the region and vice versa. According to Odum (1993), species abundance index ranging between 0-1, if e value > 1 , all existing species have an abundance in similar of evenly. Whereas if e value < 1 , then all the species abundance not evenly distributed. In both area observation have e value that less than 1, its means that all the vegetation level have almost evenly as shown by the e value that almost close to 1. Its can be said that almost of every species is able to compete and adapt to their habitats and can utilize environment resources optimally.

The evenness index (E) describe the distribution pattern of a species in a community. Both of two observation area have E value that less than 1. The lower of E value due to the

competition in utilizing existing resources, dominance and adaptation in the habitat as well as the uneven emergence of new vegetation and presence of species replacement.

From the analysis of all data presented above, Kapuas Hulu Regency has a big potential role to provide bioethanol raw material, its because it still has a lot of potency of non commercial plant and not yet utilized. In addition, based on the value of IVI, C, H', d, e, and E, non commercial plants such as *C. burckii* (F. Heim), *T. costata* (Miq.) Merr., *L. elegans* (Blume) Hatus. Ex Soepadmo., *M. garcinoides* Blume. dan *A. macrorrhiza* (L.) G. Don can be used as bioenergy raw material through further analysis.

4. Conclusions

As many as 42 species of non-commercial plant were found in Pala Pulau Region of Putussibau Utara district of Kapuas Hulu Regency, while 18 species found in Kuala Mandor B district of Kubu Raya Regency. At Pala Pulau area, especially in tree level *C. burckii* (F. Heim) has the highest IVI while the lowest is *Santrilia grifitii* (Hook.f). Engl. In poles level, *T.costata* (Miq.) Merr has the highest IVI while *C. burckii* (F. Heim) has the lowest IVI. In sapling level, the highest IVI reached by *L. elegans* (Blume) Hatus. Ex Soepadmo while *S. grifitii* (Hook.f). Engl. has the lowest. *A. macrorrhiza* (L.) G. Don has the highest IVI in seedling level and *Gluta sp* has the lowest IVI. At Kuala Mandor B, Hevea sp has the highest IVI in tree, poles and seedling level, while *N. lappaceum* L and *L. elliptica* Blume. has the lowest IVI in tree and poles level. *M. gigantea* (Reinchb.f & Zoll.) Mull. Arg. has the highest IVI in sapling level while *B. pentamera* Naudin, Ann. Sci. Nat. has the lowest IVI. In seedling, besides Hevea sp, *D. suffruticosa* (Griff ex. Hook.f & Thomson) Martelli. Also has the highest IVI while the lowest derived from *A. pauciflorum* (Benth.) I.C. Nielsen. Kapuas Hulu Regency has a big potential as bioenergy raw materials providers because of its biodiversity potency especially for non- commercial plants whose not yet utilized. In addition, based on the value of IVI, C, H', d, e and E, the non-commercial plants with the potency to analysis in further stage especially as a bioenergy source material is *C. burckii* (F. Heim), *T. costata* (Miq.) Merr., *L. elegans* (Blume) Hatus. Ex Soepadmo., *M. garcinoides* Blume. dan *A. macrorrhiza* (L.) G. Don

Acknowledgement

The author would like to express their thanks and appreciation to Indonesian Ministry of Research, Technology and Higher Education for funding this research through "Hibah Bersaing" research grant program year 2015.

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Competitive Advantages of Indonesian Plywood Industry: A Perspective from Porter's Five Forces Model

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Abstract

The understanding of industry structure is of great concern for industry strategy since defending against the competitive forces and shaping them into the company's favor area are essential to strategy. Competitive advantages provide the framework for assessing strategy and understanding the source of competitive advantage. This paper applied Porter Five Forces Model to identify the positioning of competitive advantages of plywood industry in South Sulawesi, Indonesia. Qualitative research was carried out using in-depth interview method. The interview contained the sequence of statements that were grouped into five categories (threat of new entrants, bargaining power of suppliers, bargaining power of buyers, threat of substitutes, and rivalry among existing competitors), and each category represented one competitive force. A structured questionnaire from Agricultural Innovation & Commercialization Centre (AICC) was used to identify five competitive forces that shape the company. Secondary data and literature study were also used to identify the competitive forces. The analysis of five forces indicated that entry barriers of the industry were high and there was low competitiveness of plywood substitutes. However, company needs to protect the firm against rivalry from competitors and to reduce power of suppliers.

Keywords: competitive advantages, plywood, plywood industry, porter five forces model.

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1. Introduction

Indonesia was the biggest plywood suppliers in the world since 1983 (Tachibana, 2000), supplying about 70% of the total global market (Brockhaus et al., 2012). Indonesian plywood has dominated many major markets around the world. During this period, Indonesian forest product industry mainly plywood industry has experienced rapid growth and structural change and played important part in Indonesian economy through a significant role as a gross

domestic product, foreign exchange, government revenue, and employment contributors (Simangunsong, 2012). However, the growth of this industry has decreased in line with the decline in log production from natural forests while the production of logs from plantation forests has not been able to replace it. Besides, due to economic crisis in 1997/1998, the industry experienced a decline in overseas markets that influenced the production and trade sectors. Minister of Forestry (MOF, 2009) stated that the direct impact due to the economic crisis and the deficit of raw materials are the decreasing of wood industrial capacity, especially plywood industry from 99% in 2007 to 42% in 2005. Furthermore, the production has declined to 3.1 million m³ in year 2008, a drop of 27% compared to 2007. In fact, growth in the plywood industry came at a cost. Domestic log production tapered off and domestic log prices fell relative to world price throughout the 1980s and 1990s (Hide, 2012).

In the last few years, Indonesian plywood industry has done many efforts of recovery, such as finding new market and continuing the enhancement of products image in international market. Marketing strategy was created to develop the sustainable competitive of the industry. Strategy is a deliberate search for a plan of action that will develop a business's competitive advantage and compound it (Montgomery & Porter, 1991). Strategies also explain how an industry, faced with competition, will achieve superior performance (Magretta, 2012). Competitive advantage provides the architecture for describing and assessing strategy, linking to company behavior and understanding the source of competitive advantage. A competitive firm is one that takes the market price of output as being given and outside of its control. The success of company's competitive strategy depends on how it relates to its environment; industry structure has a strong influence in defining the rules of competitive game as well as the strategies potentially available to the company (Porter, 1985).

Strategic management can be understood as the collection of decisions and actions taken by business management, in consultation with all levels within the organization, to determine the long-term activities of the organization. A good business strategy is the base ingredient for a successful business. However, there are many different kinds of business strategy. The best business strategy should be able to guide the company into a direction in which the expected internal pressure due to business continuity meets the high demand of the fast changing world for the revolutionary business plan (Porter, 2008).

This paper applied Michael Porter's industry analysis techniques to identify the existing competitive advantages as well as the key factors of business success and to create the strategy framework of the positioning for plywood industry. Porter's framework provided a dynamic and focused structural analysis of an industry called Porter's Five Forces analysis in the literature. The five-force diagnostics consists of the bargaining power of buyers, bargaining power of suppliers, the threat of new entry, the threat of substitutes, and the intensity of rivalry, allows the long-term profitability of any industry to be understood, as well as how companies can influence industry competition in their favors (Fazlollahtabar & Abbasi, 2008). Understanding the competitive forces and their underlying causes, reveals

the roots of an industry's current profitability while providing a framework for anticipating and influencing competition (and profitability) over time (ICAI, 2013).

2. Research Methodology

This study was carried out on the plywood company in South Sulawesi, PT. Panca Usaha Palopo Plywood (Panply), in Indonesia. Panply is one of plywood companies in South Sulawesi. The firm was established on November 18, 1970, drawn by a notary based on deed of incorporation in November 18, 1970 with the name of PT. Palopo Plywood and was changed to PT. Panca Usaha Palopo Plywood based on a notarised deed no.28 in September 11, 1973.

The five key factors from Porter's framework (Fig.1) were used to identify and evaluate potential opportunities and risks: threat of new entrants, bargaining power of buyers, bargaining power of suppliers, threat of substitutes, and competitive rivalry. The model helps managers formulate appropriate strategic responses from the positioning of competitive advantages of plywood company in South Sulawesi.

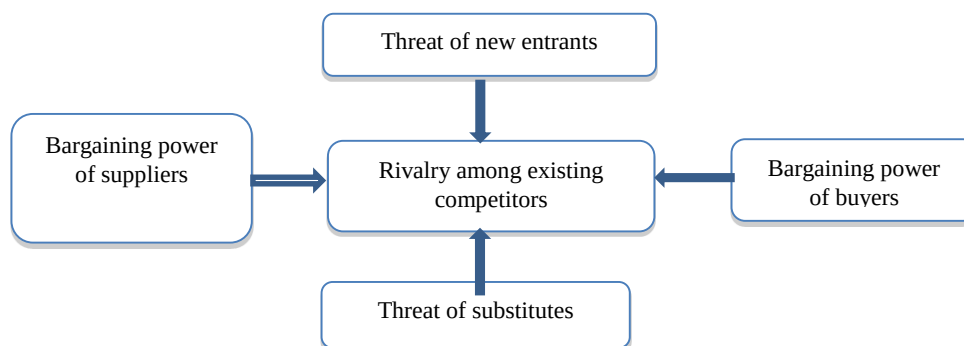


Figure 1. Porter five force model

In order to carry out a thorough analysis of the plywood company, a structured questionnaire by Agricultural Innovation & Commercialization Centre (AICC) was also used in this study. The aforementioned structure questionnaire was used in the course of the interviews as the research instrument. The questionnaire contained the sequence of statements that were grouped into five categories (threat of new entrants, bargaining power of suppliers, bargaining power of buyers, threat of substitutes, and rivalry among existing competitors); each category represented one competitive force.

In-depth interviews method was selected to assign a score to each comparison using the scale. The respondents were chosen based on the fact that they represent various activities on the firm. Director of operational and director of marketing were selected in Panply to assign a score to each competitive force from Porter's by using Likert-Type Scale Response

Anchors (by modified). The scale response measuring the strength of attitudes with a statement was used to measure the potential opportunities and risks. A score of one (1) was given if the level was considered very low, and five (5) was given if the level was strong or very high. The rating scale of the Likert response scale is as follows: very low/weak (1 – 1.4), low (1.5 – 2.4), moderate (2.5 – 3.4), high (3.5 – 4.4), and very high/strong (4.5 – 5).

3. Results and Discussions

The threat of new entrants, bargaining power of suppliers and buyers, threat of substitutes, and rivalry among existing competitors and the criteria corresponding each in Panply company can be seen in Table 1.

Table 1. Five forces and the criteria corresponding each in plywood company

Forces	Criteria	Panply
Threat of new entrants	Economic of scale	1
	Government regulation	1
	Brand loyalty	2
	Cost advantages	1
	Initial capital requirement	1
	Customer switching costs	3
	Mean score	1.3
Bargaining power of suppliers	Supplier portfolio	4
	Dependence on suppliers industry	5
	Suppliers switching costs	5
	Suppliers uniqueness	4
	Importance of suppliers	5
	Forward integration	1
	Mean score	4
Bargaining power of buyers	Buyer portfolio	1
	Dependence on buyer industry	2
	Buyer switching costs	4
	Product uniqueness	3
	Importance to buyers	2
	Backward information	1
	Mean score	2.1
Threat of substitutes	Number of substitutes	2
	Closeness of substitutes	2
	Other technology	2
	Mean score	2
Rivalry among existing competitors	Industry structure	3
	Industry demand and capacity	3
	Differentiation among companies	3
	Exit barriers	5

3.1. Threat of new entrants

The threat of the new entrants depend on the extent to which there are barriers to entry. If barriers to entry are high and a new comer can expect sharp retaliation from the entrenched competitors, obviously he will not pose a serious threat of entering (Porter, 1997). The barriers to entry of Panply washigh because any new entrants will need high investments in R&D, technology, and marketing in order to compete with the established firms. Threat of new entrants of economic scale of the plywood company was low because new entrants need more financial advantages to be able to continue to make new investments. It would be difficult for new entrants to compete efficiently in production (high cost production) where any new entrants will need high investment in raw material (logs), capital investment for fixed facilities, inventories, and absorbing start-up losses. Requirements for licenses and permits may raise the investment needed to enter the market, creating an effective barrier to entry. The plywood industry was already a well established market and the threat of a new entrant was quite low, as the investment needed to rival the devices already available was quite advance if they want to differentiate from them.

3.2. Bargaining power of suppliers (BPS)

This is how much pressure suppliers can place on a business. If one supplier has a large enough impact to affect a company's margins and volumes, then it holds substantial power. If the force is weak, then you may be able to negotiate a favorable business deal for yourself. Conversely, if the force is strong, then you are in a weak position and may have to pay a higher price or accept a lower level of quality.

The main raw material used for manufacturing plywood is wood or logs. To a plywood company, the continuity heavily depends on the guaranteed availability of logs. Logs were categorized into three groups; (1) shorea group, (2) mixed group, and (3) fancy wood. The groups of shorea were *mersawa*, *hopea*, *keruing*, *nyatoh*, *palapi*, *agathis*, *matoa*, *pulai*, *jelutung*, *kenari*, and *durian*. Mixed species consisted of *binuang*, *gopasa*, *jabon*, *palado*, and *suren*. Groups of fancy wood were *cempaka* and *rengas*. Suppliers of Panply have high power (4). The logs used in Panply were obtained from Maluku, Irian Jaya, Kalimantan, Sulawesi Tengah, Sulawesi Tenggara, Sulawesi Utara, and from local timber in local communities in Luwu regency. All the logs were purchased by direct order and contract system. Besides, lack of raw materials was also overcome with the purchase of local timber in local communities such as type of mango, nutmeg, durio, *kapok* which is generally of a small diameter with a length of logs adapted to company standards (1 meter, 2 meters, and 2.6 meters). Dependency and importance of logs suppliers in this firm were high.

3.3. Bargaining power of buyers (BPB)

If buyers have more economic power, the ability of industry to capture a high proportion of the value created will decrease, and the industry will earn lower profits. This is how much pressure customers can place on a business. If one customer has a large enough impact to

affect a company's margins and volume, then the customer have substantial power. The firm focused on the local market was significantly increased by using local woods as raw material, even though in the last few years, the plywood export in Panply was significantly increased. The power of buyers in this company has low power (2.1).

3.4. Threat of substitutes (TS)

Substitutes of plywood are particleboard, fiberboard, and Oriented Strand Board (OSB). Oriented Strand Board (OSB) is a manufactured wood product that is often substituted for plywood and used to structurally sheath walls, roofs, and floors of residential, commercial, and industrial buildings. Unlike plywood, which is manufactured by bonding thin veneers of wood products together, OSB is made with 3" to 4" long strands of wood, oriented with their grains parallel, then compressed and bonded together using wax and resin adhesives to form plywood size sheets. Particleboard, also known as particleboard and chipboard, is an engineered wood product manufactured from wood chips, sawmill shavings, or even saw dust, and a synthetic resin or other suitable binder, which is pressed and extruded. A fiberboard is a type of engineered wood product that is made out of wood fibers.

A threat from substitutes exists if there are alternative products with lower processes of better performance parameters for the same purpose. They could potentially attract a significant proportion of market volume and hence reduce the potential sales volume of existing players. Threat of substitutes for this company has low force. Minister of Forestry of Indonesia (MOF, 2009) reported that over the period 2000-2009, the number of substitutes of plywood particularly particleboard was very small compared to plywood product. It only 78.711 m³/year (2.1%) on particleboard and 3.7 million m³/year (97.9%) of the plywood.

3.5. Rivalry among existing competitors (REC)

Rivalry refers to the competitive struggle for market share between firms in an industry. Extreme rivalry among established firms poses a strong threat to profitability (Hill & Jones, 2009). This force examines how intense the competition currently is in the marketplace, which determined by the number or structure of existing competitors and what each is capable of. Market concentration measures are used to classify how competitive an industry is. The economists measure rivalry by indicators of industry concentration. The concentration ratio (CR) is one such measure. The CR indicates the percent of market share held by the four largest firms. A high concentration ratio indicates that high concentration of market share is held by the largest firms-the industry is concentrated. With only a few firms holding a large market share, the competitive landscape is less competitive. A low concentration ratio indicated that the industry is characterized by many rivals, none of which has a significant market share (QuickMBA, 2010). The four-firm concentration ratio for plywood industry of 55% suggests a medium level of concentration and a modest degree of competition. The mean of sub-force of rivalry among existing competitors of the plywood industry in South Sulawesi was a medium level.

4. Conclusions

The competitive advantages of plywood company in South Sulawesi (Panply) were threat of new entrants, bargaining power of buyer, and threat of plywood substitutes. However, the market will be more competitive from the bargaining power of suppliers and the rivalry among existing competitors. To overcome the forces and achieve competitive advantage, companies need to protect its firm against rivalry from competitors and reduce or manage supplier and buyers' power.

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Enhancing the Adaptive Capacity of the Indigenous Peoples by Promoting Sustainable and Community-Based Resin Tapping of Almaciga (*Agathis philippinensis* Warb.) in Selected Certificate of Ancestral Domain Title Areas in Palawan and Sierra Madre, Philippines

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Abstract

Almaciga (*Agathis philippinensis* Warb.), in natural forests of Palawan and Sierra Madre, yields high quality resin known as Manila copal, used as raw material for varnish, paint driers, and other industrial substance. Manila copal is considered an important dollar earner among the country's non-timber forest products. From 2004 to 2013 an average of 140,200 kilograms of Manila copal valued at US\$165,200 was exported to different countries. Resin collection is an important source of income for indigenous peoples (IPs). However, most of them practice unsustainable tapping methods leading to decline resin production and worst, death of trees. Furthermore, with climate change as a global concern, recurrence of natural calamities will have impacts on forests ecosystems, particularly on vulnerable and threatened species like almaciga. Because of this, trainings were conducted to capacitate the IPs and partners on government agencies on sustainable methods of tapping resins and provide basic knowledge on climate change related issues. Trainings were conducted in Brookes Point and Aborlan in Palawan; and Dinapigue, Isabela, and San Luis, Aurora in Sierra Madre. Covered in the training are three major topics: 1) lecture on almaciga; 2) information, education and communication on climate change; and 3) actual demonstration on proper method of tapping almaciga resin. A total of 144 participants attended. The series of training has successfully educated and capacitated the IPs who participated actively in discussions and practicum. Through the project, the IPs as well as the partners from the government agencies now understood the scientific process of resin production in trees and realized the importance of applying the FPRDI tapping technology to sustain the benefits they derive from the resins they collect. A strong desire to safeguard the untapped trees growing in the area was successfully imparted to them.

Keywords: Almaciga resins, Climate change, Indigenous peoples, Manila copal, Tapping

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1. Introduction

Almaciga (*Agathis philippinensis* Warb.) is large tree which can reach 60 meters in height and 300 centimeters in diameters. It grows naturally and abundantly in different regions of the Philippines, especially along mountain sides, on well-drained slopes or at altitude of 200 to 2,000 meters. Naturally growing almaciga trees are abundantly found in the natural forests of some ancestral domains in Palawan and Sierra Madre in Aurora.

Almaciga yields high quality resin commonly known as Manila Copal in the international market. It is one of the early export products of the Philippines. It has been used in oil and spirit varnishes, lacquers, paper size, paint driers, linoleum, oil cloth, waterproofing compounds, printing inks, adhesives, floor polish and floorwax. With the widespread logging of almaciga in 1980s to 1990s, the species was listed as potentially threatened and vulnerable species (Category B) under the 1980 International Union for the Conservation of Nature (IUCN). This prompted the government to prohibit the felling of the trees.

Exported Manila Copal comes from the remaining natural stands of almaciga trees are mostly found in the Certificate of Ancestral Domain Title (CADT) areas. The natural forests of Palawan in particular are known to be the source of high quality almaciga resin. More so, harvesting of almaciga resin is an important source of income for the indigenous peoples in the country.

The indigenous peoples basically subsist through swidden cultivation, hunting, gathering and the trade of locally manufactured products. Collection of almaciga resin and other forest products are important source of cash to them. However, most of them were practicing the unsustainable methods of resin tapping which leads to the decline in resin yield and even worst, death of almaciga trees. If unsustainable tapping methods would prevail, the almaciga trees would be in danger of extinction affecting the livelihood of most indigenous peoples that depend on it.

Furthermore, with climate change as a global concern, it is expected that the recurrence of natural calamities such as typhoons, forest fires and among others will have impacts on the biodiversity of forest ecosystem, particularly the vulnerable and threatened species such as almaciga.

Thus, it is imperative that the indigenous peoples engaged in almaciga resin tapping be informed, educated and encouraged to adopt the proper and sustainable methods of tapping almaciga resin and provide them the basic knowledge on climate change and adaptation (Figure 1).

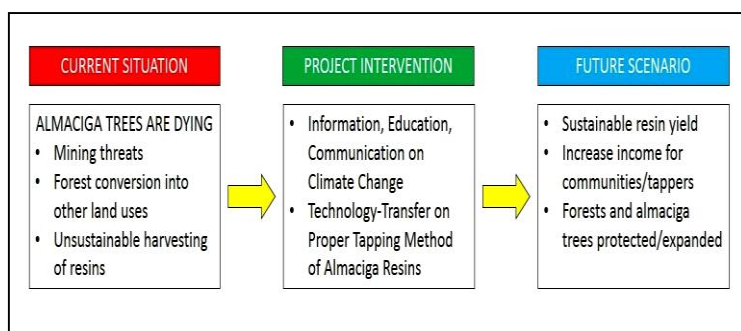


Fig 1. Project Conceptual Framework.

Through the implementation of this project, it is expected that there will be an improvement on resin harvesting methods applied by the IP beneficiaries in the project sites. The almaciga trees in the site will also be protected thus leading to the increase in species population.

Specifically, the project aims to achieve the following objectives:

1. To educate the project beneficiaries on climate change, its impacts to forest ecosystems and forest-based groups, as well as on climate change adaptation strategies;
2. To conduct techno-transfer and training on the proper methods of tapping almaciga resin for the indigenous peoples in some selected CADT areas;
3. To conduct initial tapping of some identified almaciga trees for demonstration purposes and quality assessment of resins obtained in the project sites; and
4. To conduct impact assessment on the adoption of FPRDI almaciga resin tapping technology in the project sites.

2. Material and Methods

The major output of this activity is the setting of preliminary schedules and target participants for the training on Climate Change and Almaciga Resin Tapping Technology.

2.1. Project Sites

The project was implemented in two sites, namely, in the mountainous Certificate of Ancestral Domain Title (CADT) areas of Palawan and Sierra Madre (Figure 2). Pre-selection of these sites were based on the presence of natural stands of almaciga trees and of previously or currently engaged indigenous peoples (IPs) into almaciga resin tapping.



Figure 2. Location map of project sites

2.2 Palawan

Palawan is the long narrow island lying northeast-southwest of the Philippines. It is a province abundant in natural resources, unique not only in its pristine environment, its richness in culture and the refuge it provides to wildlife and indigenous peoples (IPs).

Palawan is a biodiversity hotspot, home to endemic species – both flora and fauna that cannot be found anywhere else in the world. It is home to 30% of the country's coral reefs, has 17 key biodiversity areas (KBAs), and 8 declared protected areas. It is where the St. Paul Subterranean River or widely known as the Palawan Underground River National Park can be found which was voted as one of the 7 Nature Wonders of the World by the UNESCO Nature's World Heritage in 2011. Palawan is the country's last ecological frontier harbors vast tract of tropical rainforests covering around 1,041,850 hectares, which comprises more than 60% of the total land area of the province. Most importantly, Palawan is home to a number of IP groups namely the Cuyonon, Palawano, Taaw'tBato, Tagbanua and the Batak tribes.

Specifically, there were two sites in Palawan where the series of training on almaciga resin tapping and IEC on climate change were conducted - one in Brooke's Point and the other in Aborlan.

2.2.1. Brooke's Point Palawan

Brooke's Point is situated in the southern section of Palawan island, approximately 215 kilometers from Puerto Princesa City. The almaciga trees on Brooke's Point are known to be the source of the bulk of almaciga resin supply in Palawan. A group of IPs in Barangay Mainit, the Samahanng Palawan KatutubosaMainit (SPKM) were trained on the proper tapping of Manila Copal.

2.2.2 Aborlan Palawan

Aborlan is located 65 kilometers south of Puerto Princesa City. A group of Community Based Forest Management Peoples Organization (CBFM-PO), the Sagpangan Tribal Multi-Purpose Cooperative (STMPC), is also into almaciga resin tapping. Thus, some members of the STMPC were also trained on proper tapping of Manila Copal.

2.3 Sierra Madre

The Sierra Madre is the longest mountain range in the Philippines. The range starts in the north which covers the province of Cagayan and ends in the south covering the province of Quezon, in the east is Laguna de Bay and in west is the province of Nueva Vizcaya that from the Caraballo Mountains, that connects with the Cordillera Central range.

The Sierra Madre mountain range contains the largest remaining tract of old-growth tropical rainforest in the country. Known as the "backbone" of the northern island of Luzon, the Sierra Madre contains 1.4 million hectares of forest, representing 40% of the country's forest cover. The biological importance of the corridor is not only due to the remaining intact forest in the central part of the mountain range, but also to its high biological diversity.

Almaciga trees abound in the area. The Sierra Madre mountain range is also home to several indigenous groups such as the Aetas, Negritos, Agtas, Bugkalot, Dumagats and Remontados.

2.3.1 *Dinapigue, Isabela*

Dinapigue is located in the southeastern-most part of Isabela province, near the provincial boundaries of Qurino and Aurora. It is bounded in the north by Palanan, in the west by Echague, San Guillermo and San Mariano, and in the south by Aurora province. It is virtually land locked by Sierra Madre Mountain range on the west and the Pacific Ocean in the east.

2.3.2 *San Luis Aurora*

The municipality of San Luis is located in the central part of Aurora Province. The area is bounded on the north by the municipality of Maria Aurora, on the south by Dingalan, on the east by Baler (capital of the province), and the province of Nueva Ecija on the west. It is about 7 km from Baler, and approximately 108 km from Cabanatuan City.

The members of the SamahangKatutubonaKumikilalasaLupangNinuno in Barangay Diteki, San Luis, Aurora were trained on the proper tapping of almaciga resin.

3. Results and Discussion

3.1 *Technology-transfer on tapping of almaciga resin & IEC on climate change*

3.1.1 *Participants and Partner Cooperators*

There were five sets of training conducted in different sites. Three sets of training were conducted in Palawan and two sets in Sierra Madre (Table 1).

Table 1. Summary of training participants

	Participants			Profiles of Participants	Other Remarks
	Men	Women	Total		
Mainit, Brooke's Point, Palawan	27	6	33	- officers & members of Samahanng Palawan KatutubongMainit (SPKM) - resin tappers (men) - NGO staff (ELAC) - DENR staff	- supported by LGU and CENRO Brooke's Point, Palawan
Aborlan, Palawan	29	14	43	- officers & members of Sagpangan Tribal Multi-Purpose Cooperative (STMPC) - CBFM-PO - resin tappers - DENR staff	- supported by CENRO Narra, Palawan

Dinapigue, Isabela	17	24	41	- dumagats - resin tappers but inactive - staff of LUZMATIM	- supported by LGU and DENR Sub-office in Dinapigue, Isabela - assisted by staff of Provincial ENRO in Aurora
San Luis, Aurora	18	9	27	- officers & members of SamahanngKatutubonaKumikilalasaLupangNinuno (SKKLN) - resin tappers	- supported by Prov. ENRO and DENR Aurora
Ipilan, Brooke's Point, Palawan	16	4	20	- officers & members of NagkakaisangTribong Palawan (NATRIPAL) - NTFP-TF staff	- supported by NTFP-TF and NATRIPAL
TOTAL	107	57	164		

Lecture on Almaciga

The lecture on almaciga is divided into three sub-topics: (a) introduction to almaciga resin tapping, (b) basic structure of the stem and resin production in the tree, and (c) proper tapping method of almaciga resin.

Information, Education and Communication on Climate Change

Among the highlights of lecture on climate change include the following:

1. Defining and describing what climate change is from the context of the United Nations Framework Convention on Climate Change (UNFCCC).
2. The differences between climate and weather.
3. Reviewed the climate system flow/diagram, including the water and carbon cycles, which are both important in understanding climate change.
4. The concepts of global warming and greenhouse effect were also discussed.
5. The impacts of climate change were also enumerated: (a) drought or El-Niño resulting to water shortage, damage to crops and food insecurity; (b) La-Niña or too much rain and typhoons resulting to floods, landslide, damage to shelter and lives; (c) melting of ice or shrinking of sea ice resulting to decline in population of ice-dependent species and less food supply to sea birds, whales and seals; (d) heat causes water to expand resulting sea level rise which results to more floods in the coastal areas, submerging of lower land areas; (e) heating of the ocean can also result to coral bleaching; and (f) too much drought can also result to more forest fires, resulting to decline in forests biodiversity population, threatening the survival of most endangered species like almaciga.

Actual Demonstration on Proper Tapping of Almaciga Resin

Following the FPRDI recommended resin tapping procedure which were discussed and illustrated, actual demonstrations were conducted in the field.

Participants were tasked to take turns and perform actual tapping following the recommended steps. Even women and youth were able to get the feel of doing the actual tapping, so that their involvement in this business would not only be limited to hauling the resin products.

Impacts of the Resin tapping technology

Based on the survey, the training on resin tapping technology potentially enhanced the adaptive capacity of indigenous communities to changing environment that resulted to the following impacts.

Economic Impact

1. Increased productivity and impact

The participants' knowledge on the resin tapping was enhanced. This resulted to increase productivity and income in harvest from 16% to 33% per month using the scientific way of tapping. This translates to an additional of 400 to 825 Philippine Peso assuming the price of resin is P25.00/kilo. In Aborlan, one has slightly increased his income by 16%.

2. Improved product quality

Other participants have collected the same volume of harvest before and after the tapping but the resin harvested is of good quality as compared to their traditional way of resin tapping.

3. Access to market and establishment of better price

With the improvement in product quality, they have improved their access to market and establish better price for the products.

Social Aspect

1. Improved technical and social competence of some gatherer-participants

According to the respondents they were able to transfer/diffused the technical skills gained from the training to other resin gatherers to other adjacent barangays which they also adopted.

2. Institutional Linkages

The training serves as an avenue for the two organizations to strengthen their linkages with various agencies providing marketing and technical support like NGO's and GO's like NATRIPAL, DENR and FPRDI.

3. Trust and confidence on extension agent

The adoption of the resin tapping technology particularly on the proper width and length of tapping shows their trust and confidence to the subject matter specialist in particular and to the agency in general.

4. Community empowerment

The adoption of technology encourages the people to handle economic and social change for the local benefit through the use of their own people and their own natural resources.

Environmental Impact

Protection and Conservation of the almaciga resin

Although there was no significant increase in income among participants but the most notable impact of the trainings on resin tapping is that the participants became aware and

conscious of the importance of protecting almaciga trees through proper tapping as frequent rechipping was regulated.

Impact of IEC on Climate Change

Based on the interviews with resin tappers-respondents and one key informant, the trainings enabled them to increase their level of awareness and understanding on climate change, its causes and impact effects to their livelihood. They become conscious on the importance of protecting the almaciga trees to sustain their livelihood.

All the key informants disclosed that their knowledge gained from the training was further enhanced. The almaciga trees which is one of the life support system of indigenous people are highly vulnerable to this climate change effects, hence must be protected through scientific way of tapping.

Conclusions

The series of training conducted both in Palawan and Sierra Madre has successfully imparted its purpose of educating and capacitating the Indigenous Peoples on the proper method of tapping almaciga resins. Through the project, the IP beneficiaries now understood the scientific process of resin production in a tree and have realized the importance of applying the FPRDI tapping technology in order to sustain the benefits they derived from the resins they collect. The IPs were also educated on the basic science of climate change. They fully recognize the important role of trees in addressing the different impacts of climate change, thus, also understood their vital roles in protecting and conserving the forests and the resources they derive from it.

Acknowledgments

The project team would like to acknowledge the following for the support and assistance they rendered in the conduct of this project:

- Southeast Asian Regional Center for Graduate Study and Research in Agriculture - Seed Fund for Research and Training (SEARCA-SFRT) for the grant; and
- Forester Emmanuel P. Domingo, Science Research Assistant, DOST-FPRDI

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POSTER PRESENTATION

Crystal Structure and Functional Groups of Distilled Vetiver Root (*Vetiveria zizanionides*) Soda Pulp

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Abstract

Pulping is the most common process to produce fibers from lignocellulosic materials. One of lignocellulosic materials that available from essential oil industry in Indonesia is distilled vetiver root. The soda process is the chosen chemical pulping method of non-wood materials, because it is considered to be economically viable on a small scale. Pulp fibers are potential to be utilized as reinforcing agent in composite products. The strength of pulp fibers is affected by its crystalline structure. Furthermore, the effectiveness of soda pulping to separate lignin from pulp fibers can be revealed by the functional groups in soda pulp. The aim of this research is to characterize the crystal structure and to analyze the functional groups of distilled vetiver root soda pulp.

Keywords: Crystal structure, Functional groups, Distilled vetiver root, Soda pulp.

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1. Introduction

Cellulose, either from wood or non wood resources is available in abundant quantities, naturally. In wood and natural fibers, cellulose is attached to lignin matrix and incorporation with hemicellulose. Lignin and hemicellulose should be separated from lignocellulosic material to obtain cellulose fibers.

In nature, cellulose polymer chain consists of crystalline region and amorphous region. Crystalline region are interrupted every 60 nm with non-crystalline amorphous regions, which were folds in cellulose polymer chain, called “defects” (De Souza et al., 2002). The strength of cellulose was influenced by its crystalline structure. Cellulose crystal structural has modulus of elasticity (MoE) of 120-140 GPa (Tashiro & Kobayashi et al. 1990) and induced fiber stiffness, while the bulk modulus of cellulose was measured as 20 GPa (Cabrera et al., 2011). Cellulose modulus of elasticity depends on its crystallinity and the

interaction of amorphous and crystalline region (Cabrera et al., 2011). Due to those mechanical characteristics, cellulose has high tensile strength and functioned as reinforcing agent in wood (lignocellulosic materials). Having high tensile strength, cellulose is also potential to be utilized as reinforcing agent in composite products.

The crystallinity index (CI) of cellulose has been examined using several different techniques. Among of those techniques, XRD has some advantages. X-ray diffraction measures the fraction of molecules which are arranged in a regular repeating pattern (Mann, 1962) and gives more detailed data on features of crystalline, although less on the non-crystalline fraction of cellulose (Terinte et al., 2011). X-ray diffraction provides strong signals from crystalline fraction of the cellulose. These signals can be used to determine crystallographic parameters, like measuring the distances in the crystalline unit cell (Zugenmaier, 2001).

One of cellulose sources that available in Indonesia is distilled *Vetiveria zizanioides* from essential oil industry in Garut Distric, West Java Province, Indonesia. To extract cellulose from distilled vetiveria, lignin and hemicellulose have to be separated by pulping and bleaching process. The main goal of this study was to monitor changes in the fiber morphology, cellulose crystallinity and chemical functional groups during each phase of cellulose extraction from distilled vetiveria fibers.

2. Materials and Methods

2.1 Materials

Distilled vetiveria root fibres (dVR) were obtained from vetiveria essential oil in Garut Distric, West Java, Indonesia. The sodium hydroxide at technical grade was used in pulping process. Bleaching process used technical grade of hydrogen peroxide. Potassium hydroxide was supplied by Merck.

2.2 Cellulose extraction: pulping, bleaching and purifying processes

The dVR fibers were sun-dried and cut into ± 2 cm length. The moisture content of fibers was 8.59%. To produce soda pulp, dVR fibers were subjected to digester with ratio of liquor-to-materials was 8:1. Response surface methodology was utilised to optimise the soda pulping process and a central composite design (CCD) was adopted. The central combination for the experimental design was as follows: pulping temperature $T=170^{\circ}\text{C}$, pulping-time-at-temperature $t=2$ hours and soda concentration or alkali charge (AC) = 30%, with variable of pulping temperature, time and alkali charge are $160^{\circ}\text{C} \sim 180^{\circ}\text{C}$, 60 ~ 180 min and 20 ~ 40%, respectively. All pulping trials were carried out in batch rotary digester with $4^{\circ}\text{C}/\text{min}$ of heating rate. After cooking, the pulps was washed several times until neutralised. The vetiver soda pulping conditions are presented in Table 1.

For the bleaching process, as much of 20 g pulp (dry basis) and 300 mL distilled water were added in 500 ml erlenmeyer, then put in waterbath at 80°C . The technical grade solution of 50% hydrogen peroxide was used as bleaching agent. Every 60 min, 8 ml of 50%

hydrogen hydroxide was added into erlenmeyer, for 3 times. After 4 h bleaching process, bleached pulp was collected and washed with water.

Table 1. Vetiver soda pulping conditions

No	Variables			Sample codes
	Temperature (°C)	Time (min)	Alkali charge (%)	
1	160	60	20	V1
2	180	60	20	V2
3	160	180	20	V3
4	180	180	20	V4
5	160	60	40	V5
6	180	60	40	V6
7	160	180	40	V7
8	180	180	40	V8
9	153	120	30	V9
10	187	120	30	V10
11	170	19	30	V11
12	170	221	30	V12
13	170	120	13	V13
14	170	120	47	V14
15	170	120	30	V15
16	170	120	30	V16
17	170	120	30	V17

In order to eliminate hemicellulose content, bleached pulp were reacted with 5% (w/v) potassium hydroxide in waterbath at 80°C for 2 h, followed by washing with running water. The final stage to produce cellulose was further bleaching process with 8 ml of 50% hydrogen peroxide for an hour at 80°C.

2.3 Characterization of cellulose by X-ray diffractometer

XRD measurements were performed on a Shimadzu XRD7000 MAXima X-ray diffractometer equipped with computerized data collection and analytical tools to analyze cellulose crystallinity. The diffracted intensity of Cu K α radiation (λ = 1.54 Å; 40.0 kV and 30.0 mA) was measured in 2 θ between 10°~ 40° with scan speed of 2.0 deg/min.

To determine cellulose degree of crystallinity, we used built-in degree of crystallization software to separate amorphous and crystalline contribution to the diffraction spectrum using a curve-fitting process of Lorentzian function. Degree of crystallinity is calculated from the ratio of the area of all crystalline peaks to the total area.

The average size of crystal (Gumuskaya et al., 2003) was calculated from the Scherrer equation (Eq. 1). This is a method based on the width of the diffraction pattern in the X-ray reflected crystalline region. In this study, the crystal size were determined by using diffraction pattern obtaining from 101, 10-1, 002 and 040 lattice planes of samples.

$$D = \frac{k \lambda}{B \cos \theta} \quad (1)$$

where D is the crystal size (in nm), k is the Scherrer constant (0.84), λ is x-ray wavelength (0.154 nm), B is the FWHM (full width at half maximum) of peak diffraction (in rad), θ is the corresponding Bragg angle.

2.4 Characterization of cellulose by fourier transform infra red microscope

The ABB FT IR MB3000 was used to analyze chemical structure of dVR pulp component. The analysis was run using the KBr pellet technique. The KBr pellets of samples were prepared by mixing 2 ± 0.05 mg of pulp sample with 200 mg KBr (spectroscopy grade) in a vibratory ball mixer for 20 s. The KBr pellets were prepared under vacuum in a standard device under a pressure 80 KN.cm^{-2} for 3 min to form pellet with diameter and thickness of 13 mm and 0.5 cm, respectively. The spectral resolution was 4 cm^{-1} and the scanning range was from 400 to 4000 cm^{-1} .

3. Results and Discussion

3.1 Cellulose crystallinity and crystal size of dVR pulp soda

During soda pulping, lignin was removed from distilled vetiver root fibers then produced soda pulp. The crystallinity, crystal size and cellulose allomorph of dVR soda pulp from different pulping condition was presented in Table 2

Table 2. Vetiver soda pulp crystallinity, crystal size and cellulose allomorph

Samples	Crystallinity (%)	Crystal size (m)	d spacing (nm)		Z	Cellulose allomorph
		D(002)	101	10-1		
V1	32.58	8.20	0.5808	0.5433	-55.83	I β
V2	34.83	7.83	0.6019	0.5453	-21.81	I β
V3	44.17	8.13	0.5800	0.5446	-58.30	I β
V4	53.04	8.54	0.5755	0.5473	-68.31	I β
V5	47.55	7.69	0.5846	0.5254	-33.25	I β
V6	49.00	8.00	0.5971	0.5689	-51.30	I β
V7	53.60	8.59	0.5740	0.5562	-78.80	I β
V8	52.54	8.92	0.5923	0.5520	-44.13	I β
V9	40.20	8.69	0.5793	0.5440	-58.98	I β
V10	49.95	8.26	0.5900	0.5323	-30.30	I β
V11	48.83	8.71	0.6238	0.5639	-1.53	I β
V12	50.27	8.37	0.5915	0.5555	-48.56	I β
V13	39.47	7.63	0.5697	0.5446	-75.84	I β
V14	51.77	9.37	0.6195	0.5342	17.90	I α
V15	51.82	8.31	0.5900	0.5224	-21.33	I β
V16	46.09	8.76	0.5704	0.5236	-55.61	I β
V17	46.64	9.05	0.5884	0.5611	-58.87	I β

The crystallinity of vetiver soda pulp from various soda pulping conditions were 32.58% ~ 53.60%. Based on response surface methodology, pulping time ($p = 0.03$) and alkali charge ($p = 0.01$) were effected pulp crystallinity more significantly than of pulping temperature ($p = 0.10$), statistically. Figure 1 shows that pulping temperature has no significant influence on

pulp crystallinity. The longer the pulping time and the higher the alkali charge in vetiver soda pulping will produce higher vetiver soda pulp crystallinity. The alkali was the main factor that effected pulp crystallinity, due to cellulose structure swelling will facilitate the removal of amorphous region.

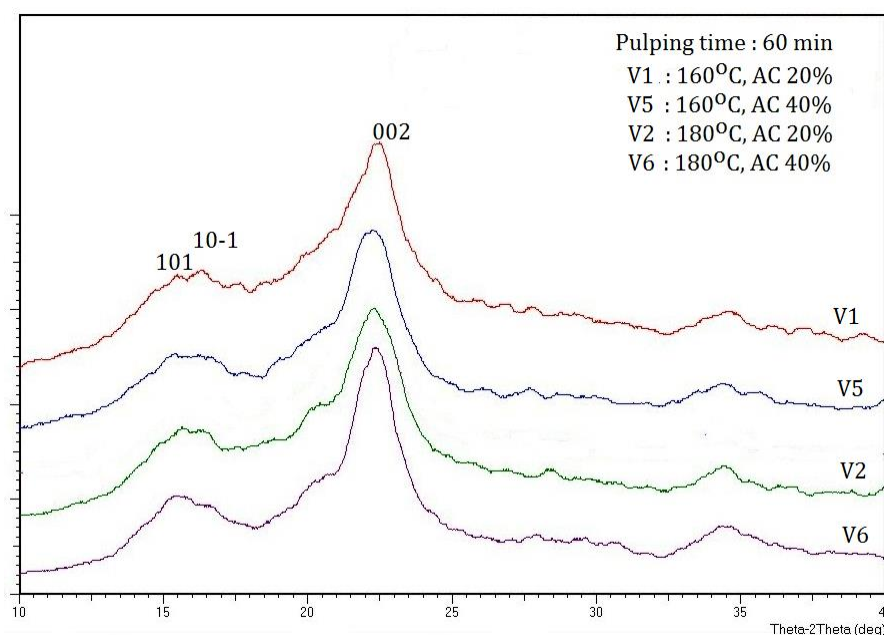


Figure 1. X ray diffractogram of vetiver soda pulp from various pulping conditions

In addition to measure cellulose crystallinity, X-ray diffraction signals can be used to determine crystallographic parameters, like measuring the distances in the crystalline unit cell (Zugenmaier, 2001) or crystal size (Nishiyama et al., 2000). The crystal length of vetiver soda pulps at lattice plane (002) were 7.63 nm ~ 9.37 nm. It shows that there was no significant difference in vetiver soda pulp's crystal length at lattice plane (002), from varied pulping conditions.

The observed cellulose allomorph in vetiver soda pulp were cellulose I β which was a cotton-ramie type of cellulose (Wada et al., 2001), except for vetiver soda pulp from pulping with 47% alkali charge. The ratio of cellulose I α /I β has been estimated by Wada et al. (2001) based on the two equatorial d-spacings of crystal using discriminant analysis. The function used to discriminate between I α and I β is presented in Eq. 2, where $Z > 0$ indicates the algal-bacterials type (rich of cellulose I α) and $Z < 0$ indicates the cotton-ramie type (rich of cellulose I β).

$$Z = 1693 d_1 - 902 d_2 - 549 \quad (2)$$

Cellulose allomorph of vetiver soda pulp that produced at pulping with 47% alkali charge was cellulose I α which more unstable than cellulose I β . According to Sassi et al. (2000), the monoclinic two-chain I β cellulose is thermodynamically more stable, since it is not only more dense (Sugiyama et al., 1991), but also tends to be the final product in the heat-annealing of cellulose (Debzi et al., 1991). Cellulose I α has lower density due to a triclinic system with one chain per unit cell (Sassi et al., 2000). Usually, transformation was occur

from cellulose I α to cellulose I β , by annealing process (Debzi et al., 1991), heat treatment (Wada et al., 2003) or under ultrasonic radiation (Briois et al., 2013). In this study, transformation of cellulose I β which was the native cellulose of vetiver, into cellulose I α was occur due to pulping process at high concentration of alkali, up to 47% at 170°C for 2 hours. High concentration of alkali tends to swell cellulose structure more intensive, expanse the crystal lattice and cause the rearrangement of hydrogen bonds, which may enhance the transformation from I α to I β .

3.2 Functional groups of dVR pulp soda from different pulping condition

FT-IR spectroscopy has been employed to provide detail about the structural characteristics of vetiver soda pulp. Pulping with alkali cause delignification of vetiver fibers. FT-IR spectroscopy analysis shows that functional groups such as metoxyl, phenolic hydroxyl, and aldehyde groups which refer to lignin, do not appear in vetiver soda pulp (Figure 2). Soda pulping has succesful delignified vetiver fibers.

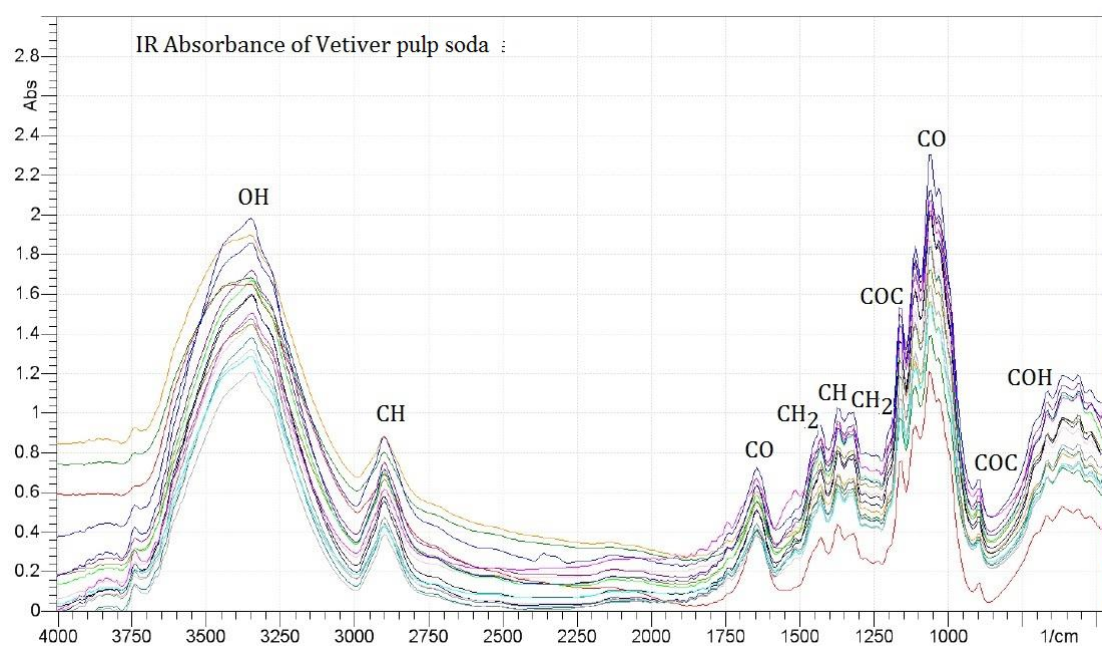


Figure 2. FTIR spectra of vetiver soda pulp from various pulping conditions

All lignins show a broad band at 3410 – 3460 cm^{-1} attributed to the hydroxyl groups in phenolics and aliphatics structures, and the bands centred around 2938 cm^{-1} and 2842 cm^{-1} , predominantly arising from CH stretching in aromatic methoxyl groups and in methyl and methylene groups of side chains (Boeriu et al., 2004). The carbonyl groups, include aldehydes (1760 - 1720 cm^{-1}) and ketones (1700 – 1670 cm^{-1}) can occur in the lignin matrix (Owen and Thomas, 1989). Aromatic skeleton vibrations at 1600, 1515 and 1426 cm^{-1} and the C-H deformation combined with aromatic ring vibration at 1462 cm^{-1} are common for all lignins (Boeriu et al., 2004).

Typical bands assigned to cellulose were located at 1427 cm⁻¹ and 1373 cm⁻¹ for CH₂ and CH bending mode, respectively. Peak at 1319 cm⁻¹ was related to CH₂ wagging in crystalline cellulose. Then the band at 1165 cm⁻¹ which associated with C-O-C asymmetric bridge oxygen and the band at 895 cm⁻¹ which associated with asymmetric out of phase ring stretching, were also assigned to cellulose. The band characteristics of vetiver soda pulp from various pulping condition was presented in Table 3.

Table 3. Bands characteristics of FTIR spectra related to vetiver soda pulp

Peaks	Wavenumber (cm ⁻¹)	Functional Groups	References
1	3348	Stretching vibration of cellulose intra molecular of	Abidi <i>et al.</i>
2	2901	OH bond	(2014)
3	1643	Symmetrical stretching vibration of the CH bond	Oh <i>et al.</i> (2005)
4	1427	Stretching vibration of the C=O bond	Bodirlau &
5	1373	Bending vibration of CH ₂ bond (symmetrical) at	Teaca (2009)
6	1319	C6 in cellulose	Oh <i>et al.</i> (2005)
7	1165	Bending vibration of CH bond in cellulose	Oh <i>et al.</i> (2005)
8	1057	Bending vibration of CH ₂ bond (wagging) at C6	Oh <i>et al.</i> (2005)
9	895	in cellulose	Oh <i>et al.</i> (2005)
10	663	Stretching vibration of COC at β-glycosidic	Oh <i>et al.</i> (2005)
		Stretching vibration of CO at C3, stretching	Oh <i>et al.</i> (2005)
		vibration of C-C	Oh <i>et al.</i> (2005)
		Stretching vibration of COC at β-glycosidic	
		Bending vibration of COH <i>out of plane</i>	

4. Conclusions

Vetiver soda pulp contains cellulose Iβ with crystallinity varied from 32.58% ~ 53.60% and crystal length were 7.63 nm ~ 9.37 nm. After soda pulping, lignin was removed from vetiver pulp. Cellulose in vetiver soda pulp was confirmed by FTIR spectra.

Acknowledgements

This research was financially supported by LIPI through Competitive Program on Material Development and Manufacture Engineering SubProgram 2015.

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Anatomy and Ultrastructure of Simpur Wood (*Dillenia Sp.*)

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Abstract

Simpur wood or *Dillenia sp.*, as one of the Indonesian fast growing tree species, has been studied extensively. In this study, morphological, anatomical and ultrastructure features of *Dillenia sp.* were examined by light microscope (Primostar Zeiss and Axio Imager A1m Zeiss) and Scanning Electron Microscope (SEM Zeiss EVO 50). The results showed that growth rings of the wood were indistinct. Two types of parenchyma were found; paratracheal axial and apotracheal axial. The wood involved two sizes of rays: uniseriate and 3-5 seriates. Other characteristics of the wood are vessels diffuse, predominantly solitary, moderately large and distinct. Perforation scalariform with 20-40 bars. Fibers very thick walls with distinctly bordered pits mainly in the radial walls, and have 1-3 mm long. Simpur wood also has long fibers and potential for pulp and paper production.

Keywords: anatomy, ultrastructure, *Dillenia sp.*, parenchyma, perforation scalariform

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1. Introduction

The need for wood in the recent time is much greater than the amount of wood available in the market. Wood demand for building materials, furnishings, flooring, etc. can be met if the policy to plant fast growing species for companies that working in the forestry field conducted and confirmed by the government as forestry policy makers.

One of the fast-growing tree species is *Dillenia sp.* This species goes into *Dillenia* genus, and *Dilleniaceae* family. All the species listed in the genus *Dillenia* there are about 60 species of plants such as trees, shrubs, or bushes, which spread from Madagascar, the Seychelles Islands in the west, the Himalayas and China in the north, as well as Southeast Asia, Australia and Fiji in part east (Lemmens et al., 1995).

The commercial name of this species in Indonesia is 'Simpur', with the name of diverse areas, such as Sempur (Java), Bawal, Jangkang (Sumatra), Kahalalo, Papanuk (Maluku), and Mayonga (Papua). The spread of types *Dillenia* in Indonesia is more easily found in Sumatera, Kalimantan, Maluku and Papua. This type of tree height average of 25 m, with a

height of free-branched of 20 m, a diameter of 50 cm or more, with the outer skin gray to brown or red to brown, not grooved and flaking (Martawijaya et al., 1989).

Simpur wood texture is a bit rough but evenly distributed, with a wooden terrace of red and brown colored sapwood younger and did not have clear boundaries with wooden terrace. Air dry density average of this wood is 0.80. This simpur wood types including class III durable and strong class among classes II and I. The usefulness of this wood is for building timber, wooden tool, plywood, flooring, boards, door and window frames, lighters as well as for the purpose of molding (Martawijaya et al., 1989).

Identification of timber in general on the field occasionally harder to do. Identification of timber is relatively practical, fast and accurate enough to do with the introduction of the characteristics of the macroscopic and microscopic. By knowing anatomical properties of wood through its ultrastructure, it is expected to know more details about the physical properties, mechanical properties or chemical properties of the wood.

The objective of this study was to determine the characteristics of anatomical structure, macroscopic, microscopic and ultrastructure of *Dillenia* sp wood. The results obtained from this study are expected to be used for timber identification guidelines in more detail to the ultrastructural level, and may provide an alternative in the form of recommendations for the proper use of the wood.

2. Materials and Methods

2.1 Materials and equipments

Materials used in this study was the samples of wood species *Dillenia* sp. obtained from natural forest area Ransiki, South Manokwari. Samples were taken from trees with a diameter of 30 cm. While the chemicals used include: distilled water, tap water, alcohol 30%, 50%, 70%, 96%, and absolute alcohol, karboxylol, toluene, entelan, acetic acid (CH_3COOH), hydrogen peroxide (H_2O_2), glycerin, safranin and 18-carat of gold.

The primary equipments used in this study were microtome, Primostar Zeiss light microscope, Axio Imager A1M Zeiss microscope and Zeiss EVO 50 electron microscope (SEM).

2.2 Method

2.2.1 Observation of macroscopic samples of wood

Macroscopic observation or thorough nature of the wood is a secondary characteristic in species identification and it is only as an auxiliary identification (Pandit & Prihartini, 2007). As observed macroscopically from wood *Dillenia* sp. were the color and pattern of wood, wood texture, grain direction, hardness and feel touch.

2.2.2 Microscopic observation of samples of wood

The observations microscopic of *Dillenia* sp. wood samples conducted in two stages, namely making preparations for slice and mercuration, as well as observation and photo taking for samples.

Samples of wood that prepared for microtomes made in 3-dimensional areas were cross, radial and tangential. To ensure the direction of each field dimensions were correct, the manufacture of wood samples assisted with a 10x magnifying glass, and the direction of the radius was appropriately addressed. Each field was cut with size of $\pm 1.5 \text{ cm} \times 1.5 \text{ cm} \times 1.5 \text{ cm}$ and tied with copper wire and labeled sample number and the name of the type of wood to be easily recognizable after softening of wood.

Mercuration preparations made in accordance with the method of the Forest Products Laboratory (FPL). Some small pieces of wood samples were taken and put into a test tube, and then treated with a solution mixture of 60% glacial acetic acid (CH_3COOH) and 40% hydrogen peroxide (H_2O_2) until the test sample is submerged. After that, the reaction tube was filled with a solution mixture of acetic acid and hydrogen peroxide as well as the sample is heated in a pan of water with a temperature of $80^\circ\text{C} - 85^\circ\text{C}$ for ± 6 hours until the sample was white and soft, easily separated. The samples were cooled and washed with water to remove the acid. Furthermore, the test sample was still bound to one another in a test tube shaken until the fibers were completely separated. Fibers that have been separated, the washed with distilled water and drops with safranin as many as 13 drops and left for 1 hour. Then washed again with distilled water to remove unused safranin (not absorbed by the fiber) and set the red color is not too dark fiber. The results of mercuration were soaked in water and stored in a safe place.

2.2.3 Observation and image capture

Data were collected for each type of cell that is vessels, fibers, axial parenchyma, rays and other features. Observations in the form of diagnostic characteristics observed in each cell, and then do the photo shoot documentation of each observation.

2.2.4 Observations wood samples using SEM

Wood samples be deducted first with a size of $1 \text{ cm} \times 1 \text{ cm} \times 2 \text{ mm}$ each number 1 sample every field cross, radial and tangential. Samples placed on the holder and subsequently coated with 18-carat gold on the surface. The next samples were inserted into the SEM tool to observe and conducted an image capture.

3. Results and Discussion

3.1 Macroscopic observation

Macroscopic observations were conducted on samples of wood *Dillenia* sp. got several things such as color and pattern, texture, grain direction, hardness, and the impression of touch. The heartwood reddish brown or purplish, and will become even darker when exposed

to sunlight. While the sapwood yellowish wood on the outside and turned into a pink and orange towards the wooden terrace.

Texture of wood *Dillenia* sp. is rather rough and evenly distributed, while the grain direction straight and slightly blended. Hardness of the wood *Dillenia* sp. is hard enough and strong classified into class I and class II-III durable. It is characterized by its difficult sawing wood sawdust is because of its very fine and tend to stick to the sawtooth, though it can be shaved until smooth. The impression of the wood surface of *Dillenia* sp. touch is felt slick.

3.2 Microscopic observation

Microscopic observation of the sample timber *Dillenia* sp. are as follows:

3.2.1 The cross section, radial and tangential

Observation of the field cross, radial and tangential can be seen in Fig.1. Fig.1 shows that the *Dillenia* sp. Wood were dominated by solitary vessels (Fig. 1(a)), with veins forming the diagonal and/or radial pattern (Fig.1(b)) and long rays (Fig.1(c)).

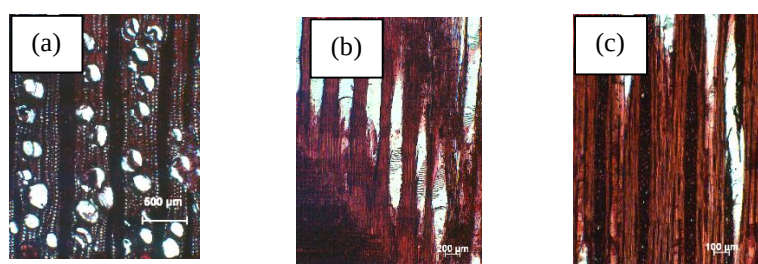


Figure 1. Observation of microscopic cross section (a), radial (b) and tangential (c) with 25x magnification

3.2.2 Vessels

Dillenia sp. wood has a not clear circumference growth ring, with a diffuse distribution system. Vessels arranged in the diagonal patterns and/or radial almost entirely solitary. Three doubles maximum radial artery was common. From the microscopic observation (Fig.2(b)) or with macromicroscope (Fig.2(a)), can be seen the tylosis in the vessel. Perforation in the section stairs-shaped vessel with 20-40 bars (Fig.3(a)). Meanwhile there is also an opposite niche between vessels (Fig.3(b)).

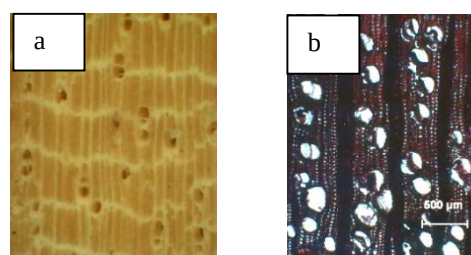


Figure 2. Macroscopic observations of cross section with 30x magnification (a) and microscopic with 25x magnification (b)

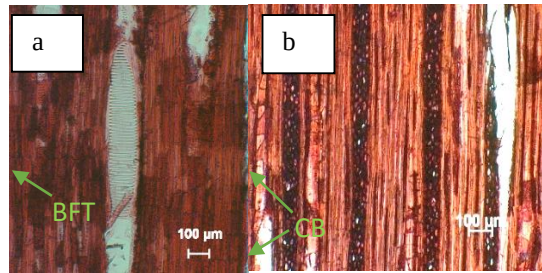


Figure 3. Observations of 50x magnification of perforation section (a) and 25x magnification of the niche between vessels (b)

3.2.3 Fibers

Fiber of *Dillenia* sp. characterized by a very thick-walled, with clear boundaries, especially in the radial section, as shown in Fig.4

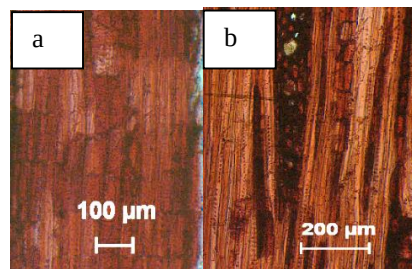


Figure 4. Observations of fibers on the radial section (a) and the tangential section (b) with magnification of 50x

Wood *Dillenia* sp. has a diameter of fiber as follows: 3119 µm of fiber length, 54.62µm of fiber diameter, 48.85 µm of lumen, 2.89µm of the wall thickness and Runkle ratio of 0.12 (Adi et al., 2014). Based on these data, wood fiber of *Dillenia* sp. longer compared to other fast-growing species such as sengon (1432 µm), Duabanga (1489 µm) and acacia (1314 µm).

3.2.4 Axial parenchyma

Observation of *Dillenia* sp. wood are rare apotrakea axial parenchyma ie parenchyma that not associated with the vessels (Fig.2(b)), and paratrakea axial parenchyma namely parenchyma associated with the vessels with form winged aliform.

3.2.5 Rays

Dillenia sp. wood rays generally consists of two different sizes, uniseriate and multiseriate 3-5 series (Fig.5(a)). Composition of rays were consisting flattened cell, square cell and upright cell (Fig.5(b)), with the average height of 4-10 mm (up to 100 cells), heteroselular with 3-6 upright cell lines.

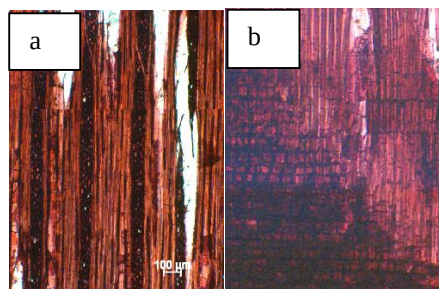


Figure 5. Structure and composition of the rays cell in the tangential section (a) and in the radial section (b) with 25x magnification

3.2.6 Tylosis and precipitate

In the *Dillenia* sp. wood, there were tylosis and precipitate that can be seen in the crosssection (Fig.6(a)) and tangential section (Fig.6(b))

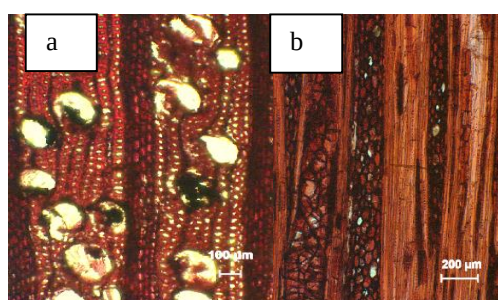


Figure 6. Tylosis and precipitate contained in the cross section (a) and tangential section(b)

3.3 Scanning Electron Microscope (SEM) observation

Cross section of *Dillenia* sp.wood at various magnifications can be seen in Fig. 7 (a) 50x magnification, (b) 100x magnification and (c) 150x magnification.

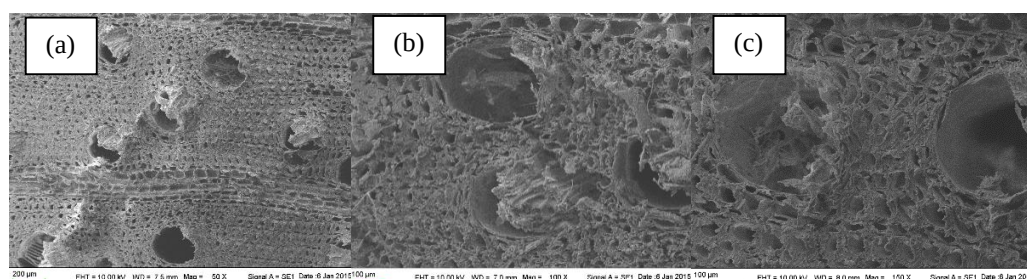


Figure 7. Cross section of *Dillenia* sp. wood with 50x magnification (a), 100x magnification (b) and 150x magnification (c)

In Fig. 7 it can be seen that the vessels are solitary, and some of them were filled by tylosis and precipitate. While the size of the wall of the vessel were thin towards thick. In Fig.7(a) also include perforations section.

Radial section of *Dillenia* sp. wood with a magnification range can be seen in Fig.8 (a) 50x magnification, (b) 200x magnification and (c) 250X magnification. In Fig. 8(a) it can be seen that the composition on the radial section cell is cell flattened cell. Whereas in Fig.

8(b), there is a niche and stairs perforation section. Dealing another niche can be seen in Fig. 8(c).

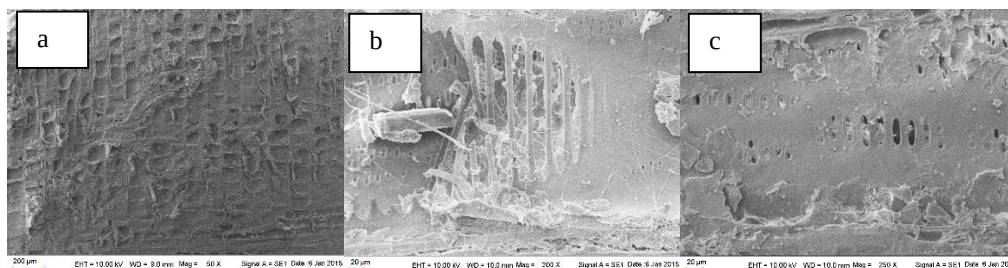


Figure 8. Radial section of *Dillenia* sp.wood with 50x magnification (a), 200x magnification (b) and 250X magnification (c)

Tangential section of *Dillenia* sp.wood with various magnification can be seen in Fig. 9(a) 50x magnification, (b) 100x magnification and (c) 200x magnification.

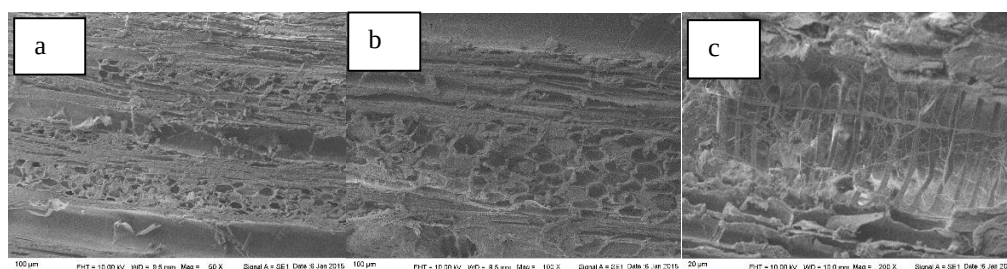


Figure 9. Tangential section of *Dillenia* sp.wood with 50x magnification (a), 100x magnification (b) and 200x magnification (c)

In Fig. 9(a) and 9(b), it appears that the rays cell of *Dillenia* sp. wood composed by flattened and square cells. Stairs perforations section can be seen clearly in the tangential section with 20-40 bars.

4. Conclusions

Microscopic observation on *Dillenia* sp. wood indicates that the vessel has a not clear circumference growth ring, diffuse distribution, arranged in a diagonal pattern almost entirely solitary. Vessels have stairs perforated section. Niche between opposited vessels and stairs shape. There are also the tylosis and precipitate in the vessels. Fiber is generally thin to thick-walled. There is a rare apotrakea axial parenchyma and paratrakea to form aliform. The width of the rays are usually composed of two different sizes, uniseriate and multiseriate 3-5 series. The composition of the rays cell consists flattened, square, and upright cell, with the average height of 4-10 mm (there are up to 100 cells), heteroselular with 3-6 of upright cell lines. *Dillenia* sp. has a long fiber size and potential to be used as pulp and paper.

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Antifungal Activities of Some Components of Teak Wood Extractives

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Abstract

Teak (*Tectona grandis*) wood under natural condition is recognized to exhibit antifungal activities. The role of individual components that contribute to those properties, however, is still unexplored. This research is aimed to evaluate teak extracts and their components against five fungi species : *Trametes versicolor*, *Fomitopsis palustris*, *Rhizopus oryzae*, *Cladosporium cladosporioides*, and *Chaetomium globosum*. Materials used in this study were wood powder from teak heartwood (72 years). The successive extraction used reflux by three solvents: *n*-hexane, ethyl acetate(EtOAc) and methano (MeOH)l. Bioassay-guided investigation by measuring the growth rate of each fungi on potato dextrose agar (PDA) medium led to the fractionation of *n*-hexane soluble extract. Column chromatographic fractionations resulted to the isolation of tectoquinone, deoxylapachol, squalene and one unknown compound (C1). The *n*-hexane and EtOAc extracts were potent mycelial growth inhibitors for *Rhizopus oryzae* (76-78%) and *Cladosporium cladosporioides* (65-73 %), while MeOH extract had higher antifungal activities against both *Trametes versicolor* (80.2 %) and *Chaetomium globosum* (83.3 %). In the compound levels, the results were varied in which deoxylapachol could exhibit all fungi species except for *Chaetomium globosum*, while tectoquinone merely deterred the growth of *Rhizopus oryzae* (58.9 %). Squalene and C1 were growth inhibitory to *Cladosporium cladosporioides* (50-63 %).

Keywords: antifungal activities, deoxylapachol, extractive, *Tectona grandis*, tectoquinone

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1. Introduction

Tectona grandis is commonly known as teak and it is a highly prized commercial timber. Teak is one of the most durable against wood destroying organisms such as fungi or termites among the woody angiosperms. Decay durability in timbers is a complex thing and depending on the combination of various factors. Undoubtedly, that the durability is associated with the presence substances in the heartwood that are toxic to fungi. Wood decay fungi reduce the mechanical strength of woods, and environmentally friendly antifungal compounds are needed to protect wood from fungal decomposition.

The most important and potent wood-destroying organisms are white- and brown-rot fungi, which attack various components of the wood cell wall. Generally, brown rot fungi depolymerize cellulose, which results in a decrease in fibre strength, while white rot fungi degrade lignin with fewer effects on the strength. Under natural condition, some works have been done to assess the inhibition against various brown-rot and white-rot fungi with varied results (Bhat et al., 2005; Kokutse et al., 2006; Da Costa et al., 1958; 1961; Rudman, 1967; Narayanamurthi et al., 1962). The toxicity of teak wood extracts or their components also were assayed against wood decaying fungi (Haupt et al., 2003; Rudman, 1961; Rudman et al. 1958; Sumthong et al. 2008).

The heartwood extract contains some highly active compounds, which may block the metabolism of the fungi. As some extractives showed high activity against brown-rot or white-rot fungi, it would be necessary to assess the activity of teak components against soft-rot and mold fungi. Although mold fungi do not reduce the mechanical strength, they could discolour any materials including wood. One report by Sumthong et al. (2006) has demonstrated the inhibition of teak extract against mold fungi *Aspergillus niger*. Further, heartwood extractives from durable species were not always toxic against broad spectrum of wood-decay fungi but rather specific to limited species (Rudman, 1965). To provide more information, in this experiment the toxicity of teak extracts and their components were evaluated against white-rot, brown-rot, soft-rot as well as mold fungi species that previously have not been tested to teak wood.

2. Materials and Methods

2.1 Spectrum determinations

GC analysis was performed with an Hitachi Model G-3 500 under the following conditions: detector: FID; column: NB-1 bonded capillary 30 m; column temperature: 120–300 °C (programming 4 °C min⁻¹), detector and injector temperature at 250 °C, held at 300 °C for 15 min, carrier gas: helium. The direct injection of EI-MS were obtained by using a JEOL XS mass spectrometry at 70 eV. FTIR spectra were recorded on HORIBA FT-710. The ¹³C (in 400 MHz), and ¹H NMR (in 100 MHz) spectra were determined by a JEOL JNX-400 spectrometer.

2.2 Extraction and Isolation

Tree of teak (72 years) was felled in Randublatung, Central Java. Wood meal was collected from the heartwood in the base part of the tree. Dried wood meal (1 kg oven-dry weight) was refluxed 3 times with hexane (n-C₆H₁₄), ethyl acetate (EtOAc), and methanol (MeOH) successively every 6 hours. Each resulting extract was filtered and concentrated in vacuo at about 45 °C to obtain dark crude residues. The weight of n-C₆H₁₄, EtOAc, and MeOH extract is 30.24 g, 22.1 g and 2.23 g. These extracts were tested as potential inhibitors of fungal growth as described below. The n-C₆H₁₄-soluble fraction was partitioned with saturated NaHCO₃, 10% Na₂CO₃, and 1% NaOH aqueous solutions in a separatory funnel.

to obtain neutral (25.5 g) and acid fractions (1.3 g). A portion of the neutral fraction (10 g) was purified by silica-gel 60 N (spherical 63–210 μm , neutral, Kanto Chemical Co., Japan) column chromatography. The extract was eluted successively with $n\text{-C}_6\text{H}_{14}$, benzene (C_6H_6), and EtOAc. The eluates with EtOAc were major (a total weight of 5.09 g) followed by C_6H_6 fractions (3.05 g) and $n\text{-C}_6\text{H}_{14}$ fractions (1.20 g).

Further $n\text{-C}_6\text{H}_{14}$ fractions was fractionated by Si-gel CC (36 g, 50 x 3.3 cm) eluted with $n\text{-C}_6\text{H}_{14}$ containing increasing amounts of EtOAc (up to 5%) to yield squalene (220 mg) and deoxylapachol (55 mg) whereas C_6H_6 fractions, by the same method, yielded tectoquinone (270 mg) and unknown compound, C1, (80 mg). The structures of tectoquinone, squalene, and deoxylapachol (Fig. 1) were identified by comparison of spectral data with published data (Perry et al., 1991; Sumthong et al. 2008; Windeisen et al., 2003; Thomson 1971).

Tectoquinone (yellow crystal), melting point 175-177 $^{\circ}\text{C}$. EI-MS : m/z (relative intensity) : 222 [M] $^{+}$ (84), 207 (44) [$\text{M}-\text{CH}_3$] $^{+}$, 194 (100) [$\text{M}-\text{CO}$] $^{+}$, 166 (82) [$\text{M}-2\text{xCO}$], 165 (94), 164 (26), 163 (34), 139 (30), 76 (20). ^1H NMR (CDCl_3) δ : 2.58 [3H, s, CH_3], 7.58 [1H, dd, $J=8.4, 0.8$ Hz, H-2], 7.77-7.79 [2H, m, H-6 and H-7], 8.09 [1H, s, H-4], 8.19 [1H, d, $J=8.4$ Hz, H-1], 8.28-8.30 [2H, m, H-5 and H-8]. ^{13}C NMR (CDCl_3) δ : 21.5 (CH_3), 127.17 (C-5), 127.17 (C-8), 127.46 (C-4), 127.52 (C-1), 131.32 (C-10a), 133.4 (C-3), 133.61 (C-6), 133.64 (C-7), 133.92 (C-9a), 134.03 (C-5a), 134.94 (C-1a), 145.29 (C-2), 183.1 (C-9), 183.7 (C-10). IR spectrum ν_{max} KBr cm^{-1} : 1718.26 (m), 1671.98 (s), 1590.99 (s), 1326.7 (s), 1295.9 (s), 850 (s), 709 (s).

Deoxylapachol (yellow gum). EI-MS : m/z (relative intensity) : 226 [M] $^{+}$ (60), 211 (100) [$\text{M}-\text{CH}_3$] $^{+}$, 197 (6), 183 (15), 165 (14), 155 (8), 152 (6), 128 (6), 115 (6), 105 (8), 104 (6), 76 (6), 51 (2). Squalene (colourless oil). EI-MS : m/z (relative intensity) : 410 [M] $^{+}$ (30), 367 (46), 341 (80), 231 (60), 217 (44), 149 (58), 137 (100), 109 (76).

C1 (white powder). EI-MS : m/z (relative intensity) : 414 (98) [M] $^{+}$, 412 (70), 400 (40) [$\text{M}-\text{CH}_2$] $^{+}$, 396 (32), 329 (26), 300 (24), 271 (28), 255 (54), 231 (26), 213 (38), 199 (16), 159 (42), 145 (42), 133 (40), 119 (38), 107 (34), 105 (40), 95 (34), 93 (32), 91 (24), 81 (32), 69 (22), 55 (30), 41 (4). IR spectrum ν_{max} KBr cm^{-1} : 2968.8 (m), 2934.1 (m), 1777.2 (w), 1751.0 (w), 1733.6 (m), 1718.2 (m), 1653.6 (m).

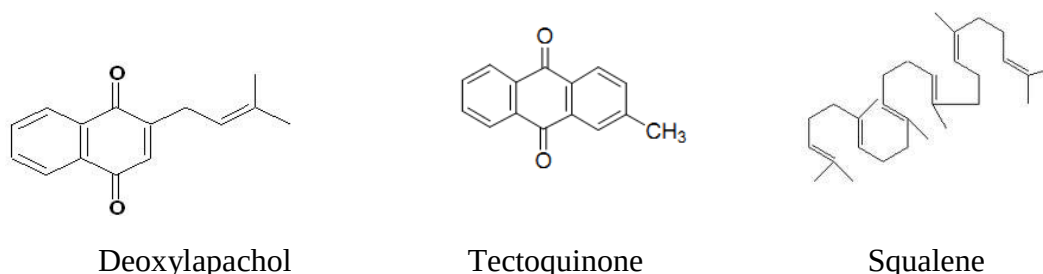


Figure 1. Chemical structures of isolated compound from $n\text{-C}_6\text{H}_{14}$ extract of Teak heartwood.

2.3 Assay for antifungal activity

The wood-decay fungi *Trametes versicolor* (white-rot) (NBRC: 30340), and *Fomitopsis palustris* (brown-rot) (NBRC: 30339), *Chaetomium globosum* (soft-rot) (NBRC: 6347), as well as mold fungi *Rhizopus oryzae* (NBRC: 31005) and *Cladosporium cladosporioides* (NBRC: 6348) were provided by the Natural Institute of Technology and Evaluation Biological Resource Center (NBRC; Tokyo, Japan). Some of these fungi are chosen routinely for antifungal tests according to Japan Industrial Standard (JIS) K1571. Cultures of each fungus were maintained on potato dextrose agar (PDA) medium (Eiken Chemical Co., Japan) and stored at 4±1°C. Before antifungal tests, each strain was incubated on PDA medium in a Petri dish at 26±1°C until the fungus covered most of the surface of the plate.

Antifungal assays were conducted referring to Sekine et al. (2009). Before fungal inoculation, test sample was dissolved in respective solvents (1 mg/ml), and 300 µl of each solution were applied to the surface of each 15 ml PDA medium in a Petri dish (88 mm diam) so that the final concentration was 5 µg/cm² in solid agar. After the application, each plate was air-dried on a clean bench for 1 hr. An equal amount of the solvent was spread on the control medium. An inoculum of each strain was obtained using a 5.5 mm diam cork-borer, and was placed on the center of the test medium. The dishes were cultured in the dark at 26±1°C and 70% relative humidity in an incubator. When mycelia reached the edge of the Petri dish of the control, the average mycelium diameter per treatment was calculated from the measurement of four radial directions. All results are expressed as means±SE. The antifungal assay was repeated three times for each sample. The antifungal activity was expressed as the percentage of growth diameter calculated and based on the diameter growth of controls as follows:

$$\text{Average growth rate (\%)} = 100 \times (\text{Da} / \text{Db}) \quad (1)$$

Da : Total average of the mycelium diameter of each sample; Db : Average diameter of control mycelium

3. Results and Discussion

3.1 Yields and antifungal properties of successive extracts

The weight and yield of n-C₆H₁₄, EtOAc, and MeOH extract in the basis of oven-dry weight wood powder (1000 g) is 30.24 g (3.93 %), 22.1 g (2.87 %) and 2.23 g (2.20 %), respectively. The n-C₆H₁₄ was comparatively potent mycelial growth inhibitors for *R. oryzae* (76 %), *C. cladosporioides* (73 %) and *C. globosum* (77 %), whereas EtOAc extract was active against *F. palustris* (81 %), *R. oryzae* (78 %), and *C. cladosporioides* (65 %) (Fig. 2). On the other hand, the MeOH extract relatively revealed mycelium growth inhibition for *T. versicolor* (80 %) and *C. globosum* (83 %), but not for *T. versicolor*, *R. oryzae*, and *C. cladosporioides*. Clearly the n-C₆H₁₄ had higher antifungal activities against soft-rot and mold fungi than the MeOH and EtOAc extract. In general, due to apparently a very low

extract concentration ($5 \mu\text{g}/\text{cm}^2$) in solid agar, the inhibition seems too low and could not generate a strong antifungal activity (below 50 % of the mycelial growth rate).

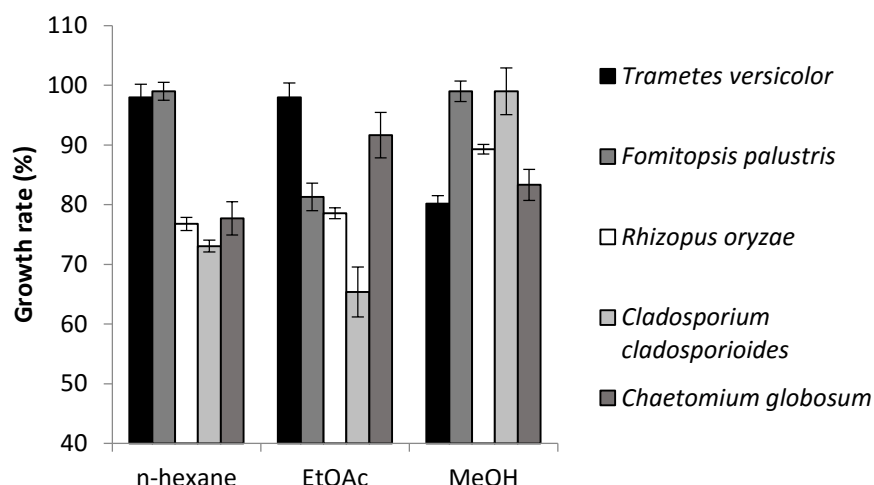


Figure 2. Antifungal activities of successive extracts from Teak heartwood against five fungi species.

Because the $n\text{-C}_6\text{H}_{14}$ extract was higher than that of EtOAc and MeOH extracts, it was investigated further. After successively washing the extract with saturated NaHCO_3 , 10% Na_2CO_3 , and 1% NaOH aqueous solutions in a separatory funnel, neutral fraction (25.5 g) and acidic fraction (1.3 g) were obtained. Neutral fraction constituted the major portion of the $n\text{-C}_6\text{H}_{14}$ extract, it was then characterized.

3.2 Chemical Compositions of $n\text{-C}_6\text{H}_{14}$ Extract

An analysis by GC-FID showed that several components of neutral fraction from $n\text{-C}_6\text{H}_{14}$ extract were detected (Fig. 3). Those compounds included quinones (deoxylapachol or its isomer, tectol, lapachol, and tectoquinone), palmitic acid, myristic acid, squalene, and some steroids (Lukmandaru and Takahashi 2009, Weindesen et al. 2003). Squalene, a triterpene, was the major component. Deoxylapachol (1), tectoquinone (2), squalene (3), and an unknown compound, C1 (4) were isolated by column chromatography separation. C1 was suggested a steroid on the basis of fragmentation pattern of its mass spectra and positive under Liebermann-burchard staining test. This compound showed a parent ion at m/z 414 and other ions were at 271, 255, 133, 107, 105, 95, 81, 69, 55, 41 which similar to β -sitosterol (Yahya et al., 2011). In order to evaluate the antifungal properties of teak heartwood extract, it was necessary to confirm the activities of isolated compounds.

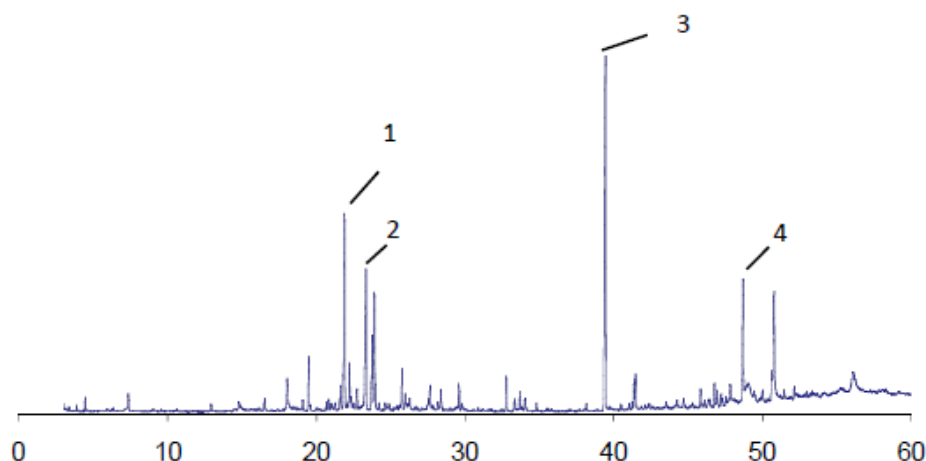


Figure3. GC chromatogram of neutral fraction in n-C₆H₁₄ extract of Teak heartwood. 1= Deoxylapachol, 2= tectoquinone, 3 = squalene, 4= C1.

3.3 Antifungal properties of isolated compounds

The antifungal activities of isolated compounds 1 to 4 were tested at 5 µg/cm² against five fungi (Fig. 4). Tectoquinone was comparatively strong mycelium growth inhibitor in *R. oryzae* (58 %) whereas deoxylapachol had medium antifungal activity against *T. versicolor* and *F. palustris* (64-75 %) but strong against *R. oryzae* and *C. cladosporioides* (57-59 %). Both squalene and C1 had antifungal activity against *C. cladosporioides* only with mycelium growth inhibitions by squalene was stronger (50 %) than C-1 (63 %) and deoxylapachol (57 %). No compound is considered to be inhibitory to soft-rot *C. Globosum*.

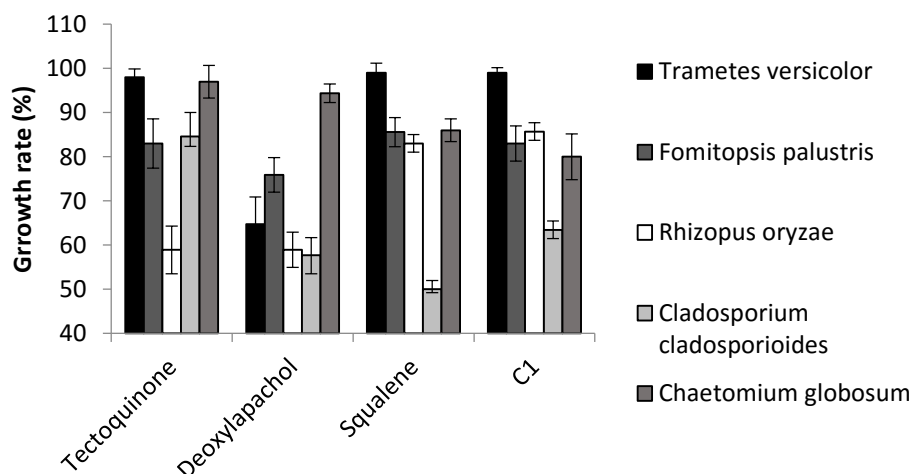


Figure 4. Antifungal activities of isolated compounds against five fungi species

The relationship between antifungal activity and chemical structure was then discussed. Deoxylapachol, which showed strong antifungal properties both brown-rot and white-rot, is a naphtaquinone. Previous finding by Sumthong et al. (2008) showed that this compound has antifungal properties against brown rot fungi (*Gloeophyllum sepiarium* and

Gloeophyllum trabeum) and the white rot fungi (*Merulius tremellosus* and *Phlebia brevispora*). Tectoquinone, an anthraquinone, did not reduce growth rates in both *T. versicolor* and *F. palustris*. This compound does not have antifungal properties in previous reports (Rudman, 1958; Rudman, 1961; Sumthong et al., 2008) against various brown-rot or white-rot fungi. These results suggest that the naphthaquinone structure is more influencing the antifungal activities, especially against brown-rot or white-rot fungi, of teak heartwood than anthraquinone structure.

In this study also found that deoxylapachol reduced growth rates in mold fungi (*R. oryzae* and CC) while tectoquinone reduced *R. oryzae* only. In line with previous finding (Sumthong et al., 2006) who demonstrated deoxylapachol and tectoquinone inhibited *Aspergillus niger* growth. The triterpene structure compounds such as squalene and C1, as expected, showed weak antifungal properties in brown-rot and white-rot fungi, however, both of them is growth inhibitory to *C. cladosporioides*. Previous finding showed that cytotoxic effect of antibiotic amphotericin B on *Saccharomyces cerevisiae* was synergistically enhanced by squalene as intermediate sterol formation (Masuda et al., 1982). This suggests that certain mold-fungi could be inhibited by quinones, triterpenes, or sterol compounds. Further research is necessary to be done in order to find out the mechanism of inhibition as well as an bioassay of active components of teak to more various fungi species.

4. Conclusions

Extracts from teak heartwood were tested for their antifungal activity by using the agar plate method. The n-C₆H₁₄ showed higher activities against *R. oryzae*, *C. cladosporioides* and *C. Globosum*. The EtOAc extract possessed notable inhibition for *F. palustris*, *R. oryzae*, and *C. Cladosporioides* while the MeOH extract had moderate effect on *T. versicolor* and *C. Globosum*. From the neutral fraction of n-C₆H₁₄ extract, four compounds were isolated (deoxylapachol, tectoquinone, squalene, and an unknown compound, C1). Tectoquinone was active against *R. oryzae*, whereas deoxylapachol was potent mycelial growth inhibitors for *R. oryzae*, *T. versicolor*, *F. Palustris*, *R. oryzae* and *C. Cladosporioides*. Both squalene and C1 inhibited mycelium growth of *C. cladosporioides* only.

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Feasibility Analysis of Composites Industry based on Coconut Coir for Vertical Garden Media

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Abstract

Indonesia is one of the largest coconut crop country in the world. Coconut coir has a weight of 35% from the total weight of the coconut tree. This fact can not be denied that the amount of coconut production has created a number of coconut coir that not widely used. To utilize the coconut coir, one of promising ways is to process the coconut coir into the planting medium. Based on the previous research, it is known that planting media from coconut coir produced has met the mechanical requirements such as strength and stiffness. Results of this research could be one of the drivers for the development of fiber composites industry. Therefore, it is needed to analyze whether the use of coconut coir into the planting media could provide benefit for the environment and society. If the results of the analysis is feasible, it is expected from stakeholders to realize that this industry is reasonable to be run and developed.

Keywords: coconut coir, composites industry, feasibility analysis, vertical garden media.

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1. Introduction

Vertical planting media based on natural fibers are suitable as a solution to get around the limited green space and open land in the urban land. The sides of the blank in some corners of the city such as the walls of buildings, narrow area, pedestrian path, interior mall, office building, the roof of high-rise buildings, residential areas, housing even billboards advertising can be filled with planting media vertical well planted with ornamental and horticultural crops or vegetables. Vertical gardens (also referred to as green walls, green façades and living walls) are an important factor in improving urban environments (Ling & Ghaffarian, 2012). Loh (2008) defines vertical gardens as: (i). Trellis systems: where plants are rooted in containers and grown up trellises. (ii). Felt systems: where plants are rooted in pockets in a felt substrate, which is in turn attached to a waterproof backing and held up by a supporting structure. (iii). Panel systems: where panels with plants and substrate are pregrown, after which they are brought to site and fitted onto a supporting

structure. Beauty, comfort and financial were gains derived from the use of vertical planting media in the urban areas. A concept that is very precise in answering the limited green space and open land in the urban area. The effect of global warming and climate change are now increasingly emboldened urban green infrastructure growing in a green city concept. This becomes a great opportunity and good prospects for vertical growing media products. Supported also that it is more environmentally friendly products that could appeal to consumers to wear compared to other growing media products are generally not environmentally friendly.

Business in the field of vertical garden does not require large capital. This business opportunity is still wide open with the growth of urban areas is rapidly, increasing the availability of land in the midst of the narrow green. The business market of vertical garden is very large. Ranging from office buildings, both private and governmental to private homes. Vertical garden business is the most profitable business and is easy to start and serve as the main business. Business property in the manufacture of vertical garden has an average value of making amounted 2.1 million to 2.4 million per square meter.

As a natural fiber and agricultural by-product, coconut coir is considered as a potential raw material to produce composite panels for vertical planting media. The module manufacturing technology of vertical planting media from coconut coir fiber is a technology package of low density biocomposites with a specific design. Product that produced from this technology can be used as vertical growing media.

Therefore, it is needed to feasibility analyze whether the use of coconut coir into the planting media could provide benefit for the environment and society. The objective of the analysis is to confirm the feasibility of applying coconut coir fiber as raw material for vertical garden media in composites industry. If the results of the analysis is feasible, it is expected from stakeholders to realize that this industry is reasonable to be run and developed.

2. Materials and Methods

The method used in this feasibility analysis is descriptive method by using quantitative data. Descriptive research includes collecting data to test hypotheses or answer questions about the current status of the study subjects (Kuncoro, 2009). The feasibility study of the financial aspects can be researched on the assessment of cash flow from an investment that includes investment cost, production cost, financial structure, sales estimate, estimate of production cost and cash flow. Fulfillment of financial feasibility criteria is done with a simple calculation which consists of the analysis Break Even Point (BEP), Net Present Value (NPV), Incremental Rate of Return (IRR), Net Benefit Cost Ratio (Ratio B/C) and Pay Back Period (PBP) (Suliyanto, 2010). Data of variable cost and fixed cost are used to determine the total cost production or total cost.

The purpose of this feasibility study is to determine whether the composite industry based on coconut coir for vertical garden media is feasible or not to run as well as how big the benefits to be obtained over a certain period of the investment period. Expected results

of the financial analysis of the composites industry for vertical planting media could encourage farmers and entrepreneurs willing to run the business.

3. Results and Discussion

Feasibility analysis of the development of the coconut fiber-based composites industry for vertical planting media consisted of capital investment estimate, estimate cost of production, revenue estimate, preparation of cash flow and the determination of investment criteria.

From the calculation, the investment needed in the industrial development of coconut fiber-based composites for vertical planting media i.e. Rp 380,000,000 consists of investment production equipment and supporting equipment.

Operating cost is the cost which determined by the amount of product was produced. Operational cost consists of fixed cost, variable and semi-variable cost. Component of fixed cost and semi-variable cost for composite production consists of expenses for electricity, gas, water and labor cost as well as travel expenses in marketing, taking raw materials and promotional cost in marketing these products through exhibitions, workshops and others are listed in Table 1 and Table 2. Variable cost consist of raw material cost, supporting materials, the cost of stationery and overhead cost are listed in Table 2. In Table 3 is shown the design for semi-variable cost.

Table 1. The design of fixed costs

No	Cost type	Cost per month (Rp)	Cost per year (Rp)	Discription
1	Electricity	415,800	4,989,600	Using for mixing and blower machine
2	Water	200,000	2,400,000	For use as much as 10 m ³ per month
3	Gas	1,000,000	12,000,000	For use of 10 kg per day
4	Transportation	2,000,000	24,000,000	To transport 2 trips per month
5	Promotion	2,000,000	24,000,000	Introduce the product to public through advertising,exhibition etc.

Table 2. The design of semi-variable costs

No	Job discription	Quantity	Salary/month (Rp)	Salary/month (Rp)
1	Technician for vertical planting media production	5	8,000,000	96,000,000
2	Security	2	2,000,000	24,000,000
3	Cleaning service	2	1,600,000	19,200,000
Quantity				139,200,000

Table 3. The design of variable costs

No.	Material type	Quantity	Unit	Cost/month (Rp)	Cost/year (Rp)
1	Coconut fiber	1,000	kg	28,000,000	336,000,000
2	PF adhesive	1,500	kg	75,000,000	900,000,000
3	Office tools		unit	200,000	2,400,000
4	Overhead cost			2,000,000	24,000,000
Quantity					1,262,400,000

The funds were needed to run the activities of the industrial development of coconut fiber-based composites for vertical planting media other than the machinery investment of production equipment is start-up capital in the form of operational cost for 1 year i.e. Rp 1,468,989,600. The total cost of the investment and working capital needed i.e. Rp 1,848,989,600.

Based on the assumptions and technical parameters have been determined previously, the production capacity of the vertical planting media per month as big as 500 sheets, with the selling price i.e. Rp 300,000 per sheet. Determining the selling price calculated on the production cost of Rp 244,900 plus the advantages of the cost production as listed in Table 4. From the results of the calculation of the vertical planting media sales will be obtained revenue Rp 150,000,000 per month.

Table 4. The selling price of vertical planting media per sheet

No.	Specification	Quantity (Rp)
1	Price of main production/sheet after tax	244,900
2	Margin (22%)	55,100
Total		300,000
Selling price		300,000

Discount factor or also known as Marginal Average Revenue Return (MARR) used by 15%. Value of discount factor can also use the bank loan interest rate of 15% (Wibowo, 2006).

From the results of the study note that the potential market for vertical planting media is still wide open, so it is assumed vertical planting media from coconut fiber per month were sold in the market as many as 500 sheets.

Table 5. The projection of production and sales from vertical planting media

Detail	Production output/month	Price per sheet	Income/month
Vertical planting media	500	Rp 300,000	Rp 150,000,000

Total Gross Income/Year	Rp 1,800,000,000

The projected of profit or loss carried out to determine the level of profitability of the planned investment activities. Calculation of profit or loss derived from the difference between revenues and expenditures. Calculation of profit or loss from the investment plan of composites industry based on coconut coir for media vertical planting media is able to generate a net profit of Rp 27,550,000 per month. When 25% of the profits entered as a reserve fund such as license and maintenance of assets, so the existing advantages are:

$$75\% \times \text{Rp } 27,550,000 = \text{Rp } 20,662,500 \text{ per month}$$

The break even point (BEP) is a point of total production or sales must be done so that the costs can be covered again or where the profit received value is zero. From the calculation, BEP from vertical planting media industry will be obtained at:

$$\Rightarrow \text{Rp } 380,000,000 / (\text{Rp } 17,907,500/\text{month})$$

$$\Rightarrow 18,4 \text{ month}$$

The development of composites industry based on coconut fiber for vertical planting media require a picture related to the cash flow consists of cash inflows and cash out. Components of cash inflows consist of revenue from the sale of products, while cash out consists of investing costs, operating costs, repayment of bank credit loans, and income tax. To determine the feasibility of the investment plan, be required calculation of NPV, IRR, PBP and the ratio of B/C. NPV analysis is done to see how the value of investments by considering changes in currency values. NPV is the difference between the present value of benefit and cost. IRR is basically a method to calculate the interest rate that equates the present value of all cash inflows with the cash flow out of an investment project. IRR used to calculate the actual rate of return.

Tabel 6. The investment criteria of vertical planting media industry for 5 years

Year	Cash flow advantage (Rp)
1	-48,989,600
2	331,010,400
3	331,010,400
4	331,010,400
5	331,010,400
NPV after discount factor 15%	779,163,417
IRR (%)	92
BEP/PP	18.4 month
Decision	Feasible

From the calculations, the NPV is positive > 0 , i.e. Rp 779,163,417. This value indicates that the investment made until the next 5 years will be obtained benefit net rated current of Rp 779,163,417. IRR of 92%, which means that these businesses can recoup up to 92%

interest rate per year. The payback period of the vertical planting media industry enterprises is less than the life of a project that is over 18.4 months. From the investment criteria above, the investment plan of composites industry based on coconut fiber for vertical planting media is feasible.

4. Conclusion

The results of Net Present Value (NPV) is positive i.e. Rp 779,163,417. The value of Internal Rate of Return (IRR) is 92% which indicated that the rate of return greater than the interest rate of specified bank. Payback Period for 18.4 months if the planned assumptions are met, so that in terms of financial investment plan for the composites industry based on coconut coir for vertical planting media is feasible. Sensitivity analysis showed that the 5% decline in revenue and 5% increase in operating cost does not affect the feasibility of the project. The results of investment criteria above conclude that the operations of coconut fiber composite industry for vertical planting media feasible during the project in accordance with the assumptions and technical parameters specified.

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Composites of Coconut Coir and Betung Bamboo Fiber: The Effect of Mixture Composition and Citric Acid Concentration

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Abstract

The physical and mechanical properties from coconut coir and Betung bamboo fiber composites have been studied. The effects of mixture composition from coconut coir and Betung bamboo fiber and citric acid percentation were investigated. Results showed that the physical properties of composites to be a better value with increasing acetic acid percentation and coconut fiber composition. At the optimum citric acid percentation of 35% with the mixture composition from 70% of coconut coir and 30% of Betung bamboo fiber could provide composites with thickness swelling and water absorbtion better than other composition. Generally, the modulus of rupture, modulus of elasticity and internal bonding also increased with increasing coconut fiber content at composites.

Keywords: Betung bamboo fiber, citric acid, coconut coir, composites, physical and mechanical properties

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1. Introduction

Generally, particleboard is a type of composite panels made from wood resources. Composite panels manufactured by compressing small wood particles materials while simultaneously bonding them with an adhesive. Particleboards are among the most popular materials used in interior and exterior applications in floor, wall, ceiling panels, office dividers, bulletin boards, cabinets, furniture, counter and desk tops. With depleting wood resources, the wood industry struggles to obtain sufficient amount of raw material for composites production. High demand for wooden materials and rises in agricultural areas and forest fires also increased the importance of composites instead of using solid woods. This condition encourage many studies on the possibility of using natural fibers or

agricultural by-products as materials in place of wood materials for composites. Various studies investigated properties of composites made from natural fibers or agricultural by-products such as rice husk (Kumagai & Sasaki, 2009), rice straw (Zhang & Hu, 2014), kenaf core (Okuda & Sato, 2008), bagasse (Widyorini et al., 2005), oil palm culm (Baskaran et al., 2013) and oil palm fronds (Suzuki et al., 1998).

As a natural fiber and agricultural by-product, bamboo fiber and coconut coir are considered as a potential raw material to produce value added composite panels such as particleboard. One of bamboo species which potential as raw material for composite panels is Betung bamboo. Therefore, various investigations were carried out to evaluate characteristics of composite panels made from bamboo fiber and coconut coir. Commonly, bamboo fiber or coconut coir composites were used formaldehyde-based adhesive. Composites of Betung bamboo or coconut coir fibers are usually made separately. Rarely mixed in the manufacture process.

The main goal of the current study is to confirm the feasibility of applying Betung bamboo fiber and coconut coir as alternative raw material for composites, which, to our knowledge, has not been thoroughly investigated before. The objectives of study are; (a) to investigate the characteristics of composites from Betung bamboo and coconut coir fibers and, (b) to study the effect of mixture composition and citric acid percentation on the physical and mechanical properties of particleboard samples.

2. Materials and Methods

The Betung bamboo culms were harvested in Cibinong Bogor. They were chipped using a hacker chipper before the chips were reduced into smaller particles about 1.5 to 2.5 cm using a knife ring flaker. Particles were dried to 8 percent moisture content. For coconut coir fibers, the production of smaller size fibers about 1 to 1.5 cm similar with bamboo particles process. The composites was made with composition variation of coconut coir fibers and Betung bamboo particles are 30:70, 50:50 and 70:30 (%). Particles were blended with citric acid resin. Based on oven dry particle weight, 25%, 30% and 10% citric acid resin were applied for composites, respectively. Composites samples were made with length x width x thickness = 25 x 25 x 0.9 cm. Hand formed mats were pressed in a hydraulic hot press at a temperature of 200° C, a pressure of 2.5 MPa for 10 minutes with a target density of 0.7 g/cm³.

Composites were conditioned for about two weeks at room temperature. Test samples were prepared and tested based on JIS A 5908:2003 standard for physical and mechanical properties.

3. Results and Discussion

3.1. Physical properties of composites

The samples from each composites were used to evaluate dimensional stability in term of thickness swelling (TS) and water absorption (WA). The samples were soaked in water

for 24 h. Weight and thickness were measured before and after the samples were soaked. The effect of mixture composition and citric acid percentation on thickness swelling (TS) and water absorption (WA) after water-soaking tests for 24 h at ambient condition are shown in Fig. 1 and 2. It can clearly be seen that the values of TS and WA of the samples decrease with increasing citric acid percentation. The thickness swelling of the composites were relatively low, ranging from 3% to 10% for 24 h immersion. The TS value of the composites satisfied JIS A 5908:2003 requirements of Type 8 Particleboard, maximum of 12%.

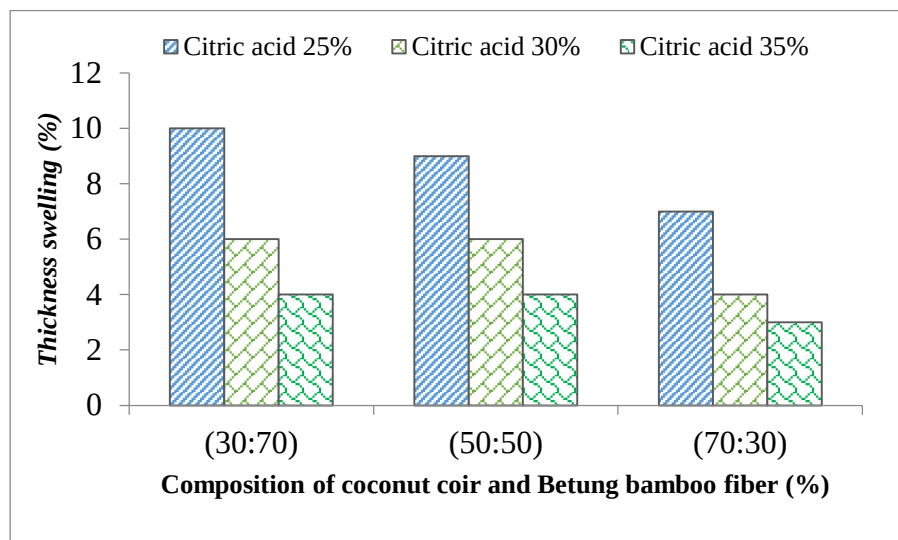


Figure. 1. Thickness swelling values of the composite samples

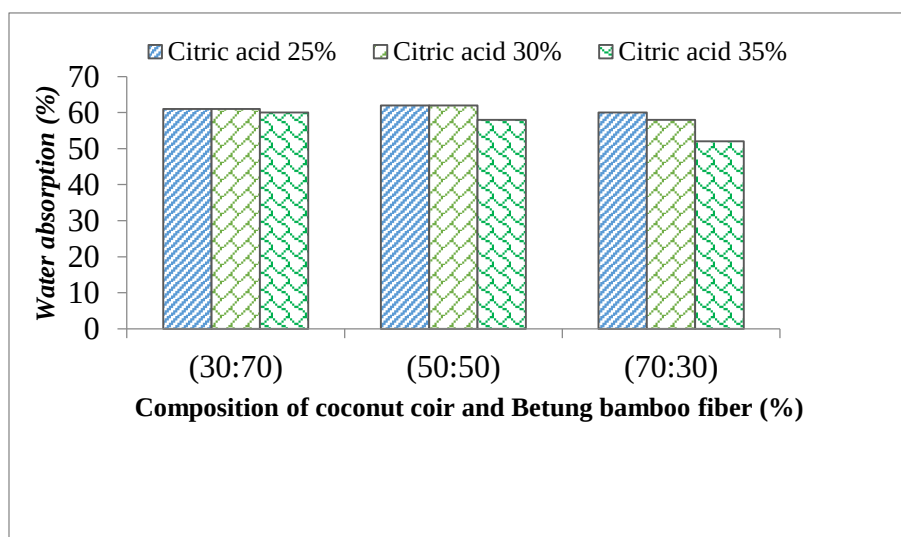


Figure. 2. Water absorption values of the composite samples

Increasing of coconut coir composition improved the thickness swelling and water absorption of the composites. This may be due to interference in the curing of citric acid adhesive, reduced wettability of the particle surface or limitation of diffusion and/or spreading of the adhesive within the particles and over the particle surface. This phenomenon is presumably due to the uniformity of coconut coir fiber that absorbs less water intake.

Uniformity fibre increased the number of fibre–fibre contact and created cross links between resonated fibres (Halvarsson et al., 2008), which improve the physical properties. Fibre length has a strong effect on physical properties of composites, as the length of overlap is shortened, the quality of the bond between two fibres is reduced (Maloney, 1993). Previous study concluded that with increasing slenderness of fibres, swelling in thickness of the composites decreased, but different results were found in a past study carried out by Tajvidi et al. (2006) and Steckel et al. (2007) who stated that the larger particles or fibres size, the higher water absorption, thus, the effect of fibre length on water uptake is dependent on fibre content. This can be explained in two ways: larger fibres lead to greater hydrophilic exposed surfaces; and poor adhesion between wood particles and the matrix generates void spaces around the wood particles. These voids in the bulk matrix are readily filled with water.

3.2. Mechanical properties of composites

The mechanical properties of the composites are shown in Figs. 3-5. Mechanical properties of the composites also followed similar trend. Increasing of coconut coir composition improved the modulus of rupture (MOR), the modulus of elasticity (MOE) and the internal bonding (IB) of the composites.

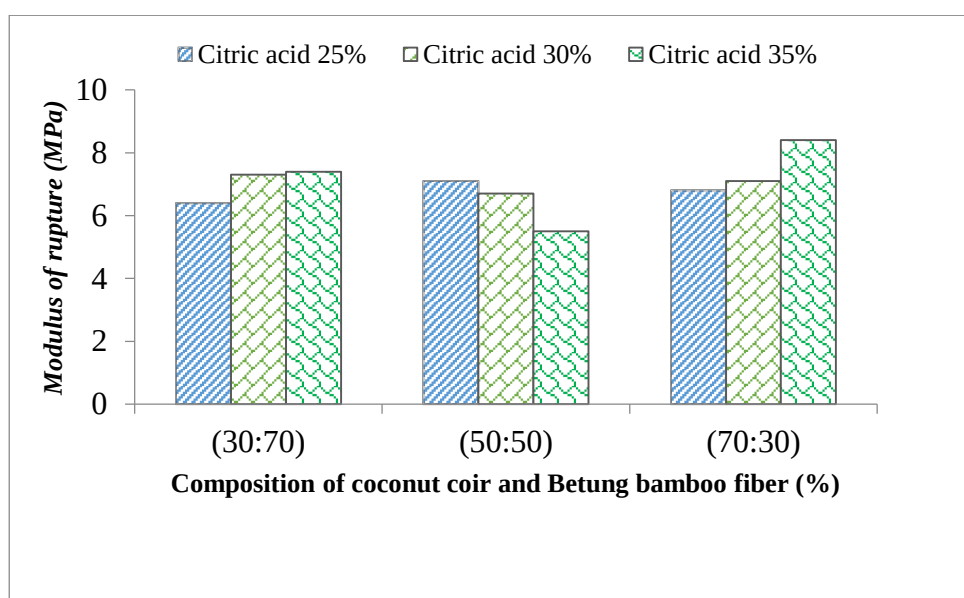


Figure3. Modulus of rupture values of the composite samples

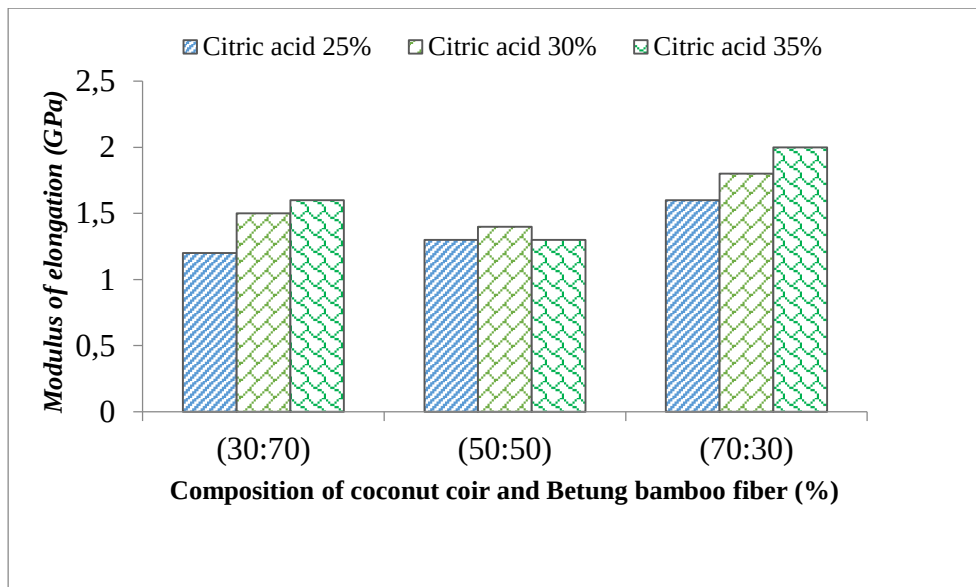


Figure. 4. Modulus of elasticity values of the composite samples

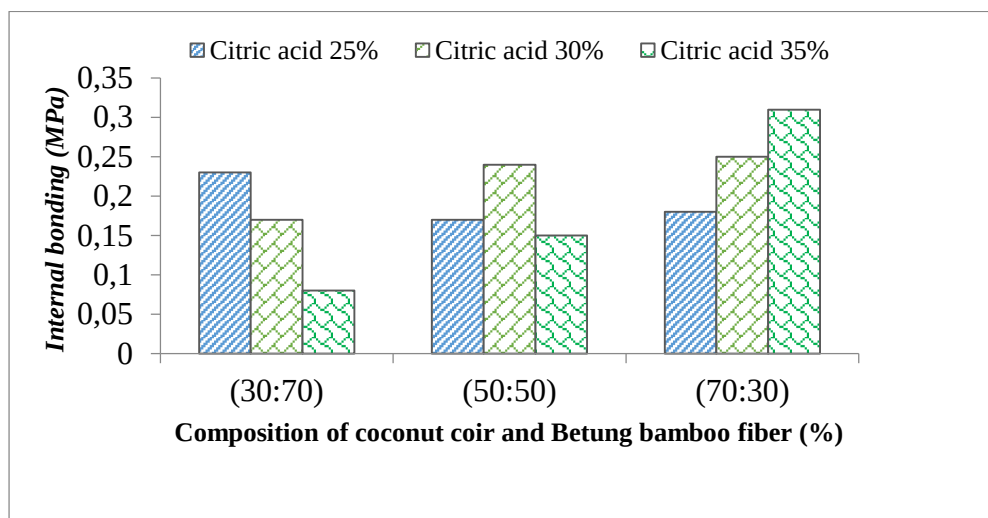


Figure. 5. Internal bonding values of the composite samples

The highest MOR value of 8 MPa was determined for composites made from 70% coconut coir fibers, 30% Betung bamboo particles and 35% citric acid as adhesive based on oven dry particle weight. Slenderness ratio (chip length to thickness, SL) was a factor that influenced the MOR properties. The increased SL ratio gave high MOR value (Biswass et al., 2011). Different MOR values in different studies were due to different SL ratios. MOE values also followed similar trends to the findings for MOR. Based on Japanese Industrial Standard (JIS, 2003), only composites with 70% coconut coir fibers and 30% Betung bamboo particles with addition 35% citric acid adhesive met minimum MOE requirement of Type 8 Particleboard, 2 GPa. Coconut coir fibers were long and thin, and were more elastic than Betung bamboo particles. In this study, composites with higher coconut coir fibers content than Betung bamboo particles showed a higher MOR and MOE.

The internal bonding of the composites were relatively high, ranging from 0.08 to 0.31 MPa. The IB value of the composites satisfied JIS A 5908:2003 requirements of Type 8 Particleboard, minimum of 0.15 MPa. The IB values increased with the increasing of Betung bamboo particles content as shown in Fig. 5. It is a well known fact that the slenderness ratio plays an important role on development of glue line between the particles (Moslemi, 1973). Higher bonding strength properties of the composites made from uniform particle can be related to better glue line development due to their geometry. Uniformity of particle enhanced MOR, MOE and IB values of the composites.

3. Conclusions

This study indicated the suitabilities of Betung bamboo particle and coconut coir fiber for making citric acid-bonded composites. Particle geometry from Betung bamboo particle and coconut coir has significant influence on the physical and mechanical properties of the composites. Composites with higher coconut coir fibers content than Betung bamboo particles are superior to those made from composites with lower coconut coir content. The thickness swelling and internal bond strength of all composites satisfied the minimum requirement of Type 8 Particleboard of Japanese Industrial Standard. The product could be used for interior applications, like furniture components, wall panels, etc., but not recommended for places under frequent humidity changes.

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Functional Stretchable Hydrogels by Combining Cellulose Nanofiber and Polymer

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Abstract

We investigated the fabrication of functional stretchable hydrogels by using surface modified cellulose nanofiber (CNF) and *N*-isopropylacrylamide (NIPAm) as an effective cross-linker and monomer, respectively. It is expected that we accomplish the unique network structures leading to an elastomeric property in comparison with conventional chemically cross-linked hydrogels. Surface modification of CNF was performed by using two different reagents, silane coupling agent and maleic anhydride, respectively. Effects of the surface modification of CNF were characterized by FT-IR, FE-SEM, and ¹³C NMR. Mixtures of the surface modified CNF aqueous suspension, NIPAm monomer, radical initiator, and catalyst were provided for the *in-situ* radical polymerization under various conditions. Thus obtained hydrogels were evaluated for the mechanical property, where the samples containing CNF modified by silane coupling agent exhibited a considerable stretchability of more than 700-fold. Besides, with maleic anhydride, we could prepare the modified CNF well dispersing in water and control elastic modulus for the hydrogel samples comprising the surface modified CNF. All of the hydrogels showed not only a highly extensional ability, but also a responsiveness to external temperature stimulus and a shape-recovery ability. Therefore, we concluded that the surface modified products of CNF acted as an effective cross-linker.

Keywords: cellulose nanofiber, hydrogel, maleic anhydride, PNIPAm, silane coupling agent

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1. Introduction

Cellulose nanofiber (CNF) attracts considerable attention in the broad field of material science and technology (Klemm et al., 2011). The bioderived nanofibers are favorable because of not only their abundance, biodegradability, and renewability but also their fine structure and excellent physical properties associated with the highly crystalline nature. For example, CNF is characterized by a large surface area ($\sim 800 \text{ mm}^2 \text{ g}^{-1}$) (Kobayashi et

al., 2014), high elastic modulus (~ 140 GPa) (Nishino et al., 1995), and low linear expansion coefficient (0.1 ppm K^{-1}) (Nogi et al., 2009). Recently, several Japanese companies have industrialized CNF production and developing uses for CNF has become a national project. One of the key approaches employed to expand the application of CNF is material functionalization via diverse hyperfine composites (Nishio, 2006; Teramoto, 2015) such as blending and interpenetrating network (IPN).

In recent years, several significant achievements have further progressed the IPN concept; the accomplishments include the creation of new classes of hydrogels. In particular, nanocomposite (NC) gel was synthesized via the *in-situ* polymerization of a vinyl monomer in the presence of clays as a multifunctional polymer crosslinking agent (Haraguchi & Takehisa, 2002). Conventional organic crosslinked polymeric hydrogels exhibit mechanically weak and brittle natures because the inter-crosslinking molecular weight M_c (i.e., the chain length between crosslinking points) generally has a broad distribution. Meanwhile, in the NC gel, the M_c is large, and its distribution is narrow. By drawing, the flexible polymer chains between the clay sheets in the NC gels should have the ability to be extensively elongated and reversed without breaking the short polymer chains. As a result, the NC gels show extraordinary mechanical properties with high strength and elongations at break in excess of 1,000 %.

In the present study, we investigated the fabrication of CNF-based stretchable composite hydrogels by combining surface-modified CNF and *N*-isopropylacrylamide (NIPAm) as a multifunctional crosslinking agent and monomer, respectively. Even though NC-type composite materials based on nanocellulose have been proposed by several groups (Yang et al., 2012), we expect to achieve unique microstructures leading to high elasticity rarely reported for CNF-based materials. The cross-linker (surface-modified CNF) with vinyl groups was prepared via silane coupling reaction (Abdelmouleh et al., 2002) and esterification (Iwamoto & Endo et al., 2014) with hydroxyl groups of CNF. Effects of the surface modification of CNF were characterized by FT-IR, FE-SEM, and solid-state NMR. Mixtures of the surface-modified CNF aqueous suspension, NIPAm monomer, radical initiator, and catalyst were provided for the *in-situ* radical polymerization under various conditions. Thus obtained hydrogels were evaluated for the mechanical property, where the samples containing CNF modified by silane coupling agent exhibited a considerable stretchability of more than 700-fold (Kobe, Yoshitani, & Teramoto, 2015). On the other hand, by esterification with maleic anhydride, we could prepare the modified CNF well dispersing in water and control elastic modulus for the successive hydrogel products. All of the hydrogels showed not only a highly extensional ability, but also a responsiveness to external temperature stimulus and a shape-recovery ability.

2. Materials and Methods

2.1 Materials

CNF (BiNF_i-s[®], Wma-100) was obtained as a 2-wt% water suspension from Sugino Machine Ltd. NIPAm and *N,N*-dimethylacetoamide (DMAc) were purchased from Wako Pure Chemical industries. NIPAm was purified by two recrystallizations from *n*-hexane and dried under vacuum at 30 °C for 1 h. DMAc was dried by potassium hydroxide pellets before use. Other reagents were used without further purification.

2.2 Surface modification of CNF

Two methods, silane coupling reaction and esterification, were conducted for surface modification of CNF. For the former, the as-provided CNF aqueous suspension was treated by a successive solvent exchange technique using acetone and DMAc with centrifugation at room temperature. The obtained suspension in DMAc (0.285 g in 100 mL) was introduced into a four-necked flask equipped with a mechanical stirrer under nitrogen flow (200 mL min⁻¹). The flask was then immersed in an oil bath thermo-regulated at 100 °C under stirring, and 3 mL of 3-(Trimethoxysilyl)propylmethacrylate (MPS, Fig. 1a) was then added into the system. Continuous stirring was conducted for 18 h. The resulting suspension of fibrous product (mCNF) was subjected to successive solvent exchange using acetone and deionized water to remove reagent residue. Meanwhile, in order to obtain CNF modified by maleic anhydride (MAH, Fig. 1b), we prepared the CNF suspension in DMAc (2.4 g in 200 mL) and used MAH (100 g). Esterification was performed at 120 °C for 3 h, and other procedures were done in a similar manner as the above. The MAH-treated product (MACNF) suspension in water was neutralized by NaOH solution (1 mol L⁻¹) until the pH of the system reached ~7 and dialyzed in deionized water for 1 week. The MACNF suspension in water was passed 3 times through the high-pressure homogenizer (mascomizer X, Masuko Sangyo Co., Ltd.) at 200 MPa to obtain the MACNF dispersion.

(a) (b)

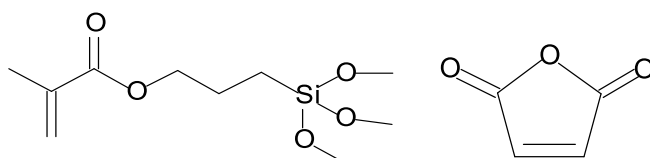


Figure 1. Structural formulae of (a) 3-(trimethoxysilyl)propylmethacrylate (MPS) and (b) maleic anhydride (MAH)

2.3 Synthesis of hydrogels

Various concentrations of cross-linker (mCNF or MACNF) dispersion were prepared in a glass tube by adding deionized water and treated with a homogenizer (Physoctron NS-52, Microtec Co. Ltd.) at 3000 rpm for 30 min. The cross linker aqueous dispersion (26 g) was mixed with NIPAm (3 g) under vigorous stirring with a magnetic stirrer. Subsequently, both

the initiator (0.03-g potassium peroxodisulfate in 1.5 mL H₂O) and catalyst (*N,N,N',N'*-tetramethylenediamine, 24 μ L) were added into the mixture under stirring. The above procedures were all performed in an ice bath shielded from light. Free-radical polymerization was then allowed to proceed in an ethanol bath at 20 °C for 20 h. Oxygen was excluded from the system throughout the synthesis by a continuous flow of nitrogen (200 mL min⁻¹). The prepared CNF-composite hydrogels contained ~90 wt% of water.

2.4 Spectroscopy

FT-IR and solid-state ¹³C CP/MAS NMR measurements were carried out at the Division of Instrumental Analysis, Life science Research Center, Gifu University. IR spectra were recorded on a PerkinElmer Spectrum 100 FT-IR apparatus over the wavenumber range 400–4000 cm⁻¹ at a resolution of 4 cm⁻¹ via the accumulation of 32 scans. A standard KBr-pellet method was employed. Solid-state ¹³C CP/MAS NMR experiments were carried out at 20 °C with a JEOL ECA-500 equipped with a JEOL NM-93030 with a spinning rate of 12 kHz, a contact time of 7 ms, a recycle delay time of 5 s, and 8192 FID signal accumulations.

2.5 Tensile test

Tensile mechanical test of cylindrically shaped hydrogel samples (5 mm ϕ ×21 mm length) containing cross-linker was conducted using a table-top type precision universal tester AGS-X (Shimadzu Corporation) under the following conditions: sample length between jaws, 1 mm; crosshead speed, 1000 mm min⁻¹; test temperature, 20 °C. The initial cross section (19.63 mm²) was used to calculate the tensile strength and modulus.

3. Results and discussion

3.1 Surface modification of CNF

FT-IR spectra for the original CNF, mCNF, and MACNF are illustrated in Fig.2. For all the spectra, two major adsorption bands were observed at 3,100–3,500 cm⁻¹ and 2,800–3,000 cm⁻¹, which were ascribed to the O–H and –CH stretching vibration bands, respectively. Meanwhile, for mCNF and MACNF, a specific adsorption band at ~1,720 cm⁻¹ was observed, which was assigned to the C=O vibration of the carbonyl groups of the MPS and MAH moieties. Besides, an adsorption band at 1,579 cm⁻¹ was appeared, which was attributed to the C=O vibration of the dissociated carboxy groups of the MAH moiety. Solid-state ¹³C CP/MAS spectrarevealed the existence of polymerizable vinyl moieties in the mCNF and MACNF.

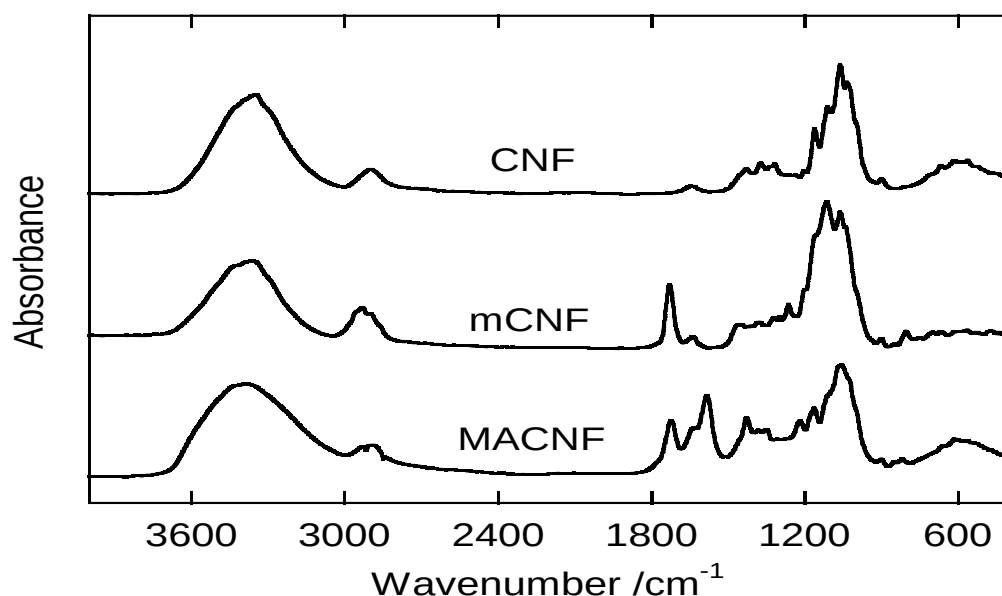


Figure 2. FT-IR spectra of CNF, mCNF, and MACNF

3.2 Synthesis and characterization of the hydrogels

The synthesized hydrogels containing mCNF or MACNF with 90-wt% water lost fluidity. In the case of using mCNF, mCNF generally had so poor dispersibility that the obtained hydrogels containing ≥ 0.1 -wt% mCNF were opaque. Although elastic modulus of the hydrogels with mCNF did not depend on the concentrations of mCNF because of the less dispersibility of mCNF, the hydrogels (0.1-wt% mCNF) extended more than 700-fold (Fig.3a). On the other hand, MACNF was well dispersed in water, and we could control the elastic modulus of the hydrogels using various concentrations of MACNF (Fig. 3b). In either case, large intercrosslinking molecular weight M_c of PNIPAm should be the origin for highly elastomeric properties of hydrogels. We thus concluded that the series of the surface-modified CNF acted as an effective cross-linker.

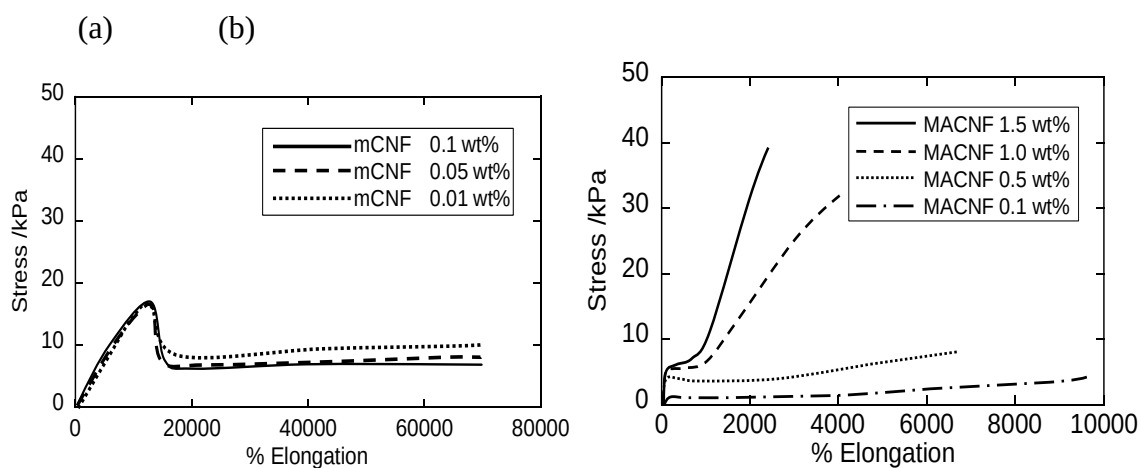


Figure 3. Stress-strain curves for cylinder-shaped (5 mm ϕ) hydrogels containing various contents of (a) mCNF and (b) MACNF

4. Conclusions

In this study, we successfully fabricated elastomeric hydrogels (water content = 90 wt %) comprising PNIPAm and mCNF or MACNF, which was surface-modified by silane coupling agent or maleic anhydride, respectively, to introduce polymerizable vinyl groups. The maximum strain of the products containing mCNF reached 700-fold at least. These specimens exhibited apparent retraction behavior. Such a high stretchability can be mainly attributed to the large intercrosslinking molecular weight M_c of PNIPAm. Furthermore, using MACNF as a crosslinker, which had high dispersibility, enabled controlling elastic modulus of the hydrogels. We therefore concluded that the mCNF or MACNF with vinyl groups acted as an effective multifunctional crosslinking agent.

Acknowledgements

The authors wish to acknowledge Professor Akiyoshi Takeno and Ms. Yui Horiguchi of the Faculty of Engineering, Gifu University for providing the tensile testing facilities. This work was financially supported by Grant-in-Aids (KAKENHI) for Exploratory Research (26620178) and Young Scientists (A) (26712016) from the Japan Society for the Promotion of Science (JSPS) and Environment Research and Technology Development Fund (3K153010) of the Ministry of the Environment, Japan.

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Improvement of Thermal Processing and Controlling Orientation for Structural Polysaccharide Nanofiber Incorporated with Flexible Polymer

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Abstract

Controlling an orientation state of polymers can improve a variety of physical properties. Recently, structural polysaccharides nanofibers have been attracting attention because of their advantages such as a large surface area, high strength, high elastic modulus, low linear expansion coefficient, etc. In particular, chitin has biocompatibility; it is thus expected to use the chitinous nanofiber (ChNF) for a wide-ranging of biomedical application. In the present study, we attempt to control an orientation state of ChNF embedded in a polymer matrix (PM) by developing a “pseudo melt-processing” method. The PM is composed of hydrophilic synthetic polymers, e.g., poly(*N*-vinyl pyrrolidone), with plasticizer such as glycerol. We first prepared ChNF/PM composites and characterized them by differential scanning calorimetry and dynamic mechanical analysis. Based on these data, we tried to perform heat-processing using some specific compositions exhibiting their glass transition temperatures (T_g) higher than room temperature, by means of a screw extrusion or uniaxial film drawing. We measured the wide-angle X-ray diffraction patterns and birefringence of the processed samples, which verified a preferential orientation of the ChNF in the PM.

Keywords: Chitin nanofiber, Orientation control, Polymer matrix, Pseudo-melting process.

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1. Introduction

Polysaccharide nanofiber, such as cellulose nanofiber (CNF) and chitin nanofiber (ChNF), attracts considerable attention in the broad field of material science and technology (Klemm et al., 2011). The bioderived nanofibers are favorable because of not only their abundance, biodegradability, and renewability but also their fine structure and excellent physical properties associated with the highly crystalline nature. Besides, chitinous nanofibers have a large potential for developing specially functionalized materials in medical and sanitary fields (Hashiwaki et al., 2014), because of their biological properties such as

biocompatibility and antibacterial and wound healing activity. Recently, several Japanese companies have industrialized nanofiber production, and developing uses for them has become a national project. One of the key approaches employed to expand the application of CNF is material functionalization via orientation Control (Putra et al., 2008; Iwamoto et al., 2011).

For polysaccharide nanofiber-based materials, however, it is generally difficult to apply a preferential orientation since hydrogen bonds between hydroxyl groups occur not only intra- and intermolecularly within the crystallites but also between the hydroxyl groups exposed on the surface of nanofibers. In recent years, several interesting achievements have progressed the polysaccharide nanofibrous orientation; e.g., by wet-spinning of TEMPO-oxidized CNF by extruding its water suspension into an acetone coagulation bath with a syringe (Iwamoto et al., 2011) and by bacterial cellulose incubation with an oxygen permeable substrate of polydimethylsiloxane with ridged morphology (Putra et al., 2008).

In the present study, we attempt to control an orientation state of ChNF embedded in a polymer matrix (PM) by developing a “pseudo melt-processing” method. The PM is composed of hydrophilic synthetic polymers, e.g., poly(*N*-vinyl pyrrolidone)(PVP), with plasticizer such as glycerol (Gly). We first prepared binary and ternary composites and characterized them by differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA). Based on these data, we tried to perform heat-processing using some specific compositions exhibiting their glass transition temperatures (T_g) higher than room temperature, by means of a screw extrusion or uniaxial film drawing. We measured the birefringence and wide-angle X-ray diffraction patterns of the processed samples, which verified a preferential orientation of the ChNF in the PM.

2. Materials and Methods

2.1 Materials

ChNF (BiNF-i-s® chitin, SFO-20002) was obtained as a 2-wt% water suspension from Sugino Machine Ltd. Characteristics of the ChNF according to the brochure of the manufacturer are as follows: the average fiber diameter, 10–50 nm; degree of polymerization of chitin, 300; viscosity, 3000 mPas (25°C). The PVP sample was purchased from Nacalai Tesque, Inc.; its nominal weight-average molecular weight was 360,000. Gly and other reagents were obtained from Wako Pure Chemical Industries and used without further purification.

2.2 Preparation of composites

Binary and ternary composite sheets containing ChNF, PVP, and Gly were prepared from the aqueous mixture of ChNF suspension and the other ingredient solutions. As an example, the procedure for ternary composites is mentioned below: 3-wt% aqueous solutions of PVP and Gly were prepared separately and mixed with the 2-wt% suspension of ChNF in the prescribed proportions. After stirring for 24 h at 25°C, each mixture was poured into a Teflon tray, and a composite sheet was prepared by gentle solvent evaporation at 60 °C and

~450 mmHg and successive vacuum drying at 40 °C for ≥ 48 h. The samples were coded as follows: a code ChNF/PM-10/90(75/25) denotes the composite combined with 10-wt% ChNF and 90-wt% PM composed of PVP/Gly = 75/25 (wt/wt).

2.3 Thermal processing

Film specimens ca. 0.2-mm thick were prepared by hot-press molding (120–160°C, 30 MPa) of the cast composite samples. Each of the thermally-molded film strips was fixed onto a hand-cranked drawing device placed in a thermo-regulated oil bath. The film was then uniaxially stretched to the desired draw ratio at a temperature of $T_g + 30^\circ\text{C}$ (T_g was determined by DMA measurements). The deformation rate was 9 mm/min. After the drawing process, the film specimens were quickly cooled to 20°C.

On the other hand, rotating extrusion was performed as follows. The as-cast composite samples were milled with a Wonder Blender WB-1 (Osaka Chemical Co., Ltd.). The pulverized samples were fed to a compact single-screw extruder (Imoto, Co. Ltd.) of L/D = 20. Extrusion was conducted at 40–60 rpm and 110–150°C.

2.4 Measurements

DSC was carried out using a DSC7020 (Hitachi High-Technologies Corporation) with the following ordinary procedure. The samples (5 mg) were heated from 30°C to 200°C at a heating rate of 20°C/min and maintained at 200°C for 1 min. The samples were then rapidly cooled (at $\sim 70^\circ\text{C}/\text{min}$) to 0°C. Subsequently, the samples were again heated to 300°C at a heating rate of 20°C/min.

DMA measurements were conducted by using a TA Instrument Q800 apparatus for the film specimens. Strips of rectangular shape ($30 \times 5 \text{ mm}^2$) cut from the film specimens were used for measurements of the temperature dependence of the dynamic storage modulus (E') and loss modulus (E''). The measuring conditions were as follows: temperature range, -100–200°C; scanning rate, 2°C/min; oscillatory frequency, 1 Hz.

Birefringences (Δn) of drawn polymer films were measured at 20 °C using an Olympus CX60 polarized optical microscope with a Berek compensator. Δn is defined as the difference, $\Delta n = n_{\parallel} - n_{\perp}$, between the refractive indices parallel ($n_{\parallel}$) and perpendicular ($n_{\perp}$) to the draw direction.

WAXD fiber pattern measurements were made at 20 °C using a Rigaku FR-E SuperBright diffractometer. The radiation source was Ni-filtered $\text{CuK}\alpha$ (wavelength, 0.154 nm) operated at 45 kV and 45 mA. Collimator size, camera distance, and exposure time were 0.50 mm, 150 mm, and 1830 s, respectively.

3. Results and Discussion

Fig.1a displays selected data of DSC thermograms obtained for a series of PVP/Gly composites. In the DSC curve of PVP alone, a clear baseline gap reflecting the glass transition is observable. As shown in Fig. 1a, a series of PVP/Gly blends gave rise to an

appreciable degree of dropping in the PVP T_g , indicating a plasticization of PVP by mixing with Gly. However, the glass transition of Gly ingredient was observed for the combinations of ≥ 40 wt% of Gly at almost the same positions for the unblended Gly. From these results, we judged that the pair of PVP/Gly is partially miscible; the PVP-rich combinations (≥ 70 -wt% PVP) are miscible pairs.

With regard to the binary systems containing ChNF, it was of particular interest to estimate how the thermal transitions of PVP and Gly varied with the composition, since the chitinous material showed no significant transition in the temperature range of the DSC scan. The results of the measurements are shown in Fig. 1b and 1c. In the composites of ChNF/PVP, the T_g of the PVP component tended to shift to the higher temperature side as the ChNF-contents increased. There is a broadening of the width of the transition for the composites containing ≥ 40 -wt% ChNF. The results may allow us to consider this binary system to be in a more-or-less compatibility state probably due to a formation of hydrogen bonds between C=O of PVP and O-H of ChNF. However, the other binary composite ChNF/Gly exhibited rather lower T_g than that of the Gly *per se*, which indicates a poor inter-component interaction between ChNF and Gly.

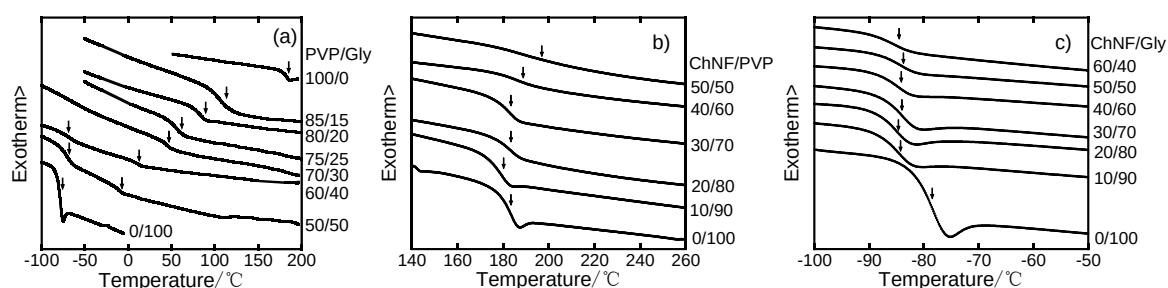


Fig. 1. DSC thermograms (second heating scan) obtained for binary systems of (a) PVP/Gly, (b) ChNF/PVP, and (c) ChNF/Gly. Arrows indicate T_g positions

For the ternary system ChNF/PVP/Gly, in other naming, ChNF/PM, since the molecular mobility of PVP is improved by the addition of Gly, we can easily recognize the effect of the ChNF addition on the PM (PVP/Gly) phase structure. As shown in Fig. 2, the T_g position of the ternary system containing 25-wt% ChNF shifted to the higher temperature side in comparison with those for the PVP/Gly binary system (Fig. 1a). This means that the ChNF component prevents the molecular motion of the PVP constituent plasticized with Gly, by an intimate mixing and inter-component interaction. The observed composition-dependent T_g shift also indicates a good dispersibility of ChNF in the PM.

In order to clarify the interaction state, the T_g variation were plotted against the PM composition. Fig.3 illustrates the T_g variation as a function of (a) PVP concentration (vol%) in the PM and (b) molar ratio of carbonyl (PVP) and hydroxyl (Gly) groups. These two series of plots clearly shows that the T_g increased with increasing PVP content in the PM for all of the systems. As shown in Fig. 3a, when the PVP component occupied over about half of the PM in volume, a clear T_g of the Gly can be observed. With regard to the stoichiometric

ratio of the functional groups, C=O of PVP and O-H of Gly, Fig. 3b indicates that the excess quantity of the hydroxyl groups gave rise to a phase separation. This is because for the Gly-rich compositions, the excess amount of O-H could not be consumed by forming the hydrogen bondings with the C=O of PVP. On the other hand, for the ChNF-containing systems, with an increase in the ChNF concentration, the T_g increased but the T_g -increase was not remarkable for the PVP-rich compositions, which may be due to less plasticization for these compositions.

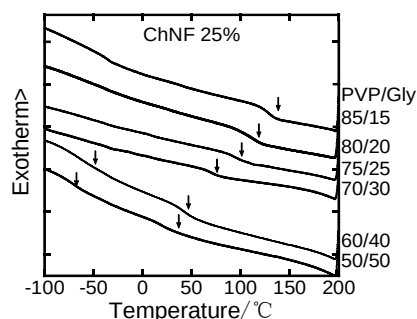


Figure2. DSC thermograms (second heating scan) obtained for the ternary system of ChNF/PVP/Gly containing 25-wt% ChNF. Arrows indicate T_g positions

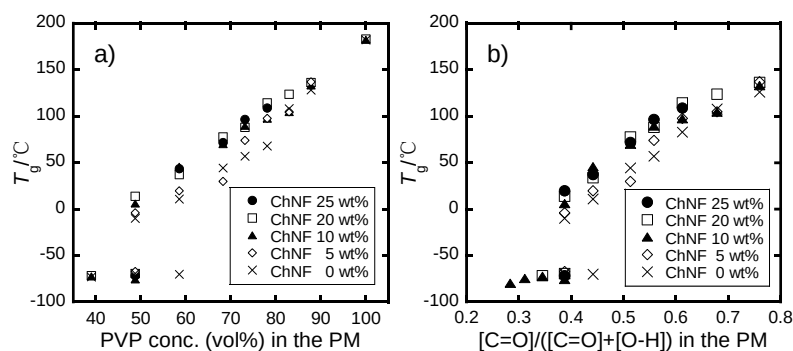


Figure 3. Plots of T_g vs. (a) PVP concentration (vol%) and (b) molar ratio of carbonyl (PVP) and hydroxyl (Gly) groups.

Through the use of DMA, an assessment of the mechanical properties is facilitated at wide-ranging temperatures. Via DMA, three parameters are obtained as a function of temperature: the storage modulus (E'), loss modulus (E''), and loss tangent ($\tan \delta$). $\tan \delta$ is defined as the ratio of E''/E' : if $\tan \delta < 1$ then elasticity dominates, whereas viscosity does for $\tan \delta > 1$. In the T_g region, a maximum appears in each of the E'' and $\tan \delta$ versus temperature, while there is a decrease in the E' due to loss in stiffness, so that the plot of E' versus temperature reveals a drop. These parameters are sensitive to many processes, including structural homogeneities and molecular motions, thus changes in the immediate environment of a given polymer chain caused by intimate mixing can be recognized from changes in location of the E'' and $\tan \delta$ maxima.

Fig. 4 shows the temperature dependence of E' and $\tan \delta$ for a PM (PVP/Gly = 70/30) containing 0, 10, 20, and 25 wt% of ChNF. The binary PVP/Gly film exhibited a primary dispersion peak centering 68°C in the $\tan \delta$ versus temperature curve; this dispersion can be associated with the glass transition of the PM sample. We call the peak temperature as $T_{g, \text{DMA}}$ conveniently. The peak is situated at a temperature higher than T_g (44°C) determined by DSC, indicating that the two analytical tests responded somewhat differently to the same relaxation process (Macknight et al., 1978). With regard to the reference PM, an important observation is the rapid and intense fall of E' in the glass transition region (Fig. 4a), reflecting the activity in micro-Brownian motion of the polymer chains, enhanced more and more with elevating temperature after onset of the transition on heating.

Fig. 4b illustrates that the respective $\tan \delta$ curves for the ChNF-containing composites produce a peak maximum at a temperature of 75–95°C. Another significant change in the thermodynamical property of the PM invited by the incorporation of ChNF component can be seen in the E' data for the composites. First, the moduli of the composites containing ChNF were always higher than that of the PM. Second, the locking-in of ChNF led to a drastic suppression of the E' -drop in the glass transition region, in contrast to the rapid declining behavior of the PM (no ChNF). Degree of the suppression was remarkable for the composite with a higher ChNF content, 20 wt% of ChNF. Similar decrease in $\tan \delta$ maximum was observed for the ChNF composites. A slight deviation in the order of E' -drop and lowering $\tan \delta$ maximum against the ChNF content was observed for the 25-wt% nanofiber composite, which may be attributable to a tightened network formation of ChNF in the composite and diminished intercomponent interaction between the nanofiber and PM.

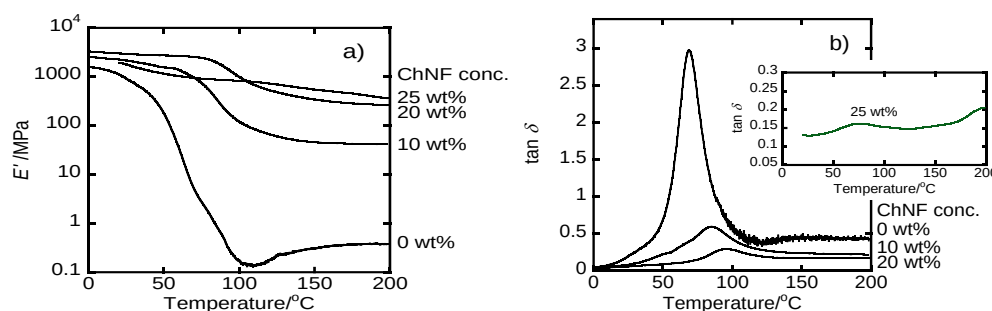


Figure 4. Temperature dependence of (a) E' and (b) $\tan \delta$ for the composites containing the PM of PVP/Gly = 70/30, measured at 1 Hz.

Actually, a composite of ChNF/PM-10/90(75/25) could be processed using a single-screw extruder. The extruded strings are shown in Fig. 5. The extrusion process was conducted at 40–60 rpm and 150°C. However, the ChNF content was restricted to be ≤ 10 wt% for successful extrusion and no birefringence was observed for the processed samples.

On the other hand, the as-cast films containing ChNF were favorably stretched uniaxially at a temperature of $T_{g, \text{DMA}} + 30^\circ\text{C}$. Fig. 5 exemplifies visual appearances of as-cast and stretched films of ChNF/PM-10/90(70/30). Optical birefringence (Δn) derives from the orientation of ChNF with inherent anisotropic polarizability. As illustrated in Fig. 6, the PM-

70/30 shows negative Δn . For the ChNF-containing composites, the inherently negative Δn was intensified by the preferential orientation optically negative ChNF.

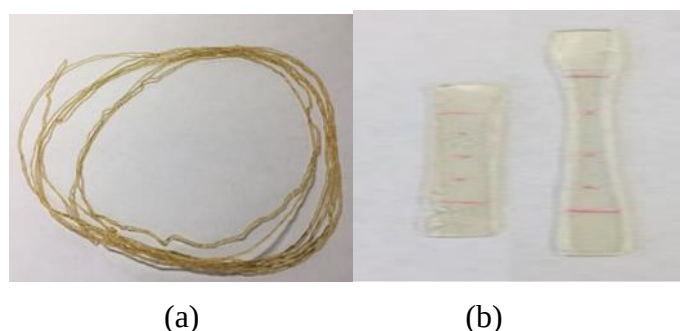


Figure 5. Visual appearances of (a) the ChNF/PM-10/90(75/25) strings extruded with a single-screw extruder at 150°C and (b, left) as-cast and (b, right) stretched (at $T_{g,DMA} + 30^\circ\text{C}$) films of ChNF/PM-10/90(70/30)

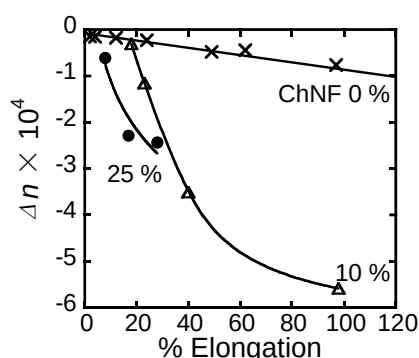


Figure 6. Plots of Δn vs. % elongation for the composites containing PM of PVP/Gly = 70/30 in weight.

Fig. 7 presents a X-ray fiber diffraction pattern of a drawn (% elongation, 100) film of ChNF/PM-10/90(70/30). The drawn film exhibits equatorial arcs mainly due to the (020) and (110) planes of α -chitin crystallite. To evaluate the degree of orientation, we calculated the orientation index f_c of the main chain by azimuthal breadth analysis (Fig. 7b):

$$f_c = (180^\circ - \beta_c)/180^\circ \quad (1)$$

where β_c was determined from the azimuthal half-width of the (110) diffraction. The f_c value was determined to be 0.61. We thus successfully accomplished to fabricate the composite of ChNF uniaxially oriented in a considerable degree, by thermally stretching its films combined with the PM.

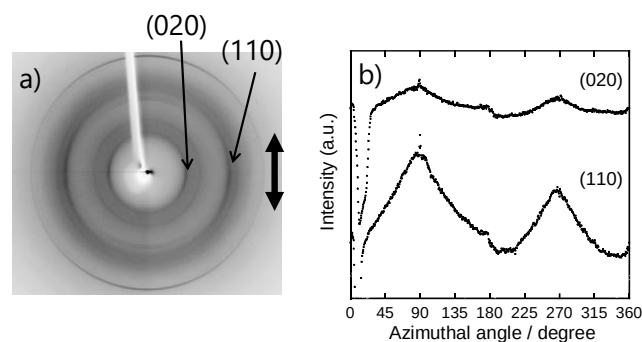


Figure 7. (a) X-ray fiber pattern for a stretched (% elongation, 100) film of ChNF/PM-10/90(70/30), together with (b) azimuthal intensity profiles of the (020) and (110) diffractions of ChNF. A double-headed arrow in (a) indicates the draw direction

4. Conclusions

We succeeded in fabricating thermally-processable materials based on ChNF via embedding in PVP matrix plasticized with Gly, which enabled to apply a uniaxially orientation by thermal drawing. The important thing for this achievement was a good dispersion state and inter-component interaction to some extent for the combinations of ChNF and PM. Such a composing situation allowed us to apply a considerable stress to the composite films and preferential orientation of the ChNF constituent.

Acknowledgements

This work was financially supported by Grant-in-Aids (KAKENHI) for Exploratory Research (26620178) and Young Scientists (A) (26712016) from the Japan Society for the Promotion of Science (JSPS) and Environment Research and Technology Development Fund (3K153010) of the Ministry of the Environment, Japan.

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Anatomical Features and Fiber Characteristics of Two and Five Year-old Platinum Teak Wood

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Abstract

Teak wood (*Tectona grandis* L.f.) is one of the popular woods in Indonesia. Unfortunately, it has a long-rotation and trees harvested after 60 years of growth, hence this become a problem insatisfying the increasing demand from the market. Recently, LIPI has developed Platinum Teak-a fast-growing teak wood-by tissue culture method. It was expected to reduce the harvesting time. Due to limited information of the wood quality, the objective of this study is to investigate the basic properties, especially for anatomical features and fiber properties. Platinum Teak wood, which were obtained from Cibinong Science Center with the age is 2 and 5 years, were used in this study. Fiber characteristic, macroscopic and microscopic features were observed in this study. The results showed that Platinum Teak has similar anatomical features with conventional Teak wood. It has semi ring porous and growth ring boundaries. Heartwood and sapwood was clear, and tyloses also founded in the 5 years-old of Platinum Teak wood. Both of Platinum Teak woods were consists of juvenile wood and the trend of the fiber length was increased from the pith to the bark.

Keywords: anatomical features, fiber characteristic, platinum teak wood.

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1. Introduction

Teak wood is one of the popular woods in Indonesia. It has not only high strength and durability but also a beautiful pattern (Martawijaya et al., 1989; Soerianegara & Lemmens, 1994). Unfortunately, this wood has a long rotation which is time to harvest approximately 60 years. Therefore, stock of Teak wood from the forest is limited and its price is more expensive than others wood. Many efforts have been conducted to solve this problem, make shorter the cultivation time and shorten the rotation of this wood. In addition, some researcher has been investigated to increase the utilization of plant genetic engineering with tissue culture for fulfill the demands of Teak wood.

Utilization and development of this technique has been increasing recently which was produced clones which growth rapidly and similar properties to their parent trees (Hendaryono & Wijayani, 1994). LIPI has developed Platinum Teak through this method (Suara Pembaruan, 2011). Unfortunately, Platinum Teak wood has limited

information about its basic properties due to the new Teak wood species. Other problem is similarities properties to their parent also unknown. Generally, knowing character of the wood can be using identification technique through its anatomical features. It is very important for wood distinguishing features. It could be used also to know similarities between clone and its parent. Hence, the objective of this study is to investigate the basic properties of this wood, i.e. anatomical features and fiber properties.

2. Materials and Methods

This study used Platinum Teak wood which obtained from Cibinong Science Center with the age is 2 and 5 years-old. Fiber characteristic, macroscopic and microscopic features were observed in this study. Fiber dimension and derived values were determined using maceration by Franklin's method (Dodd, 1986; Silitonga et al., 1972). Parameters for macroscopic feature were color, grain, texture, etc (Mandang & Pandit, 2002). The anatomical features, which were observed and reported, referred to the International Association of Wood Anatomist (IAWA) standard (Wheeler et al., 1989). As a comparison, 10 years-old Teak wood from community forest and some conventional Teak wood from Bogor (samples were prepared from FORDA, Ministry of Forestry, Indonesia) were also investigated in this study.

The quantitative characteristics of microscopic structure were determined for 10 – 25 times per samples, which depended on the variation of: (1) Vessel diameter, $n = 25$; (2) vessel frequency per mm^2 , $n = 10$; (3) rays frequency, $n = 10$; (4) rays height, $n = 25$; (5) fiber length, $n = 25$; (6) fibers diameter and cell wall thickness, $n = 15$ respectively (Silitonga et al., 1972).

3. Results and Discussion

Figure 1 shows anatomical features of Platinum Teak wood, Teak wood from community forest, and conventional Teak wood.

Anatomical features of Platinum Teak wood were not significant difference with the conventional Teak (Martawijaya et al., 1989), both for macroscopic and microscopic features, as well as Teak from community forest. General feature like growth ring boundaries were distinct. Early and late wood cell were clear different, and there were also marginal parenchyma (terminal/initial). Heartwood and sapwood were clearly in the Platinum Teak (5 years-old), and the proportion of heartwood was higher than Teakwood from community forest. It has specific smell also in Platinum Teak (5 years-old) and there were tyloses in the vessel cell. Vessel cell: semi ring porous, solitary, simple perforation plates, inter vessel pit alternate. Vessel diameter about $136.16 \mu\text{m}$ ($98.88\text{--}161.43 \mu\text{m}$) and $12 \text{ per } \text{mm}^2$ for 2 years-old Platinum Teak, $132.48 \mu\text{m}$ ($102.71\text{--}198.58 \mu\text{m}$) and $12 \text{ per } \text{mm}^2$ for 5 years-old Platinum Teak, $165.85 \mu\text{m}$ ($124.59\text{--}233.44 \mu\text{m}$) and $11 \text{ per } \text{mm}^2$ for Teak (com. forest), $153.95 \mu\text{m}$ ($126.9\text{--}182.89 \mu\text{m}$) and $6 \text{ per } \text{mm}^2$ for Conventional Teak. Rays: 4-10 seriate for 5 Platinum

Teak and Conventional Teak, and 1-3 seriate for 2 years-old Platinum Teak and Teak wood (community forest).

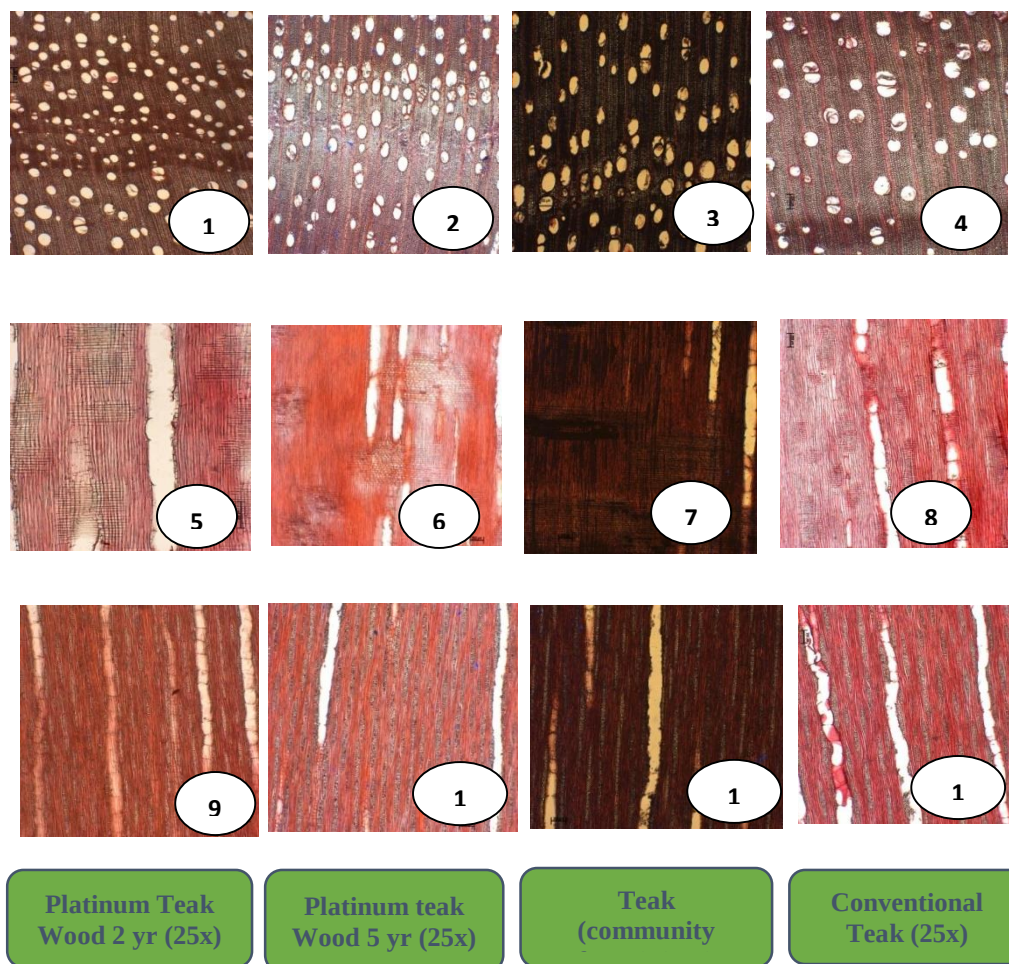


Figure 1. Anatomical properties of Teak wood (No. 1-4 = cross section of Teak wood; No. 5-8 = radial section of Teak wood; No. 9-12 = tangential section of Teak wood)

Rays: width (w), height (h)

- ❑ 2 years-old Platinum Teak (w 24.32-46.26 μm , h 236.13-786.24 μm)
- ❑ 5 years-old Platinum Teak (w 51.42-67.62 μm , h 347.7256-971.207 μm)
- ❑ Teak Wood (com. for.) (w 35.14-57.88 μm , h 413.52-981.62 μm)
- ❑ Conventional Teak Wood (w 35.14-64.86 μm , h 252.28-785.12 μm)

Figure 2 shows macroscopic features of Platinum Teak wood. The figures show that there were tyloses in the vessel of Platinum teak wood.

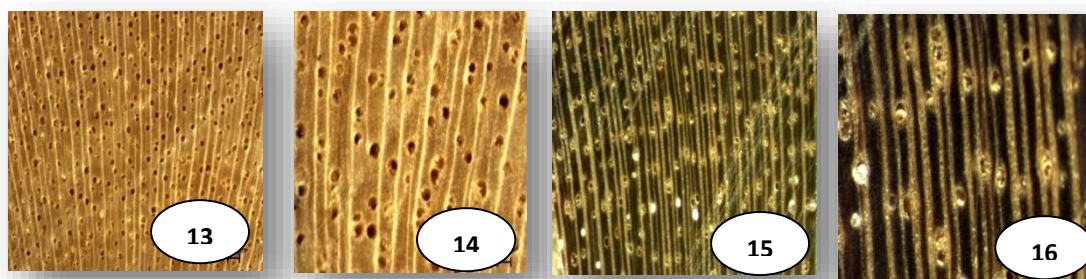


Figure 2. Macroscopic properties of Platinum Teak wood (No. 13-14 = 2 year-old Platinum Teak wood; No. 15-16 = 5 year-old Platinum Teak wood)

Figure 3 and 4 show that fiber length increased from pith to the bark. It was indicates that both Platinum Teak wood consist of juvenile wood. Juvenile cell is cell that formed in the early of the growth (Panshin& de Zeeuw, 1980; Bowyer et al.,2003). These cells were unstable, thin, and short. Since many properties of wood were affected by cell ages, Platinum Teak wood may has low of dimensional stability.

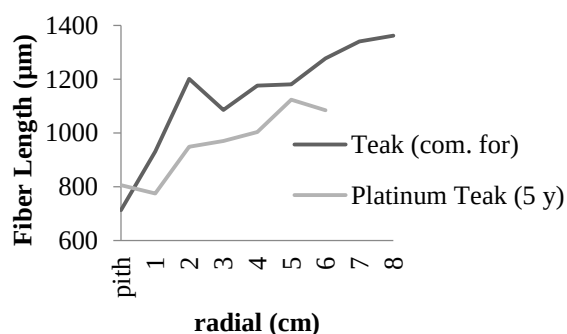


Figure 3. Fiber length of 5 y Platinum and Community forest Teak

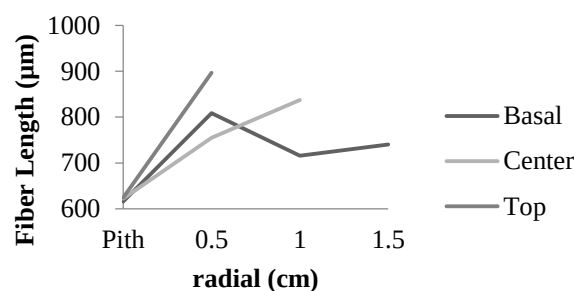


Figure 4. Fiber length of 2 y Platinum Teak wood

4. Conclusions

Anatomical features were needed to identify the character of the wood. The result showed that there were not significant difference in the term of macroscopic and microscopic features from Platinum Teak compare with other Teak wood, i.e. from community forest and conventional wood, as well. Increasing fiber length from the pith to the bark indicates that the woods were consists of Juvenile wood.

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The Substitution Effects of Oil Palm Shell Charcoal, Coconut Fiber and Oil Palm Empty Fruit Bunch Fiber on Physical and Mechanical Properties of Composite for Railway Brake Blocks

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Abstract

Research on development of composite for railway brake blocks with natural resources substitution have already done. Charcoal from oil palm shell with carbonization temperature of 800°C used as friction modifier, whereas coconut fiber and empty fruit bunched fiber used as reinforcement material. Composites were formed into 100mm x 30mm x 15mm mold (length x width x thickness). The composition of composites consisted from aluminium oxide, oil palm shell charcoal, barium sulphate, phenolic resin, calcium hydroxide, nitrile butadiene rubber (NBR), ferrum, and coconut fiber / empty fruit bunched by weight percentage, respectively for 10%, 25%, 16.75%, 14.75%, 12.5%, 5%, 14%, and 2%. All materials made in powder form with a size of 40 mesh to 60 mesh. The manufacture of railway brake blocks were divided into two stages. First stage by mixing all the forming materials, except natural fiber. After being mixed uniformly, fibers placed into the mixer and stirred for 10 minutes. Samples were placed into the mold and pressure given with heated to 200°C. Samples were removed from the mold and experienced by post-curing process, which was still receiving heat without pressure. Samples were conditioned at room temperature for 7 days then tested for physical and mechanical properties using PT Kereta Api Indonesia (KAI) specifications techniques for railway brake blocks T 358 N type. Composites brake block from oil palm shell charcoal and empty fruit bunched fiber are slightly better than composite brake blocks from oil palm shell charcoal and coconut coir fibers.

Keywords: Coconut fiber, Empty fruit bunched, Oil palm shell charcoal, Physical and mechanical properties, Train brake blocks

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1. Introduction

In the development countries such as Indonesia, train were the main option of public mass transportation. Train transportation was an efficientest transportation moda, reduce the fuel usage, minimalize the traffic jump, improve the efficiency of time and power and thus increase the work productivity. In 2011, 1.92 millions passengers use train as public transportation, and 19 tons of goods can be brought by the train. PT Kereta Api Indonesia (KAI) as the regulatory Trains government had 486 of locomotive units, 1,716 unit of passenger carriage and 6,249 units of goods carriage in 2012. The much amount of trains formation require brake block unit in huge number. Beside that, the limitation of time usage increase the usage of brake blok units every years.

Annually, PT. KAI require 448,000 brake block units for maintanin the trains operation. Requirement of brake blocks unit were fullfilled by imported scheme and just in a few number supported by domestic producion. PT. KAI had also replace the metallic brake blocks with the composite brake block units. Lighter weight, higher in wearnes number, and easier in maintenance make the composite brake block units more benefit compare than the metallic brake blocks units.

The development of the use of composites is also motivated by the desire to increase product performance and competition in the global market for lightweight components. Among all materials, composites have the potential to replace the use of steel and aluminum has been used widely with better quality. The composite material can replace steel to save 60-80% based on weight, and replace aluminum component about 20-50% based on weight (Jones, 1999).

Generally, composite materials formed by reinforcement fibers (fibers) in the resin matrix. Reinforcing materials may include fibers, particles (particulate) and whisker material can be polymers, ceramics and metals, while the binder or matrix material can be include metals, plastics and ceramics. Fiber amplifier produces strength and stiffness to the composite, while the matrix confers resistance to the environment (Mazumdar & Sanjay, 2002).

Along with the development of science and technology and the rapid growth of the industry, impacting on degradation of environmental quality. Therefore, studies are being developed in the world is more directed to research of environmentally friendly materials to the green sciences and green technology. Natural fiber is a material widely used in composites research-based natural materials, or better known as the biocomposites.

In the composite brake blocks, constituent materials used in accordance with its function, which consists of a function as a binder, filler, reinforcement, and a friction modifier. Binder or matrix used to bind the composition of the material in composite brakes, filler used to keep the overall composition friction material, reduce production costs and improve the properties able to create (manufacturability) composite brakes. Reinforcement could improve the mechanical properties of materials (compressive strength, shear and bending), and friction modifier is used to determine the nature of brake friction material, consisting of lubricant and abrasive material (Yun et al., 2010).

Based on constituent functions of composite brake blocks, natural fibers from oil palm empty fruit bunches (EFB) and coconut coir fiber, as well as coconut shell charcoal and palm oil shell charcoal has a chance to be used in composite brake blocks. Besides the great potential in Indonesia, TKKS fiber and coconut fiber can be used as filler, and coconut shell charcoal and oil palm shell charcoal can be used as friction modifier (Alam, 2012).

The objectives of this study is to know the substitution effect of oil palm shell charcoal, coconut fiber and empty fruit bunched fiber for physical and mechanical properties of composite for railway brake blocks.

2. Materials and Methods

The organic materials were used alumina (Al_2O_3), black graphites, barium sulfate (BaSO_4), phenolic resin, calcium hydroxide ($\text{Ca}(\text{OH})_2$), iron powder (ferrum), and nitrile butadiene rubber (NBR). For substitute the graphite were used coconut shell and Oil palm shell charcoal and, substitute the synthetic fiber were used coconut fiber and oil palm fruit branch. The material composition was presented on Table 1.

Table 1 Materials composition of composite brake block unit

No.	Materials	Percentage (%)	The function
1	Alumunium Oksida (Al_2O_3)	10.00	Abrasive
2	Graphite / coconut shell charcoal/ oil palm shell charcoal	25.00	Friction modifier
3	Barium Sulfate (BaSO_4)	16.75	Filler
4	Phenolic resin	14.75	Binder
5	Calcium Hydroxide ($\text{Ca}(\text{OH})_2$)	12.50	Filler
6	Nitrile butadiene rubber (NBR)	5.00	Filler
7	Iron powder	14.00	Filler
8	Coconut fiber/ oil palm fruit branch fiber	2.00	Reinforcement
Total		100.00	

Then, all composition of materials were mixed about 15 minutes with mechanical mixer and molded at the temperature of 250°C for 1 hour. The specimen from the mold was cut for density measurement, flexural, weariness, hardness and shear test.

3. Results and Discussion

All of the specimens were successfully tested. The specimens test include the physical and mechanical test. The Physically test such as measurement of materials density, and the mechanically test include compressed, flexural, weariness, hardness and shear test. The result of materials test was presented on Table 2.

Table 2. Physical and mechanical characteristic of brake blocks composite

Variable Composition	Density (g/cm ³)	Compressed Str. (N/cm ²)	MOR (N/cm ²)	Modulus Young (N/cm ²)	Wearness rate (mm ³ /Nm)	Hardness (HRR)
OP charcoal & coconut fiber	1.85	6,038	1,849	444,136	0.0935	101.39
OP charcoal & OP fiber	1.84	9,260	1,756	434,068	0.0215	108.33
Coconut charcoal & coconut fiber	1.81	6,847	1,152	442,453	0.0563	103.83
Coconut charcoal & OP fiber	1.78	5,851	1,730	356,746	0.0734	107.27
Graphite-coconut fiber	1.91	5,269	961	392,611	0.2268	94.33
Graphite & OP fiber	1.92	4,247	1,771	445,318	0.2894	100.78
PT. KAI spesification	1.8-2.4	>2,500	2,400-4,000	24,000-150,000	-	70-105

All of the samples fullfill the PT. KAI spesification for density standard (1.8-2.4 g/cm³), excepted for coconut charcoal-OP fiber (1.781 g/cm³). It caused by the lower density of coconut charcoal-OP fiber compare to coconut fiber-OP charcoal. Density measurement of the composite brake block with differs composition was shown in Fig.1.

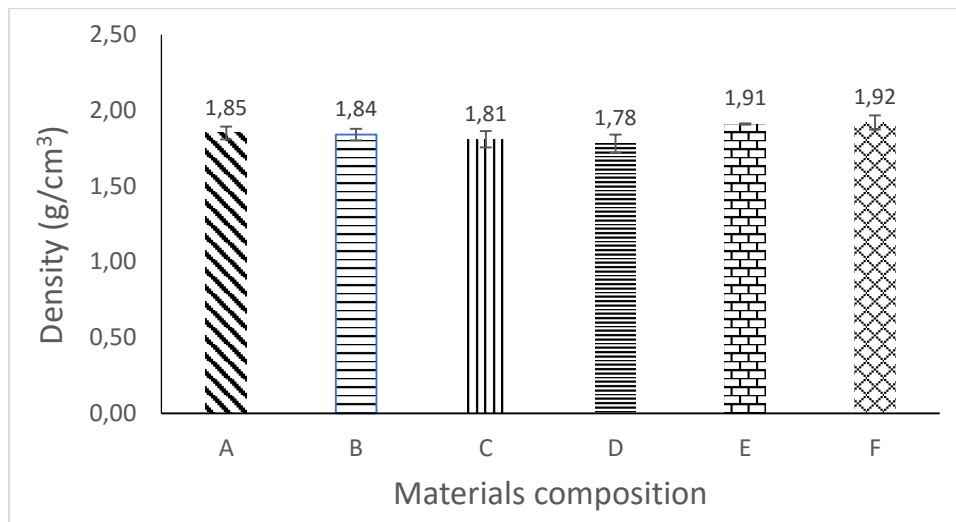


Figure 1. Density of composite brake block with different composition

With ;

A : combination of OP charcoal- Coconut fiber

B : combination of OP charcoal-OP fiber

C : combination of coconut charcoal- Coconut fiber

D : combination of coconut charcoal- OP fiber

E : combination of Graphyte- Coconut fiber

F : combination of Graphyte- OP fiber

From the Fig.1, all of samples have the similar density. The majority of composition have density more than 1.8 g/cm³, excepted the combination of coconut charcoal-OP fiber.

Value of all composition in compressed strength fulfill the PT. KAI specification (>2500 N/cm²). Result of the compressive strength was shown in the Table 3 below.

Table 3. Compressive strength of different brake block composition

Variable Composition	Compressed Strength. (N/cm ²)
OP charcoal & coconut fiber	6,038
OP charcoal & OP fiber	9,260
Coconut charcoal & coconut fiber	6,847
Coconut charcoal& OP fiber	5,851
Graphite-coconut fiber	5,269
Graphite & OP fiber	4,247
PT. KAI spesification	>2,500

From the table above, combination of OP charcoal and OP fiber has highest compressed strength value. It is more higher than graphite-OP fiber combination. Modulus of Rupture (MOR) of overall combination were not fullfill the PT. KAI standard (2400-4000 N/cm²). MOR for brake block train system can be increased by supporting backing plate on the brake block composite. The value of modulus of rupture on different composition was presented in Fig.2.

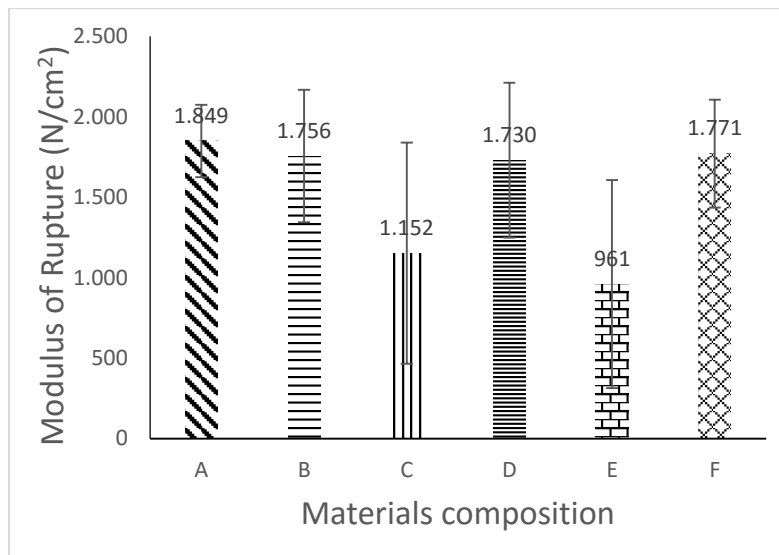


Figure 2. Modulus of rupture in different composition

Value of modulus elasticity on different composition was shown at Fig.3 below. Value MOE Composites of brake blocks upper than PT KAI specification (24,000-150,000 N/cm²). Therefore, mechanical characteristic of natural materials in composition of brake blocks could fullfill the PT. KAI standard.

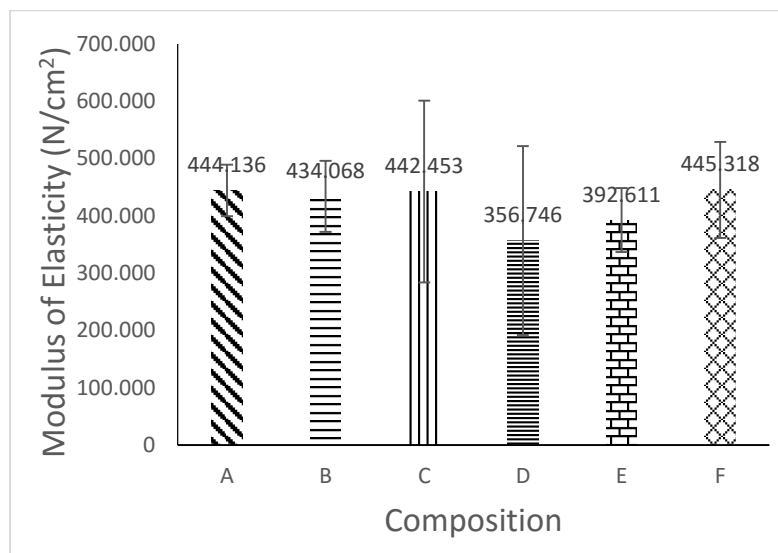


Figure 3. Modulus elasticity of different brake block composition

Wearness rate of different brake blocks composition was presented on Fig.4. Wearness rate show the durability of material holds specific load in the specific distance. As small wearness value so durable the materials. Composite with OP charcoal and OP fiber combination had the smallest wearness rate (0.0215 mm³/Nm). Therefore, it can be the best candidate for brake blocks materials.

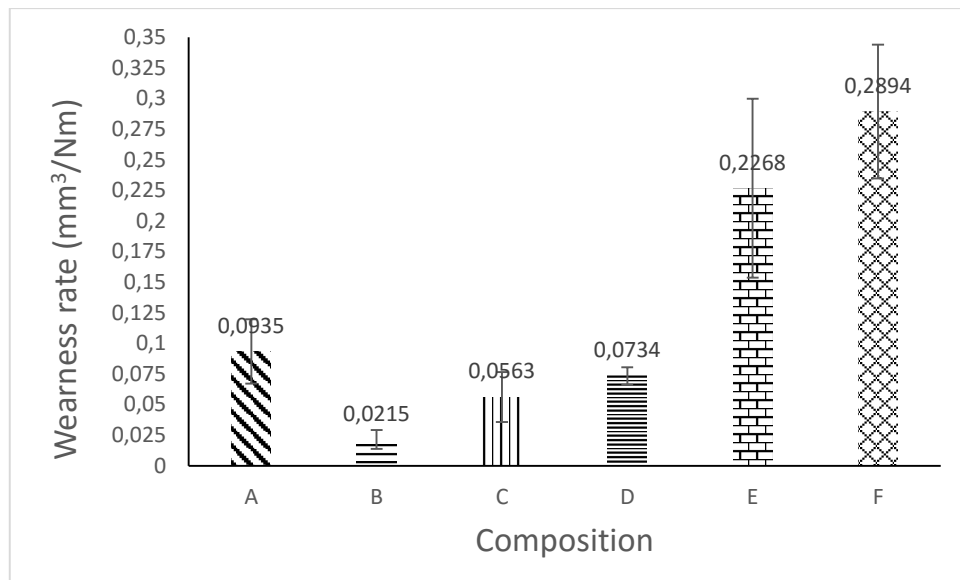


Figure 4. Wearness rate of different brake block composition

Hardness of materials could show the strength of materials to accept load. The result shows that all of the composition get the hardness value bigger than PT.KAI specification (75-105 HRR). The information of hardness value was presented in Fig.5.

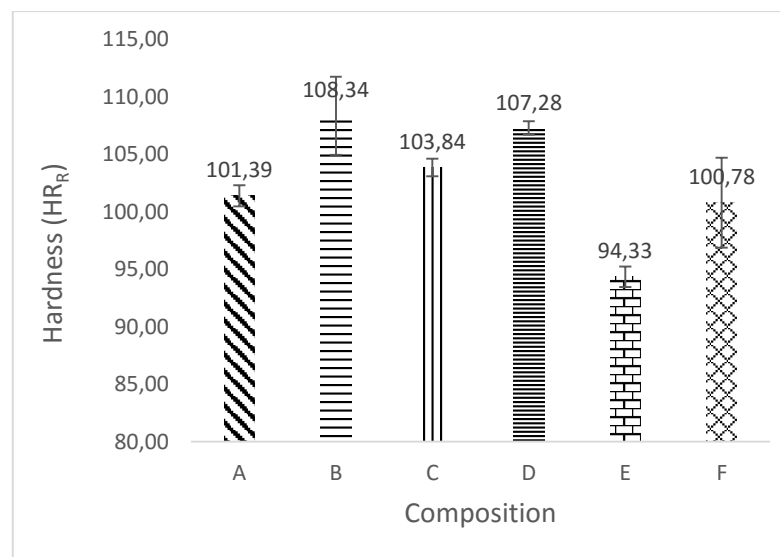


Figure 5. Hardness of different brake block composition

4. Conclusions

Natural resources is available to substitute the non-renewable resources in the manufacturing of composites brake block unit. Composites brake block from oil palm shell charcoal and empty fruit bunches fiber are slightly better than composite brake blocks from oil palm shell charcoal and coconut coir fibers.

Acknowledgment

The authors gratefully acknowledge support from the Sub Activities Advances Materials and Nano-technology, Competitive Program, Indonesian Institute of Sciences (LIPI).

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Identification of Actors in Rattan Industry Development in Ambon Island (Case Study in the Village of Suli, District Salahutu, Central Moluccas)

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Abstract

Indonesia is the world's largest producer of Rattan. Approximately 85% of rattan raw materials in the world is produced by Indonesia. Rattan industry development in Indonesia, especially in the central Molucas district still encounter various problems one of which is the role and interests of the various actors in the development of this industry. For that reason, this study aimed to identify the various actors involved and the role that the development of the rattan industry. The method used a case study, in which data collection was conducted through in-depth interviews and participant observation. The data were analyzed using theory Bryant and Bailey, 1997 and theory Principal Agent. The results showed that the various actors involved in the rattan industry such as: rattan traders/farmers, craftsmen, Rattan stores, Department of Forestry and Departement of industry Governments. Rattan industry is need: to increased awareness of the importance of the rattan sector for decisions-making in all levels, the introduction of an incentive scheme for rattan cultivation to increase the economic benefits for rural households and strengthening support for local collector organizations on methods for reducing post-harvest losses, enhance storage, and others according to the needs and the provision of comprehensive training and support for local specialists in rattan producing areas.

Keywords: actor, rattan, rattan industries

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1. Introduction

Rattan has long been known as a commodity of non-timber forest products which important and potentially in Indonesia. There are estimated around 4-5 million people are

involved in basic industries rattan (ITTO, 2007). Peluso explained that the rattan is Non-timber forest products and the forest-based small-scale enterprises (FBSSEs) which plays an important role for more than 100,000 people in Indonesia. The rattan industry activities provide employment opportunities for collectors, traders and the activity of the processing of non-timber forest products that have a low cost for the ecology of the forest (Jacobs, 1982 in Peluso, 1983). Small and medium industries, including rattan furniture industry is important for Indonesia because besides contributing to the state revenue also create jobs, and substitute imported goods with low price (Tambunan, 2006 in Parlinah, 2010).

The development of the rattan industry has various problems, among others, the unbalance condition of profit margins distribution occurs in the rattan value chain as an example in the Philippines, where the biggest benefit is from the industry (14.05 pesos / stem), and the smallest is from the organization of society and from the owners of harvesting permits (0.42 pesos / stem). While the rattan collectors earn 10.00 pesos / stem, where they acquire rattan in the forest so that the issued capital only in the form of labor and time (IRG, 2006), the same thing also seen at the situation of the rattan industry in Indonesia. The amount of the distribution of profits earned by each of the actors along the value chain, among others, determined by the form of principal relationship (grantor trust) -agent (receiver belief) that occur between actors in the chain. This happens because each actor wants to maximize profits earned. Nugroho (2003) in Parlinah (2010) suggests that the emergence of a mismatch of information between sellers and buyers result in partnerships vulnerable to opportunistic behavior. This condition will determine the institutional that occur in the value chain, so that will affect the competitiveness of rattan products in global trade.

Seeing the many actors along the chain of the rattan industry and the number of workers who depend on continuity of supply of raw materials, it is necessary to find and to develop policies that will push for an increase in planting rattan in the communities, the sustainability of the industry assured and remain sustainable forest. Research on the institutions in the rattan industry is very important, because it will greatly help create collective action of each actor so that various problems in the development of the rattan industry encountered can be resolved. Therefore, this study aims to outline the various actors involved in the rattan industry. Knowledge and understanding of it will be useful for the various parties involved in making the policy of the development of rattan industry management

2. Materials and Methods

The study was conducted in the village of Suli, Salahutu District, in the province of Moluccas. The village of Suli was chosen as the study site because of its location is the center of the rattan industry. This research uses the case study method, where data collection is done through in-depth interviews and participant observation. Interviews involve farmers as many as 2 respondents, rattan traders 3 respondents, craftsmen 15 respondents, rattan shopkeepers 8 respondents, Buyers 10 respondents, Maluku Provincial Forestry Office 1 respondent, the Department of Industry and Trade of the City of Ambon 1 respondent. Data

analysis was performed by actor oriented approach of the theory of Bryant & Bailey (1997) and the relationship of Principal-Agent.

3. Results and Discussion

3.1. Identification of actors and relationships that entwined

Bussiness of rattan at Suli involves many actors, both located in Suli and which is outside Suli. The actors involved include rattan farmers, traders from Suli and outside Suli, rattan craftsmen, owners/stores and buyers. Domestic stores in addition to acting as a buyer of semi-finished furniture from artisans, both these actors are also conducting finishing of its own furniture before the furniture is resold. The results showed that there are some ways of the craftman connect with buyers and suppliers of raw materials. Based on the flow of information of rattan orders, then the furniture production process can be categorized into (1) the production of rattan based on the buyers order and (2) the production of furniture is not based on orders. From both of these categories, which are occurred in Suli, is furniture production is not based on orders. For rattan furniture is made based on order from the domestic buyers, the orders can be derived from the retailer/store which is doing the finishing process itself, the retailer/store that is not doing the finishing process itself or directly orders from the final consumer. The actors involved are farmers, rattan traders from Suli and outside Suli, craftsman, and rattan shop. The Design and specifications of furniture made in accordance with the wishes of the buyer (buyer driven).

3.2 Farmers and rattan traders

Farmers do not have many options to whom will sell because of a relatively small number of rattan traders moreover the rattan farmers also act as merchants who sell directly to the craftsman. Farmers obtain information of rattan buyers from the farmers who ever sell rattan or buyers who come alone for looking rattan. The rattan sales by farmers as the principal to the rattan buyers/traders act as the agent is generally done in the form of raw rattan. The Clearance permits of rattan harvest are not enforced among farmers because the farmers harvest directly from their garden. The payment form from the buyers to the farmers generally is paid in cash. The selling price of rattan is average of Rp 1,500, - per stem with a diameter of between 3-3.5 cm. and to rattan with diameter of 5-6 cm at a price of USD 2000.- per stem. Although at the time the transaction occur a negotiation process, but the price of rattans determined by the principal/farmers. This is caused by the little amount of rattan farmers / traders in Ambon and natural conditions, especially climate (rainy season) which greatly affect the harvest process so that it is often in the rainy season, many craftsmen are difficult to get raw rattan material and the seizure occurs between traders.

3.3 Rattan traders with craftsmen

The rattan sales conducted in Suli usually craftsmen (agent) immediately come to the stock pile or the sales of rattan belonging to the merchant (principal). Craftsmen always establish communication with farmers or traders to obtain the necessary raw rattan. Purchasing rattan per stem can be done by way of self-selection and payment for

transport is borne by the buyer, as well as the cost of unloading rattan. Raw rattan in Suli came from the surrounding forest and from the village of Waai, and the village of Alang.

3.4 Craftsmen with domestic retailers or stores

The rattan yields in Suli more dominant marketed with the purpose of the domestic market, where craftsmen (agent) produce furniture with product specifications has been determined by the buyer (principal) or to make furniture with a common design. Payment by the buyer is given after the goods are shipped. Briefly, the relationships which occur between the actors in the rattan industry chain are presented in the following Table 1:

Table 1. Relationship between actors that occurred in the rattan industry

Person	Sales System	Payment System	Description
Farmer-Rattan traders	Raw rattan	Cash	
Rattan Traders- Craftsmen	Raw rattan	Cash	Transport costs borne by craftsmen
Craftsmen-Store	Rattan furniture per pcs or per set	Cash	Design according to the orders/ general, transport costs borne by the buyer

3.5 Government with farmers, craftsmen and shopkeepers

Rattan as non-timber forest products is not yet fully becomes an important concern to be developed by the government. Maluku people have not looked at the rattan as one of the natural resource that has potential so that it is often left in the forest unutilized. Rattan began utilized by the communities of Ambon mainly initiated by migrant communities, especially ethnic of Toraja. Rattan furniture industry center on the island of Ambon are managed by the ethnic of Toraja.

Rattan farmers on the island of Ambon do not cultivate rattan particularly, but tend to harvest from which has been available in their forest/Dusun. The Government has not specifically train the farmers to develop the cultivation of rattan. The role of government, especially the Department of Forestry of Moluccas Province limited to the identification of the villages that have the potential as a producer of rattan. 10 villages have been identified which have the potential of raw rattan is on the island of Ambon (Department of Forestry of Moluccas Province, 2014). Government in particular Department of Industry and Trade Moluccas Province has conducted mentoring programs for craftsmen and shop owners where the rattan processing technical training and had sent some craftsmen and shopkeepers for a comparative study to craftsmen in Java and Kalimantan.

3.6 Rattan industry institution in Maluku

The activity of the communities in the rattan industry in general is a part-time activity for collector farmers or housewife individually or in groups around industrial sites. The opportunity to engage in these activities, including the activities of rattan collection/harvest depending on the season and market needs in settlement of its areas. Another factor contributing to the activities of the collection of rattan among other property rights to the rattan (Dusung) and access to the rattan buyers, the need or desire to participate in the work group for the collection of rattan. This is in line with that expressed by (Dunn, 1975; Jessup & Peluso, 1986; Peluso, 1980 in Pelluso, 2000).

Although the community involvement in the rattan industry, including part-time or seasonal nature, especially for rattan gatherers and labor, this rattan industry still remains important for their livelihood. Biological properties of rattan where for a long time without need to be harvested would rapidly improve the yields in subsequent years. This gives the collector for not to cut when market prices are low, or when the opportunity to earn the income more profitable. When the other job opportunities become scarce and the reduced demand for other forest products the rattan roles still exist, and the pressure to collect becomes larger in the rural workers household economy which is unskilled.

The number of workers that involved in the rattan industry in Suli is varied according to the activities involved. For workers in the store are 2-5 people and the labor recruited for the craftsmen activity are 2-5 people/industrial location while the labor for cleaning the rattan are women (housewives) 5-20 person/craftsmen location. The housewives around the location craftsmen working as a cleaner of rattan with wage for small rattan are paid of Rp 250/stem and for big size of rattan will be paid of Rp 500/stem. The species of rattan which processed by craftsmen in Suli are Manau rattan (*Calamus manniq*), Batang air rattan (*Calamus ornatus warb*) and Tohiti rattan (*Calamus inospeblume*) and Bulu rusa rattan (*Daemonorops robusta Warburg*).

Labor wages in the furniture industry is enforced by implementing a payment system based on the price of design that agreed and the amount of product made. Supply of the good rattan quality can be guaranteed for the long term and the involvement of local people in this industry, as well as the offer of business loans from the government, especially the Department of Industry and trade into factors driving this business continues to grow.

However, some problems still faced by the rattan industry in Suli such as: a). The technologies of raw rattan processing: first, assuming the high quality rattan after cut where to maintain quality is very dependent on the weather. After cutting, the rain or immersion in river water repeatedly or for a certain period of time can cause discoloration and may also cause fungus to grow, that both reduce the quality and price of rattan. The quality of poor rattan can be identified by the presence powder post beetles, black water spots, uneven color, or rotten sections of the stem). Second, the use of machines processing raw rattan by craftsmen still using the simple equipment and have not use sophisticated machines yet as shown in the rattan business in other provinces. b). Needs to access capital by the government is still difficult to obtain because the perpetrators of these businesses is still

individually, and there is no attempt yet to cooperate in an institution that can group them for the opportunity to gain credit access where the government obliges credit access obtained by the business group instead of individuals. c). Skills/expertise of rattan craftsmen in this industry still requires training for the development of a product design as it has been owned by craftsmen in Java and other provinces.

The entrepreneur of rattan is currently looking for ways to get more and better quality of the rattan supply and are willing to experiment with rattan processing to further stages. Future expansion will be possible if the supply of good quality can be guaranteed for the long term, manufacturing skills can be taught to local people, and private or government incentives stimulate the establishment of processing centers in the province.

A non-timber forest product, especially rattan, has played an important role in the subsistence economy of households and traders for centuries in Indonesia. Unfortunately, rattan processing industry is still in the embryonic stage, and may not appear without changes in specific policies and practical program to encourage them (Pelluso, 2000). The profit obvious for developing the rattan processing industry in Maluku, is the potential offered to increase the income of rural communities traditionally that engaged in the tasks of initial collection and transportation of the rattan to become interior products. It is essential combined with a program to encourage the rattan plantation and not only utilize the yields of rattan that have been available in an existing forest, the right policy environment, and the improvement of rattan processing in rural areas in particular developing human resources and management organization.

4. Conclusions

Increased awareness of the importance of the rattan sector for decisions-making in all levels. Institutional strengthening and coordination regarding rattan conservation, management and processing issues, including the promotion of more government and private sector cooperation and coordination to enhance the contribution of rattan for poverty alleviation and economic prosperity. The introduction of an incentive scheme for rattan cultivation to increase the economic benefits for rural households, such as the provision of credit and technical assistance for the development of small-scale plantation and harvesting and marketing arrangements that benefit. Strengthening support for local collector organizations on methods for reducing post-harvest losses, enhance storage, and others according to the needs and the provision of comprehensive training and support for local specialists in rattan producing areas.

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Physical and Mechanical Properties of Bent Laminated Veneer Lumber (LVL)

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Abstract

Conventional manufacturing of wooden bent is inefficient in wood materials usage. Manufacturing of wooden bent with wood viscoelastic characterization can improve efficiency of wood usage. Unfortunately, the technique was not used proper yet due to limitation of the equipment, long time processing and problem in fixation setting. Usage of bent form component give mechanical benefit compare than the flat form. The mechanical and physical characteristic of bent LVL in different radius and veneer thickness were present in this article. Bent LVL were made by 25 and 35 cm in bent radius and 3 cm in thickness board. The veneer comes from Sengon wood (*Paraserianthes falcataria* (L) Nielsen) with ± 2 & 6 mm in thickness. The veneers were 0.27 g/cm³ in density at dry air condition and cut in longitudinal direction. Improvement of bent LVL was used cold press method with water based polymer isocyanate glue. Usage of isocyanate glue was 300 g/m² in two surface layer. The veneers were arranged in the bent mold and compressed for 24 hours, then conditioning in room temperature for 7 days. Moisture content, density, water absorption, thickness swelling, and fixation in the curve LVL were tested. The result shows that physical properties of 2 mm veneer has higher than 6mm (veneer thickness). Mechanical properties of bent LVL, which is made by 6mm veneer thickness, has higher bending stress from LVL which is made by 2mm in veneer thickness.

Keywords: Bent LVL, mechanical properties, physical properties, Sengon wood, veneer.

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1. Introduction

The bent wooden beam was majority used in the daily life. The conventional of bent wooden manufacturing was inefficient in wood materials usage. The special technique of wooden bent usage wood viscoelastic characterization can improve wood usage. Unfortunately, the technique was not used proper yet due to limitation of the equipment, long time processing and problem in fixation setting. Usage of curve form component give mechanically benefit compare than the flat form (Darmawan, 2006 & 2007).

Bent wooden manufacturing was made by arranged the veneer sheets one by one which is known as Laminated Veneer Lumber (LVL). LVL as engineered wood products (EWP) has higher qualification compare than solid wood. LVL can be produced end-less in length, physical and mechanical characteristic homogeneity, and more easier to curve (Bakar, 1996; Rosalita, 2008). Wood veneer was able bented in radius and thickness ratio within 29-70 (Stevens & Turner, 2005).

Improvement of bent LVL with cold press method can use water base polymer isocyanate glue. Characteristic of Isocyanate glue was reported by Yanto et al., (2005). Utilization of optimal glue can produce bent LVL, whic passed the JAS 1639/1986 standard (Darmawan, 2010). This article presented physical and mechanical characterization of bent LVL in different bent radius and veneers thickness.

2. Materials and Methods

Bent LVL were made by 25 and 35 cm in bent radius and 3 cm in thickness board. The veneer from Sengon wood (*Paraserianthes falcataria* (L) Nielsen) with ± 2 & 6 mm in veneer thickness. The veneers were 0.27 g/cm^3 in density at dry air condition and cut in longitudinal direction. Improvement of bent LVL used cold press method with water based polymer isocyanate glue for 300 g/m^2 in two surface layers. The veneers were arranged in the bent mold and compressed for 24 hours, then conditioning in room temperature for 7 days. Moisture content, density, water absorption, thickness swelling, and fixation in the bent LVL were tested. The code of tested specimen were arranged as below :

R35 and R25 show the targeted radius of bent LVL, which are 35 cm and 25 cm in targeted radius. Then, third numeric of the sample code show the thickness of the used veneer; which are 6 mm and 2 mm. Mechanical test was bending stress test with static load. Stresses estimation in curved beam based on Singer & Pytel (1995), Khurmi (2002), and Wallace illustrated on the Figure 1 below:

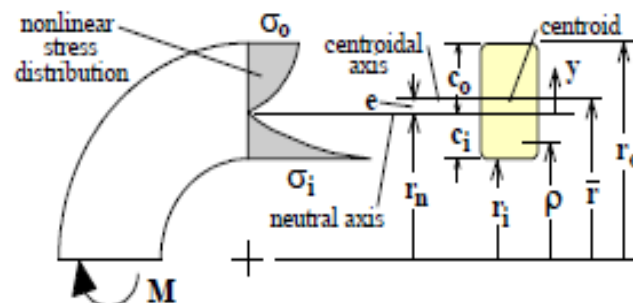


Figure 1. Schematic illustration of inner and outer stress on bent LVL.

From the Fig.1, inner stress and outer stress could be estimated based on the equation 1 and 2 below:

Inside position :

$$\sigma_i = \frac{M \cdot c_i}{e \cdot A \cdot r_i} \quad (1)$$

Which are;

- σ_i (Ti) : inner stress (kg/cm²)
- M : bending moment (kg.cm)
- C_i : distance between inner surface to neutral axis (cm)
- A : area of the beam cross section (cm²)
- r_i : giraffe radius inner surface section (cm)
- e : centroidal axis of the beam (cm)

Outside position :

$$\sigma_o = \frac{-M \cdot c_o}{e \cdot A \cdot r_o} \quad (2)$$

Which are;

- σ_o (To) : outer stress (kg/cm²)
- M : bending moment (kg.cm)
- C_o : distance between outer surface to neutral axis (cm)
- A : area of the beam cross section (cm²)
- r_o : giraffe radius outer surface section (cm)
- e : centroidal axis of the beam (cm)

Results and Discussion

3.1 Physical characteristic of bent LVL

The result of bent wood physical characteristic was shown in the Table 1. Overall bent LVL had water content that fullfill of SNI 01-6240-2000 standard which is below 14%. The thickness swelling point between JAS 2003 standard for LVL. The result from delamination test reported that the bent LVL did not show any fail for 2 and 6 mm in veneer thickness. Darmawan et al., (2009), reported that utilization of glue which is minimum 280 g/m² could produced good physical bent wood. Therefore utilization of 300 g/m² glue could make a good lamination.

Table 1. Physical characteristic of bent LVL

Code	MC (%)	Density (g/cm ³)	Water Absorption (%)	Thickness Swelling (%)	Delamination (%)
R35-6	11.19	0.31	76.94	1.52	(-)
R25-6	11.26	0.30	80.96	1.68	(-)
R35-2	10.16	0.36	64.24	1.58	(-)
R25-2	10.21	0.35	68.60	0.89	(-)

Sengon wood has light density and classified on fast growing wood species (Kikataet al., 2002; Rosalita, 2010). This wood had thin of cell wall and huge of void cell, therefore it is very sensitive to air humidity and water influences. Bent wood from thick veneer relatively had higher water absorption and thickness swelling than thin veneer. Utilization of thin veneer produced more lamination line in the thickness target than the thick veneer. Due to more lamination line, bent LVL from thin veneer had low water content, water absorption and high density. Each materials will back to basic form at the its elasticity stress limit. In manufacturing of bent LVL, glue was a main factor to make a bent form from veneer arrangement, which is prevent deformation to the initial form. Figure 2 shows fixation degree from bent LVL.

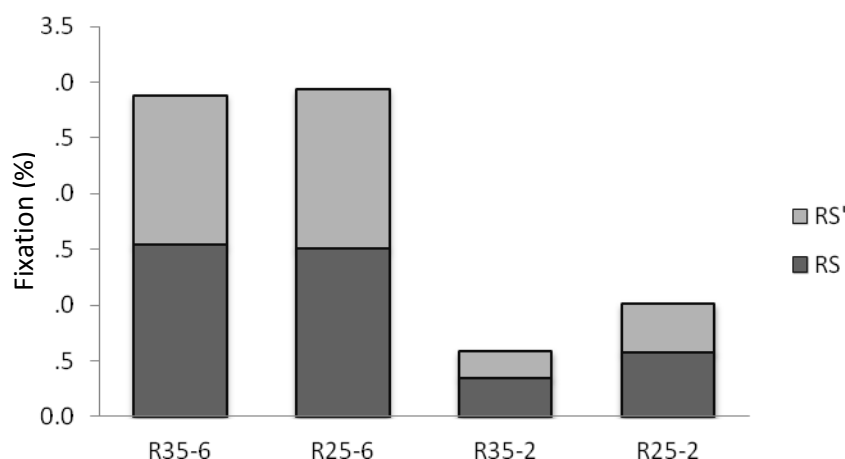


Figure 2. Bent LVL fixation.

The figure above explained that RS was recovery offset of the bent LVL radius spring back after been released from the mold. Then, RS' was recovery offset after soaking test. The value of RS was equal with the RS' value. The value of RS' and RS for one type bent LVL figuring the deviation of the targeted radius. It shows that transformation of radius fixation

was a function of bent length transformation. Spring back of bent LVL still occur after bent LVL was released from the mold. Bent LVL fixation value was influenced by veneer thickness and a tiny lamination line. Thicker veneer generate bigger spring back, so it has lower fixation transformation. Different bent radius was not so influence in the bent LVL with veneer 6 mm in thickness, otherwise usage of veneer 2 mm in thickness with bigger bent radius (R35) has better fixation rate.

3.2 Mechanical characteristic

Bending stress value of bent LVL was shown in the Fig. 3. The test result shows the highest bending stress of bent LVL with the 35 cm curve radius (R35) and 6 mm in veneer thickness (R35-6). The lower result was obtained at curved radius 25 cm and 2 mm in veneer thickness (R25-2). From the mechanical testing data, we could estimate the inner (Ti) and outer stress (To) with the equation 1 and 2 on bent LVL. At the outer side obtained lower stress compared than the inner side. Usage of bigger veneer in thickness (6 mm) produced higher bending stress.

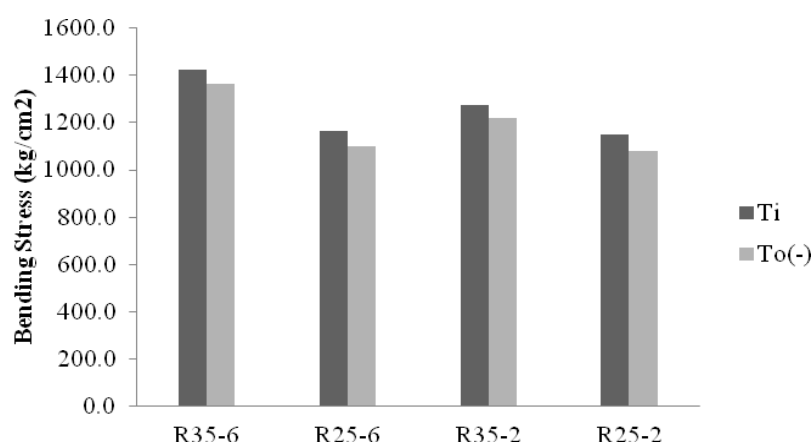


Figure 3. Bending stress of bent LVL ; Ti was inner stress and To was outer stress;

Lamination was one kind of joining technique from two or more component and the lamination line was a weaker point. Used fewer lamination line at thicker veneer could minimize the weaking zone. The MOR's value of plate Sengon LVL were presented in Fig. 4 below.

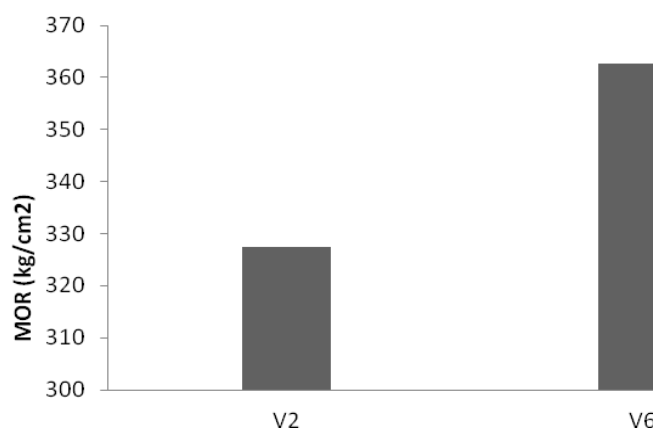


Figure 4. Modulus of Rupture of plate Sengon LVL.

From the figure above, MOR of Sengon LVL with 6 mm in thickness (V6) was higher than MOR of Sengon LVL with 2 mm in thickness (V2). Much number of glued lines made Sengon LVL more stronger. It could increase toughness and modulus elasticity of boards. Curved beam give the artistical value and better mechanically benefit compare the its flat form. Although bent LVL was made from a light density and low quality woods, could strong as wood beam from a heavy density and high quality woods in the flat form.

3. Conclusions

The physical properties of bent LVL such as moisture content, density, water absorption, thickness swelling, and fixation in the bent LVL, which the veneer thickness is 2 mm, were higher than 6 mm (veneer thickness). Mechanical properties such as bending stress of 6 mm in veneer thickness of bent LVL, were higher compared than 2mm in veneer thickness of bent LVL.

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Wood Materials in EcologyArchitecture

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Abstract

Due to the growth of the industry's development, such as oil and gas industry, agriculture and other non-oil sectors, this is also increasing the pollution level of water, air and land caused by their industrial development. To prevent this environmental pollution, it is very necessary to have an effort to control the environmental pollution by establishing ambient air quality standards, air emission quality standards, marine water quality standards, and so forth. The globalization requires a significant change in all areas, such as the timber industry with the demands of: (i) raw materials from the forest plantations, (ii) eco-labeling, (iii) non-waste materials, and (iv) wood industry integrated, and (v) must be environmentally friendly. Meanwhile, construction material products in the future are demanded to be more environmentally friendly. There are several considerations that apply the products are made made from recycled materials, products with formaldehyde emissions that can hold carbon longer by using chemicals that are non-destructive, and raw materials was unrelated to illegal trade.

Keywords: ecology architecture, globalization demands, materials

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1. Introduction

Ecological approach on designing architecture (eco-architecture) was not determining what supposed to happen in architecture, having nothing distinctive nature binding as a standard. It includes harmony between human and nature. Eco-architecture also containing dimensions of time, nature, socio-cultural, space and building engineering. To approach the problems of architectural design to the ecology concept, it means aimed at the management of land, water and air for the ecosystem sustainability. It also has effective of using our non-renewable natural resource (energy) with seeking alternative energy like sunlight, wind, water, and bio-energy.

The selected material must have efficiency energy, starting from the utilization as natural resources to come up with the use in a building and enables recycling (sustainable); and as a waste that can be in accordance in the nature cycle. Conservation of natural resources and sustainability of ecosystem cycles in nature, the election and the utilization of building materials with emphasis on recycling, the residents health and the impact on the environment,

efficiency energy, and maintaining of the local potential. The harmony of architectural design with nature must be able to preserve the environment, both local vegetation and other living things, by extending the green area which are expected to improve the absorption of CO₂ resulted from human activities, and preserve the habitats of other living things.

2. Demands in wood industrial

2.1. The raw material from plant forest

In 2003, the national production of logwood is 11.42 million m³, and it is increasing rapidly in a period of four years into 31.49 million m³ in 2007, and become inflated again 31.98 million m³ in 2008. In this case, the contribution of the industrial plant forest is 22.32 million m³ (69.8 percent of total the Indonesian logwood production) in 2008. But, in the period 2000 - 2009, the rate of forest damage in Indonesia has reached 1.51 million ha per year (Wirendro et al., 2011). The high forest damage requires rescuing the forest and would need stopping natural logging in order to give breathing (renewable resources). Another thing to be done is also by developing plant forest as an effort to fulfill the demands of the national wood industrial in Indonesia. Thus, there is no other choice for wood industrial, except switch from natural forest to the forest plant.

2.2. Ecolabel (Green Stamp)

Generally known as eco-labelling or green stamp, a green seal said the origin of labeled wood products is derived from the forest managed in a sustainable forest. Here must not impose only from the plant forest, but could be derived from natural forest followed principles of sustainable forest management. The presence of green stamp should be appreciated, for being the main incentive for various countries as producer of tropical timber for management of sustainable forest and become an incentive for marketing and sale of wood products.

2.3. Zero waste

Actually, the zero waste concept has been long publicly stated, but it very difficult to embodied by wood industrial in Indonesia. Nowadays, the concept of zero waste has already been started to apply; where the small and large diameter of timbers have arranged its use. This makes wood industry more efficient in the raw materials utilization. For example, the woods that considered not suitable for production still can be processed into other valuable products. For example, undesired wood is going into an enumerator machine make wood chips which will be further processed into wood pulp. Wood pulp can be used as raw materials for paper and fiberboard manufacture.

2.4. Wood industrial integration

Actually from the beginning the establishment of wood industry in Indonesia, like plywood industry, is being done to make integrated of wood industrial. Since 1967, forest management system has been introduced in order to increase benefits of natural forest production and to develop wood industry in Indonesia (Roda et al., 2007). During 1970 – 1979, it was recorded 70% of log wood (20.3 million m³) were exported, and 30% was used as the raw material for wood industry. While 1980 - 1989 is the peak of wood industry

development in Indonesia which supported by government policy on construction of wood industrial integration with plywood as core business and increased processed wood for the domestic and international market.

2.5. Environmentally friendly

The raw material of wood resulted from the forest is a part of technology of forestry products processing. Until now, the utilization of wood materials are still quite high, although its potential gradually is actually diminishing (Kasmudjo, 2010). Meanwhile, wood products in the future are required to be environmentally friendly, both in the process of production or utilization of these products. There are several aspects should be considered in of environmentally friendly practices: (i) recycling products, (ii) products made by the formaldehyde emission, (iii) products that can hold carbon, (iv) use of the non-destructive chemicals, and (v) raw materials derived from the results of legal trade.

3. Architectural design and technology of building materials

Architects need to learn about technology development of building material, application of building technology and standard necessary in the architectural design by quantitative approach (Hart, 2011). Embodiment of architectural design need awareness of real picture in its application causing the impact of material utilization in a building can be estimated its lifetime period. Thus, the use of material in architectural creations should be noted from the implementation stage to the post of execution stage or maintenance building. In designing building, an architect need to understand about the nature of building materials either physically or mechanically, thus the utilization of material in architecture design is consistent with the environmental conditions.

The utilization of natural resources (example: wood material) should be applied in closed cycle concept, recyclable and energy saving start from collecting in plant forest until reuse, adjustment on the environment, climate, cultural, and the economic. Frick and Suskiyatno (2007) explained the horrific impacts of technology can be resolve with the utilization of protective technology (having protection), simple technology, alternative technology or soft technology (high-tech technology often are defined as a hard technology). Soft technology like low pollution in the environment is an ecological technology; always give an equilibrium between technology and environment, nature and human.

Wood as traditional material for building does not contain a chemical substance, thereby safe for human health. Wood inclusion in the building material category can be cultivated, recycled, and can be transformed into another shape. The simple of wood transformation are gypsum board, cement board, composite wood, and others (Anonymous, 2013). Wood material is ecologically eligible, because: (1) exploitation and its production using less energy; (2) the transformation could be returned to nature; (3) exploitation of making, using, and its maintain have less pollution to the environment; and (4) derived from local sources.

4. Conclusions

Nowadays, the development of wood industry have increased, thereby required the presence of integration of wood industrial resulting the wood products that complied with environmentally friendly criteria. The utilization of wood materials should be in accordance with closed cycle concept, recyclable, and efficient of energy (energy saving) starting from harvested at plant forest until reuse in another wood products (transformation).

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Termite Biodiversity and Intensity of Residential Houses Deterioration in Taman Darmaga Permai ICiampea Bogor

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Abstract

Termites attack make building service life of being shorter. Building components which are attacked by termites are made of lignocellulose. The objective of this research was to understand the species of termites, distribution of termites and intensity of the damage building. Identification of termites species used baiting method (ASTM D 1758-06 2008) with burying ± 280 pine woods. The Intensity of building damage was done by components building survey in Taman Darmaga Permai I Residence, Ciampea, Bogor. There were five species of termites in research location such as *Macrotermes gilvus*, *Odontotermes javanicus*, *Coptotermes curvignathus*, *Schedorhinotermes javanicus*, dan *S. sarawakensis*. The widest spreading of termites species found was *O. javanicus* from Termitidae family. Most of home building conditions were in medium conditions (87.91%). Mechanical factors caused the highest percentage (40.75 %) of the damage building than biological (37.36 %) and physical factors (21.13 %).

Keywords: Baiting method, Distribution, Pine wood, Subterranean termites, Urban pest.

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1. Introduction

Termites frequently destroy wood as part of the construction of buildings and other cellulose material in the building. Nowadays, termite attacks of buildings is a very important issue by considering the intensity of their attacks which are high and extend, so that the value of losses due to termite attacks tend to increase from year to year. Subterranean termite is

the most occurring and potentially destructible pest on every building. According to Nandika (2015), the intensity of the termite and magnitude of damage caused is very high. Nandika (2015) reported that economic losses inflicted for damage in residential areas of Indonesia in 2015 was estimated at Rp 8.7 trillion. Widespread of housing area infection, will be followed by increasing number of termite colony in house buildings. Therefore, it is estimated that the threat of termite attack on the buildings will remain high.

The demography of Bogor city which has high rain intensity and humidity could be a major factor causing building damages. Damage of buildings like decay and crack could be an access for termites to attack the buildings. Termites not only attack the components of a building containing cellulose, such as window or door frame, door, roof components, and plafond, but also attack the building contents such as furniture and sculpture. This will certainly inflict high cost in economical aspect on the maintenance of constructed buildings. Based on those facts, the results of this research are expected to provide information about diversity and distribution of subterranean termite species at any residential area and to identify its intensity on house buildings.

2. Materials and Methods

This research was conducted in January until June 2013 at Taman Dramaga Permai I, Ciampea, Bogor, at the Laboratory of Quality Improvement Wood Technology, Department of forest products, Faculty of forestry, Bogor Agricultural University (IPB).

The instruments used in this research were bottle collection of termites, brush, digital camera, stereo microscope, thermometer and humidity (Krisbow), instrument measuring the intensity of light of the sun (Krisbow), transparent plastic, surgical instrument of termite, and soil driller. The materials used were composed of pine wood (*Pinus merkusii*) stakes 1.9 cm x 1.9 cm x 45.7 cm in size, oil painted (red colour) and alcohol 70%.

2.1 The identification of the species of termites in the housing

Identifying species of termites in housing area will require stakes. Stakes were made of pine wood of size 1.9 cm x 1.9 cm x 45.7 cm in drier air condition. The top of the stakes were painted with light colors (red) to help mark the location of stakes during the observation. Size of the stakes used were followed the ASTM-D 1758-06 2008 standard.

Installation of stakes was performed on tread house building and public facilities which were not covered by concrete layer or other artificial layer. Stakes mounted as many as 280 pieces which have been spread around the housing area. Stakes were immersed vertically into the soil with an estimated 1/2 part was below the soil surface, and the other half part was above the soil surface as shown in Fig. 1. Stakes were planted approximately two to three months.

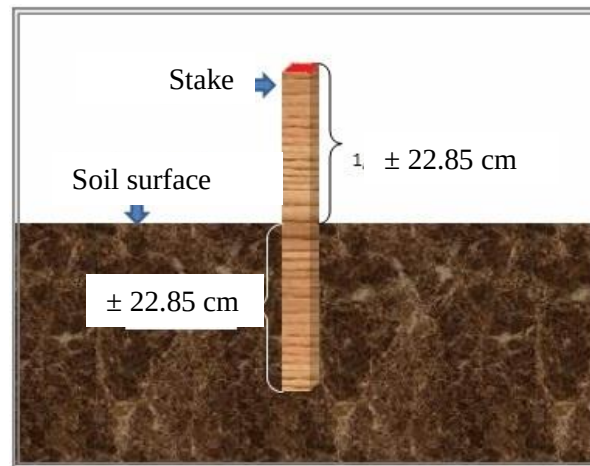


Figure1.Installation of stakes

Stakes were observed each month for insect infestation for a total of three months. Stakes that were attacked by soldier termites were extracted into a clean bottle containing alcohol 70%. Furthermore, termite species that attacked stakes were also identified in the laboratory based on literature or key identification according to Tho (1992). Collected termite species were photographed and observed using a 10 times-scaled microscope for whole insect body and 30 times-scaled for the head part including the antenna and mandible.

2.2 Damage intensity of house building

Damage intensity of termites to building was conducted by survey and interview activities. A total of 91 houses were surveyed with data collected on building components such as the roof, roof frame, rafter, ceiling, wall, wall frame, floor, door frame, window, door, foundation, drainage system, as well as on utilities with each component given a score according to the criteria specified below (Table 1).

Table 1 Score of building components

Condition	Score	Explanation
Good	5	Building components are still functioning properly and there is maintenance periodically
Medium	4	Building components are still functioning properly and there is maintenance periodically
Minor damage	3	Building components are still functioning, but 10% of components have symptoms of damages (decay, crack, termites attack, discoloration).
Medium damage	2	Building components are still functioning, but 10 - 40% of components have functional damage (decay, crack, termites attack, discoloration).
Serious damage	1	Above 40% of the building components have –functional damage (decay, crack, termites attack, discoloration).

Source: Sulaiman (2005)

Weighing was – done to determine the scale of priority on building components. Value of weighing was affected by side effects that inflicted between the damage of building

component and the other components if the mentioned components was not repaired immediately. Technique of weighting for each group components can be seen on Table 2.

Table 2 Technique of weighing for each group components

No	Object	Rating (%)	Evaluation Value Result					Value	Rating x Value
			Good	Medium	Minor Damage	Medium Damage	Serious Damage		
1	Roof	27							
2	Foundation	21							
3	Wall frame	19							
4	Ceiling	10							
5	Wall	9							
6	Door/window frame	6							
7	Floor	4							
8	Drainage system	3							
9	Utility	1							
Total		100							

Source: Sulaiman (2005)

To get solidity value of building obtained by a formula as follows:

$$\text{Value of building condition (\%)} = \frac{\text{Total Rating} \times \text{Value}}{500} \times 100\% \quad (1)$$

Next category of house building condition was grouped into five classes, depending on the percentage obtained. The values and predicate category of building conditions are showed in Table 3.

Table 3 Value and predicate category of building conditions

No.	Value of building conditions (%)	Predicate category
1	81 – 100	Good
2	61 – 80	Medium
3	41 – 60	Minor damage
4	21 – 40	Medium damage
5	0 – 20	Serious damage

Source: Departemen Permukiman dan Prasarana Wilayah (2003)

2.3 Data Analysis

Data processing of damage intensity of building was done using *Microsoft Excel* 2010. However, the analysis of data to determine the relation between age, frequency maintance and renovation against building condition was carried out by *Cross-tabulation Chi-square* using software *SPSS 16.0 for Windows*.

3. Results and Discussion

4.1 Diversity of subterranean termites

The results of identification and method of determination according to Tho (1992) showed that there are five species of subterranean termites were attacked 16 stakes at Taman Darmaga Permai ICiampea, Bogor. Identified termites were members of two termites family,

namely Rhinotermitidae and Termitidae, as well as including member of four subfamily, such as Coptotermitinae, Rhinotermitinae, Termitinae, and Macrotermitinae. Diversity of subterranean termites in Taman Dramaga Permai I, Ciampea, Bogor are showed in Table 4.

Table 4 Diversity of subterranean termites in Taman Dramaga Permai I, Ciampea, Bogor

No	Location	Family	Subfamily	Species
1.	A8b	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
2.	B11a	Rhinotermitidae	Rhinotermitinae	<i>Schedorhinotermes javanicus</i>
3.	B11a	Rhinotermitidae	Rhinotermitinae	<i>Schedorhinotermes javanicus</i>
4.	B12a	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
5.	C8a	Rhinotermitidae	Coptotermitinae	<i>Coptotermes curvignathus</i>
6.	C13b	Rhinotermitidae	Rhinotermitinae	<i>Schedorhinotermes sarawakensis</i>
7.	C14a	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
8.	C15b	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
9.	C18a	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
10.	C20a	Termitidae	Macrotermitinae	<i>Macrotermes gilvus</i>
11.	C22b	Termitidae	Macrotermitinae	<i>Macrotermes gilvus</i>
12.	D8a	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
13.	D19a	Rhinotermitidae	Rhinotermitinae	<i>Schedorhinotermes javanicus</i>
14.	Garden	Termitidae	Macrotermitinae	<i>Odontotermes javanicus</i>
15.	Garden	Rhinotermitidae	Coptotermitinae	<i>Coptotermes curvignathus</i>
16.	Garden	Rhinotermitidae	Coptotermitinae	<i>Coptotermes curvignathus</i>

The species that were found at the area of research are *C. Curvignathus* (attacked six stakes), *S. javanicus* (attacked three stakes), *S. sarawakensis* (attacked six stakes), *O. javanicus* (attacked eight stakes), and *M. gilvus* (attacked one stakes). Beside that, *S. sarawakensis* termite was also found to attack dead trees and *O. javanicus* attacked a fence bamboo. Fig.2 is a result of photograph of soldier termites caste that found at location of research.

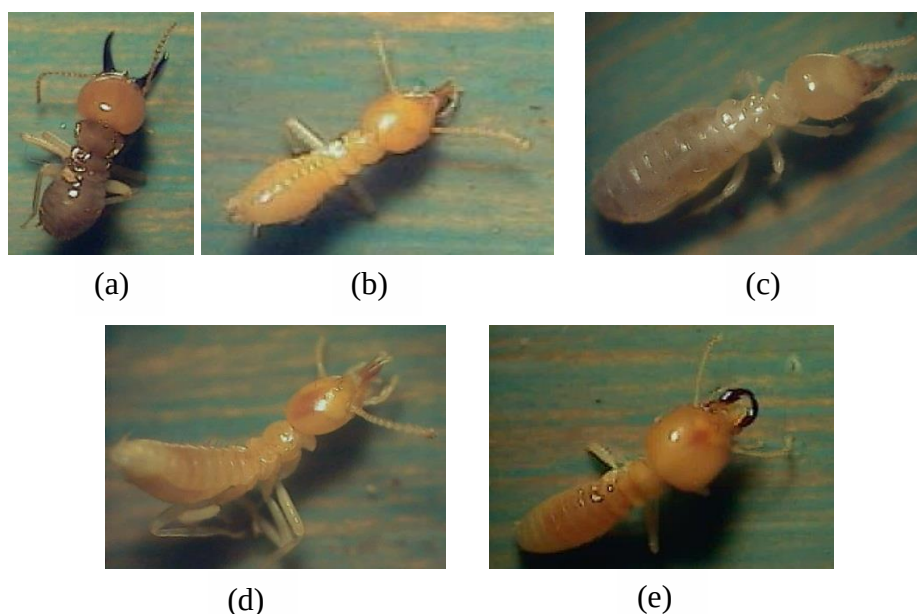


Figure 2. Termites were found at location of research, (a) *M. gilvus*, (b) *O. javanicus*, (c) *C. curvignathus*, (d) *S. javanicus*, (e) *S. sarawakensis*

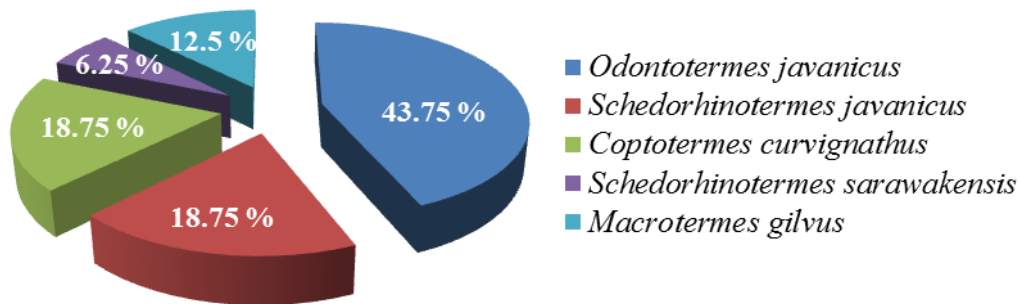


Figure 3. Frequency of termites diversity that attacked stakes in Taman Dramaga Permai I, Ciampea, Bogor

Fig. 3 show that species of termites that have the most wide distribution is *O. javanicus* with attack frequency of 43.75%. Meanwhile species that have the narrowest distribution was *S. sarawakensis* with frequency of 6.25% with *M. gilvus* and *C. curvignathus* species recording attack frequencies of 12.5% and 18.75% respectively. Also, *S. javanicus* was found to have attack frequency of 18.75%. Distribution of termites could be seen on Fig. 4.



Figure 4. Distribution of termites at Taman Dramaga Permai I, Ciampea, Bogor

The results showed that the Termitidae (56.25%) family was more dominant than the family of Rhinotermitidae (43.75%). According to Wang et al (2003), species of Rhinotermitidae are found more often beyond natural forest or in the areas of natural forest which has been converted into plantage or state areas. The subfamily of Rhinotermitidae found at the area of research, includes Coptotermitinae with *C. Curvignathus* and

Rhinotermitinae with members *S. javanicus* dan *S. sarawakensis*. According to Tarumingkeng (2000), members of family Rhinotermitidae which have the most attack on buildings are species from the genus *Coptotermes*. These termites belong to vicious termites that attack wood and buildings (Nandika et al., 1999). Meanwhile subfamily of Termitidae found at the area of research is subfamily Macrotermitinae with members *M. gilvus* and *O. javanicus*. According to Tarumingkeng (2000), species of family Termitidae that oftenly attack the building are the *Macrotermes* spp., *Odontotermes* spp., and *Microtermes* spp.

3.2 Damage intensity of house building

The results showed (Fig. 5) that most house buildings at Taman Dramaga Permai I were in medium condition (87.91%) category while the remaining buildings were included in good condition (8.79%) and minor damage category (3.30%). The overall building condition that were categorized has good condition was because of frequent maintenance and treatment. The maintenance conducted by painting the building frequently, approximately one to three times a year. According to Allsop et al. (2003), paint is one way of preventing wood from mold attack. Treatment on building was mostly conducted on the door or window frame, door, and window which are often attacked by termites. This was estimated because, wood that were used at the beginning of the construction are made from species which has low strength and durability and therefore vulnerable to termites, beetles and mold attacks as well as cracks.

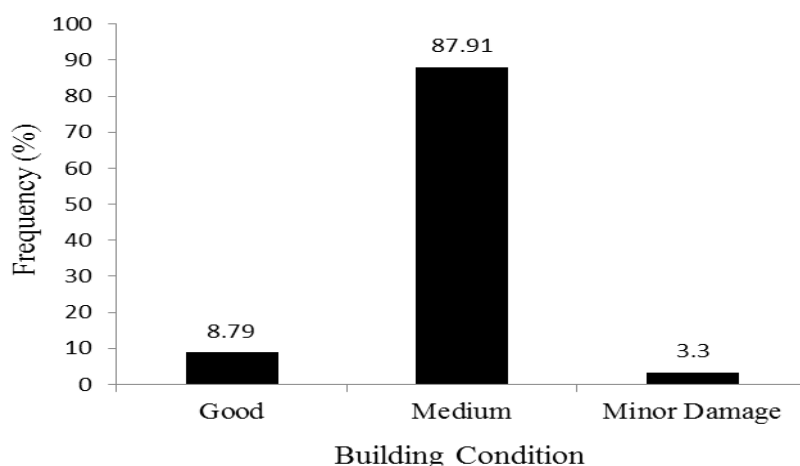


Figure 5. House building condition at Taman Dramaga Permai I, Ciampea, Bogor

3.3 Type and form damage of house building

The mechanical damage factor recorded the highest intensity (40.75%) followed by type of damage cause by biological factor (37.36%) and physical factor (21.13%). The most biologically damage that occurs was decay on the roof.

According to Priadi (2011), Bogor city is amongst some of the places vulnerable to termites damages. Therefore, it was estimated that this is one of the supporting factor of growing other wood destroy organisms in the house building. Besides decay, the other biological damages were caused by termite attacks, dry wood termite attacks, beetles, molds, and lichens. Meanwhile, mechanical damage found at the research area was cracks. Whereas, physically damages occurred were found to be abrasions of paint and discoloration.

Figure 6. Damage frequency of house building

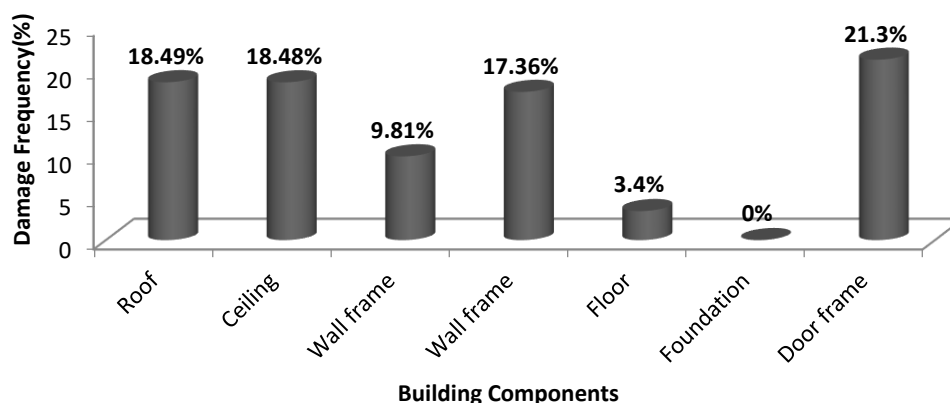


Fig. 6 showed that roof (18.49%), ceiling (18.48%) and door frame (21.3%) were components with the most damage. Meanwhile, floor and foundation were components with a scarce damage. Type of damage that mostly occurred on the roof components were cracks and decay. Meanwhile, the common form of damage which mostly occurred on the floors was crack of ceramics.

5. Conclusions

The results of the research concluded that there were five species of subterranean termites at Taman Dramaga Permai I, comprising of *C. curvignathus*, *S. sarawakensis*, *S. javanicus*, *O. javanicus*, and *M. gilvus*. Termite species that had the most wide distribution was *O. javanicus*. Whereas termite species that had the narrowest distribution was *S. sarawakensis*. The results of survey on damage intensity of house buildings showed that most of the buildings fell under the medium condition category. Meanwhile there were also damages found caused by dry wood termite attacks and other organisms.

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TIME SCHEDULE

November 5th, 2015 (Thursday)

11.30-12.30	:	Registration of Participants
12.30-13.30	:	Ishoma and Lunch
13.30-14.00	:	Opening Ceremony
14.00-14.15	:	Documentation Session (Photograph)
14.15-16.05	:	General Lecture (Keynote Speeches)
14.15-14.35	:	Theme 1: Prof. Suminar S. Achmadi (Bogor Agricultural Univ.)
14.35-14.55	:	Theme 2: Prof. Tsuyoshi Yoshimura (Kyoto University)
14.55-15.15	:	Theme 3: Prof. Hiroshi Uyama (Osaka University)
15.15-15.35	:	Theme 4: Prof. Mohd. Hamami Sahri (Univ. Malaysia Sabah)
15.35-16.05	:	Discussion
16.05-16.20	:	Coffee Break
16.20-16.40	:	Invited speaker session
16.40-17.40	:	Parallel presentation session 1
17.40-18.15	:	Parallel presentation session 2
18.00-19.00	:	Break, Ishoma, Banquet

November 6th, 2015 (Friday)

08.00-08.30	:	Registration + Coffee Break
08.30-10.20	:	General Lecture (Keynote Speeches)
08.30-08.50	:	Theme 1: Prof. Paridah Md. Tahir (Univ. Putra Malaysia)
08.50-09.10	:	Theme 2: Prof. Yoshikuni Teramoto (Gifu University)
09.10-09.30	:	Theme 3: Prof. Jun-Ichi Azuma (Osaka University)
09.30-09.50	:	Theme 4: Dr. Ing. Ansgar Frenzel (Thermo Scientific, Germany)
09.50-10.20	:	Discussion
10.20-10.50	:	Standing Posters
10.50-11.20	:	Parallel presentation session 3
11.20-13.15	:	Lunch
13.15-14.15	:	Parallel presentation session 4
14.15-15.15	:	Parallel presentation session 5
15.15-16.15	:	Parallel presentation session 6
16.15-16.35	:	Coffee Break
16.35-16.45	:	Closing Ceremony

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(IWoRS) 2015
Bandung, 5-6 November 2015**

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175.	Effendi Tri Bahtiar	Dr.	Fahutan IPB
176.	Deni Zulfiana	M.Si	Research Center for Biomaterials, LIPI
177.	Aris Sigit Sarmanto		Research Center for Biomaterials, LIPI
178.	Faizatul Falah	M.T	Research Center for Biomaterials, LIPI
179.	Bambang Subiyanto	Prof. Dr.	Indonesian Institute of Sciences
180.	Dewi Nilawati		Research Center for Physics, LIPI

DISCUSSION SESSION

Field : **Biocomposite**

Parallel : 1

Moderator : Juliana Abdul H.

Time :

PIC Room : Room 2

No	Presenter	Question/Comment	Name	Clarification
1.	Lisman Suryanegara	1. Why the sample is heated from 0-120°C? 2. Does the semicrystalline includes nano or not?	-	1. The sample is heated started at -20°C but not shown in the Figure since there is nothing happen.
2.	Subyakto	1. How many replicates done? 2. How can presenter convince people to use this two spp of bamboo?	-	1. 5 replicates done. 2. Can lose both spp. Yet sembilang (less popular) spp are more uniform and suitable to be used as ply bamboo.
3.	Lisman Suryanegara	1. How to reduce the formaldehyde emission if the mc is high?	-	1. Yes, it is need to reduce.
4.	Muhammad Navis Rofii	-	-	-

Note:

DISCUSSION SESSION

Field : **Biocomposite**

Parallel : 2

Moderator : Suhasman

Time : 17.00 – 18.00

PIC Room :

No	Presenter	Question/Comment	Name	Clarification
1.	Ismail Budiman	1. Relationship between density of the sample and the result of the study?	Prof. Yusram	1. The effect of density is not very big.
2.	Akira Sakakibara	1. The density of the samples are different. How could you determine this if you stated that the properties is different?	Prof. Yusram	1. We were uniformed the thickness, not the density.

Note:

DISCUSSION SESSION

Field : **Biocomposite**

Parallel : 5 & 6

Moderator : Subyakto

Time :

PIC Room : Ismail B.

No	Presenter	Question/Comment	Name	Clarification
1.	Juliana (B.19)	1. Thermographs result polymer degraded below 150°C?	Nyoman W.	1. Data will be checked again.
2.	Neni (B.26)	1. Are there harmful bacteria after some time?	Novi Tri	1. Microbial content is not yet analyzed. However, heater is used.
3.	Neni (B.26)	1. Cost of biotoilet?	Nyoman W.	1. About Rp 15 million.
4.	Yusram (B.24)	1. Can we use solvent to have more disperse IC?	Nyoman W.	1. The type of IC is different (more viscous).
5.	Jesica (B.23)	1. Why CLT has lower strength than solid wood?	Wahyu	1. Maybe due to defect (cracks) of inter lamina.

Note:

